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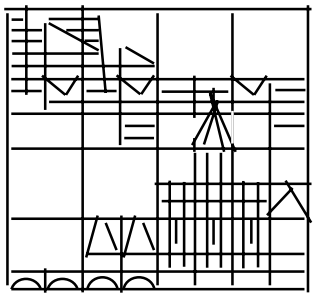

Investigation of the Critical Factors of Success in Telepathology – an International Comparison Study

DISSERTATION

zur Erlangung des Doktors der Naturwissenschaften
an der Universität Konstanz

eingereicht von
Ingrid Hosch
Oktober 2001

Betreuer:
Professor Rainer Kuhlen, Universität Konstanz
Professor Klaus Kayser, Universität Heidelberg

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Beim Promovieren gewinnt so mancher den Eindruck,

im 'wissenschaftlichen Glashaus' zu sitzen,

während das Leben draußen

ganz andere Takte spielt –

Die Kunst ist wohl,

beides sinnvoll und ausgewogen

zu vereinen!

(eigene Anmerkung)

Preface

This study is an independent approach to examine the factors of success in telepathology. Therefore it was neither financially supported by any telepathology supplier, network provider or pathological association, nor did a telepathology user or non-user have an impact above-average. The attitude of independence was also kept up when investigating the robotic-dynamic telepathology system SAMEBAS in Basel (CH), a telepathology approach from which vital factors of success could have been gained. This way I was able to get a neutral impression of the situation in telepathology.

That the study is written in English is not common at the University of Constance. Please, do not expect a rhetorical-lyrical report, since it is not William Shakespeare writing it. I tried to do my best in making my research findings accessible for international participants of my study and readable for people, who are not familiar with the German language.

Expression of Thanks

I wish to thank all the persons who participated in this study and who answered the questionnaire as it was quite a lot of effort and patience they invested. Further I want to thank all the friends and colleagues, who gave support with very valuable advice and criticism and thereby helped to increase the quality of this study. These are first of all Prof. Kuhlen and Prof. Oberholzer from the University Hospital of Basel and his colleagues. I also want to thank Ivar Nordrum, Bruce Dunn, and Peter Schwarzmann who were the first ones agreeing to participate at my study. Thanks to Prof. Schlake and Mrs. Kemptny of the German Medical Board of Pathologists who helped me by promoting pathologists to participate at this study. Yet, special thanks go to Roswitha Puca, who supported my statistical analyzes, and Katrin Hockenjos, Moritz Hahn, Rouven Kraft, and Marc Ivanchak for the extensive correction work. I am lucky that they still call me a friend.

A research study is not just a scientific encouragement, but also a psychological one, as most of the PhD-students may confirm. I had to learn a lot about my personality and about the way I react in a certain situation. I want to thank all my friends, who accompanied me at the frequently occurring periods of frustration and pessimism (Gerlinde Münch, Doris Schleier, Roswitha Dieterlen, Barbara Seuster).

Abstract

The research study at the University of Constance, Department of Information Science had been set up in 1998 to investigate the factors of success in telepathology. Telepathology is a field of telemedicine and has been defined as the practice of pathology by visualizing an image from a distant location on a video monitor rather than viewing a specimen directly through a microscope. In short words, telepathology is ‚pathology at distance'. It is mainly used for primary tele-diagnostic, tele-consultation (expert's second opinion), quality assurance, proficiency testing, distance learning and education, expert discussions, or even for staff meetings. The PhD study started with an extensive analysis of recent literature and a detailed field study at the University of Basel (Prof. Oberholzer). There a dynamic-robotic telepathology system is employed for tele-diagnostic and quality assurance purposes. Then questionnaires were designed and sent to users and non-users (350 pathologists) of telepathology systems to request their opinion about certain criteria in telepathology such as political impact, liability concerns, geographical localities, reimbursement and efficiency criteria, questions about security, user friendliness of systems, etc. The meaning of criteria could have been rated by a scale from +4 (high impact/very important) to zero (no impact). Some open questions enabled participants to add comments about certain aspects. 40 users and 72 non-users returned their questionnaire.

All judgements referring to the interest in certain telepathology services, the relevance of various factors to telepathology's success, and the judgement of advantages and disadvantages were distinguished in users' and non-users' ratings. Further values were investigated by regarding the age, computer experience, attitude towards new technologies, size of institution/department, degree of specialization, and participant's interest in cooperation. In addition, several accuracy aspects were examined by referring to the kind of system employed (static or dynamic) and by the qualification of the sending client.

In summary, 'accuracy' aspects and the meaning of ‚equipment quality' achieved the highest ratings, whereas political, structural or geographical criteria were given a secondary importance for telepathology's success. Considering the average ratings of criteria, the highest ratings are at 3,7 (3,6 at users; 3,8 at non-users) and the lowest at 2,4 (2,7 at users and 2,3 at non-users). Consequently, all regarded criteria have proved to have an impact on telepathology's success. The final relevance of a criteria is strongly dependent on the specific situation of a pathologist and the desired service which will be introduced.

Erfolgsfaktoren der Telepathologie – Zusammenfassung

Definition und Geschichte

In der vorliegende Forschungsarbeit wurden die Erfolgsfaktoren der Telepathologie detailliert untersucht.

Telepathologie ist ein Teilbereich der Telemedizin. Die einfachste Definition von Telemedizin bezeichnet diese schlicht als 'Medizin auf Distanz[1]' [Houtchens, 1995, p. 93]. Dementsprechend ist Telepathologie *‚Pathologie auf Distanz'*. Beschreibt man es konkreter, so versteht man unter dem auf den medizinischen Bereich Pathologie beschränkten Begriff ‚Telepathologie' den Einsatz von Telekommunikationstechnologien und Computern zur Durchführung von externen pathologischen Ferndiagnosen (Bildbefundung am Monitor über das Netz) sowie zum Austausch und zur Sammlung von Daten, Bildern und pathologischem Wissen zwischen räumlich entfernten Orten [Bashshur, 1995, p. 82; Dunn, 1996/(2), p. 463].

Die Idee der Telemedizin existiert schon lange. Bereits im Jahre 1920 wurden Schiffe im Notfall über Radiofrequenzen medizinisch beraten [Williams, 1995]. Einige Jahre später, im Jahre 1956, wurde die erste 'face-to-face' Konsultation in Nebraska (USA) in der Psychiatrie erfolgreich getestet [Wyman, 1994; Müller, 1996, p. 9]. Als die NASA im Jahre 1960 telemedizinische Systeme als Medium zur medizinischen Überwachung und Behandlung ihrer Astronauten entdeckte, wurden immer mehr medizinische Tele-Anwendungsbereiche erforscht und bald auch kommerziell eingesetzt. Jedoch erst mit der Entwicklung von digitalen Technologien und hochqualitativer Bildverarbeitung sowie der Einführung des Internets, kam es zur weltweiten Entwicklung ganzer Telemedizin-Netzwerke (z.B. Eastern Montana Telemedicine Network oder das West Texas MEDNET). Die erste telepathologische Anwendung wurden 1968 in Boston getestet. Pathologische Bilder wurden mittels statischer, asynchroner Datenübermittlung zur Auswertung an einen Experten übertragen. Seit 1990 finden statische, als auch dynamische real-time Telepathologiesysteme, bei denen der Tele-Experte das Mikroskop des Senders oftmals ferngesteuert bedienen kann, zunehmende Akzeptanz.

Betrachtet man die Einsatzgebiete, so werden Telepathologiesysteme zur Durchführung von Telediagnosen (Erstgutachten) und Telekonsultationen (Zweitgutachten) eingesetzt. Sie eignen sich aber auch sehr zur Fort- und Weiterbildung sowie zur Durchführung von Online-Diskussionen und Foren, bei denen Problemfälle besprochen werden. Ausserdem wird seit mehreren Jahren der Einsatz von Telekommunikationsmedien zur Entwicklung und Verbesserung von 'computer-aided' Diagnoseverfahren und 'Quality Assurance' Aktivitäten (z.B. DNA-Cytometrie oder quantitative Cytologie) in der Pathologie erforscht.

Aufbau und Methoden der Untersuchung

Aufgrund aktuell veröffentlichter Literatur wurden die Problembereiche von Telemedizin- und Telepathologieprojekten herausgearbeitet und strukturiert. Zusätzlich wurde das dynamisch-robotische Telepathologiesystem von Prof. Oberholzer (Kantonsspital Basel/CH)

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[1] Hierunter fallen u.a. Bereiche wie Teleconsultationen von Patienten mittels Videokonferenzsystemen oder Telemonitoring von Patienten in medizinisch instabilem Zustand (Herzinfarkten oder Risikoschwangerschaften). Weitere Bereiche sind in der Arbeit beschrieben.

eingehend vor Ort untersucht und Interviews mit weiteren Pathologen durchgeführt. Im Anschluss daran wurden zwei Fragebögen entwickelt – einer für Nutzer und einer für Nichtnutzer von Telepathologiesystemen (siehe Anlage 5). Von den 370 an Pathologen versandten Fragebögen wurden 112 ausgefüllt an die Universität Konstanz zurückgeschickt (Nutzer: 140 verschickt, 40 zurück; Nichtnutzer: 230 verschickt, 72 zurück). Die Umfrage an Nichtnutzer war auf Deutschland beschränkt.

Erfolgsfaktoren

Wie der Begriff bereits suggeriert, sind Erfolgsfaktoren jene Kriterien, welche zum Erfolg- bzw. Misserfolg der Telepathologie wesentlich beitragen. Diese Faktoren werden in Kapitel 10-16 ausführlich beschrieben. Zuerst einmal sind dies politische Einflüsse sowie Managementaspekte und strategische Entscheidungen. Es wurde die Bedeutung von Gesundheitspolitik und –reformen, von Pathologieverbänden, Krankenversicherungen als auch organisationsinterne Strukturen und die Akzeptanz von Ärzten und Patienten betrachtet. Da die Telepathologie von funktionsfähigen Systemen und Netzwerken abhängig ist, wurde auch die Qualität der technischen Ausstattung (Mikroskop, Kamera, Workstation, Monitor, Interfacedesign) und der Netzwerke sowie deren Stabilität und Sicherheit untersucht. Telepathologiesysteme dienen zur Kommunikation mit räumlich entfernten Pathologen. Dies ist jedoch nur möglich, wenn die verwendeten Applikationen kompatibel sind. Deshalb wird die Problematik von Standards und Protokollen, von pathologischen Prozessen und Daten in Kapitel 14 aufgezeigt. Auch Effizienzaspekte, Investitionskosten und deren Finanzierung, Leistungserstattung und Einsparung sowie die Veränderung von Prozessen werden angesprochen. Als letzter Bereich wurden die Faktoren, die die Diagnosequalität beeinflussen, herausgearbeitet. Hierbei wird zwischen der Verwendung statischer und dynamischer Systeme unterschieden.

Die verschickten Fragebögen zielten darauf ab, die angesprochenen Problembereiche auf ihre Bedeutung hin zu betrachten und zu bewerten. In den meisten Fällen stand den Teilnehmern hierfür eine Bewertungsskala von +4 (große Bedeutung) bis Null (keine Bedeutung) zur Verfügung.

Ergebnisse

Die Ergebnisse der Untersuchung sind in den Kapiteln 17-19 dargestellt. Da die zu bewertenden Kriterien, trotz Zusammenfassung in konzentrierte Problembereiche, immer noch sehr umfangreich waren, wurden diese anhand einer statistischen Faktorenanalyse zusammengefasst. Eine Faktorenanalyse wurde ausserdem zur Kumulierung der Telepathologieserviceleistungen, der Vor- und Nachteile, als auch bei den Kriterien, die die Diagnosequalität beeinflussen können, durchgeführt.

In Kapitel 18 werden die Bewertungen der *Nutzer und Nichtnutzer* der Telepathologie dargestellt und diskutiert. Zusammenfassend wurden die Kriterien, die die Diagnosequalität beeinflussen, am höchsten in ihrer Bedeutung für den Erfolg von Telepathologie Systemen eingestuft. Hier waren vor allem Nichtnutzer sehr sensibel. Auch der Qualität der Ausstattung wurde ein hoher Einfluss zugesprochen. Kriterien, die auf einen reibungslosen Workflow und auf die Stabilität von Systemen abzielen, wurden von beiden Gruppen ähnlich bewertet und an Platz vier und fünf gesetzt. Die Bedeutung einer rechtlichen Klarheit (Platz sechs) und der Einfluss von Standardisierung und Systemintegration (Platz sieben) wurden wiederum von Nichtnutzern als wesentlich dringlicher eingestuft. Hier ist klar ersichtlich, dass Nichtnutzer eine reduzierte Diagnosegenauigkeit durch Telepathologie

befürchten und daher die rechtliche Situation geklärt wissen möchten. Ausserdem scheinen sie nicht in isolierte Lösungen investieren zu wollen, was die hohen Wertungen für Systemintegration anzeigt. Managementaspekte wurden von den Nutzern hoch eingestuft. Nutzer scheinen bei der Einführung ihrer Systeme schlechte Erfahrungen gemacht zu haben, was auch viele Kommentare in der Literatur belegen. Kosten- und Effizienzkriterien erscheinen an vorletzter Stelle. Viele Projekte werden Augenblicklich durch Forschungsgelder finanziert, so dass die oftmals fehlende Leistungserstattung nicht die höchste Priorität erhielt. Dennoch ist dieser Aspekt mit einer durchschnittlichen Bewertung von 3 (Skala +4/sehr wichtig bis 0/unbedeutend) sehr ernst zu nehmen. An letzter Stelle sind politische und strukturelle Kriterien zu finden. Da Telepathologieprojekte jedoch häufig an geographisch schwierig zu erreichenden Orten angesiedelt sind und politische Boykottierung nicht selten zur Einstellung bzw. Nichteinführung der Telepathologie geführt hat, sollte die im Vergleich zu den anderen Aspekten niederen Wertungen nicht dazu führen, dass dieser Bereich unterschätzt wird.

Insgesamt waren die durchschnittlichen Bewertungen (siehe Kapitel 18.3.2) zwischen 3,7 und 2,4 Punkten. D.h. dass die meisten betrachteten Kriterien einen Einfluss auf den Erfolg der Telepathologie haben. Wie stark die jeweiligen Aspekte zum tragen kommen, hängt oftmals vom Einzelfall ab.

Zuletzt wurden die Bewertungen im Hinblick auf bestimmte Eigenschaften der Nutzer analysiert, z.B. Alter, Computererfahrung, Einstellung zu neuen Technologien, Spezialisierungsgrad des Pathologen, Grösse des Institutes, Art des genutzen Systemes. Die Ergebnisse dieser Unterscheidungen sind in Kapitel 19 zu finden. Ausserdem wurden die Gründe der Einführung von Telepathologie, das Interesse anTelepathologieleistungen, die aktuelle Nutzung und die gewünschte Einführungsstrategien sowie die Ursachen von Diagnoseungenauigkeiten analysiert und im Ergebnisteil ausführlich diskutiert.

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Abbreviations

ADICAP	Association for the Development of Informatics in Cytology and Anatomic Pathology
AIM	Advanced Informatics in Medicine
AITN	Arizona-International Telemedicine Network
ATM	Asynchronous Transmission Mode
CAP	American Society of Clinical Pathologists
CCD	Charge-Coupled Device (e.g. a CCD camera produces digital data directly)
DICOM	Digital Imaging and Communications in Medicine
FEST	Framework for European Telemedicine Services
FTP	File Transfer Protocol
G7	A group of the seven most industrialised nations in the world
HCFA	Health Care Financing Administration
HIS	Hospital Information System
HL-7	Health Level-7 data communications protocol
HMO	Health Maintenance Organization (insurance provider with special variable conditions; US-system)
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ITU	International Telecommunications Union
JPEG	Joint Photographic Experts Group
JPEG	Joint Photographic Experts Group; coding algorithm for images with a compression rate up to 1:1200
LAN	Local Area Network
MPEG	Motion Picture Experts Group; compression of digital moving images
NLM	National Library of Medicine
PACS	Picture Archiving and Comminication System
PCA-factor	Principal component analysis = statistical procedure to analyze variables, which can be accumulated to a factors
RIS	Radiology Information System
ROC	Receiver Operating Characteristic
SE	Standard error; standard error is calculated by standard deviation / root extraction of n (n = amount of judgements)
SGML	Standard Generalized Markup Language (ISO 8879 - standard for system integration)
SNOMED	Systematized NOMenclature of MEDicine
SNOP	Systemized NOmenclature of Pathology
STM	Synchronous Transmission Mode
TM	Telemedicine
TP	Telepathology
WAN	Wide Area Network
WHO	World Health Organization
WWW	World Wide Web
XML	Extensible Markup Language (standard format for data integration; variation of SGML)

CENARIOS IN TELEPATHOLOGY

DYNAMIC TELEPATHOLOGY

„A 38-year-old woman, who lived 300 km from the nearest hospital, was referred with a tumor in her left breast. A fine-needle aspiration cytology specimen had previously shown signs of malignancy. The surgeon resected the tumor and ordered a remote frozen-section diagnosis. Since this was a case of elective surgery, our department (University Hospital of Tromsoe) had been notified about the forthcoming frozen section the day before. When the tumour was resected, the remote hospital connected their workstation to our workstation by dialling from the screen. In addition, they telephoned the pathologist on call to summon him to the telepathology studio. The surgeon handled the gross specimen under the guidance of this pathologist. The resected tumour was cut in two. It had a whitish appearance. A specimen for frozen section was selected and the pathologist went back to his office while it was prepared. It was ready after about 15 min. In accordance with normal procedures, two pathologists made the microscopic diagnosis. The whole consultation lasted about 35 min. The diagnosis was breast carcinoma. The breast was ablated and the axillary lymph nodes removed. This material, along with the resected tumor and the frozen section, was sent by mail to our department for the usual final diagnosis. The diagnosis of infiltrating lobular carcinoma was in accordance with the frozen-section diagnosis.

...Before this service was available, women with breast tumors stayed one day at the hospital for tumor resection. They then returned home and waited for the histological diagnosis to arrive about a week later. Those with a malignant diagnosis then had to return to the hospital for further surgery.“ [Nordrum, 1997, pp. 172-173]

STATIC TELEPATHOLOGY

“.... The local pathologist selects the images that he/she considers representative of the diagnosis and captures them by using his/her workstation. The selected images are delivered to the remote workstation together with a brief clinical history and patient data, when available in the patient record. The remote pathologist formulates a diagnostic hypothesis, by visualizing the images on the monitor of the remote workstation.” [Della Mea, 1996, p. 25]

Introduction

The following study investigates various factors for their influence on telepathology's success and pitfall. 40 users of pathology systems and 72 non-users participated at the study in Constance. How the study is designed, which methods are employed, the objectives, as well as the delimitation of the research study are described in chapter one. The next parts are divided in four basic units. First a characterization of telemedicine in general (chapter 2-5), second a description of telepathology (chapter 6-9), third an explanation of various criteria of telepathology success (chapter 10-16), and fourth the illustration and discussion of the empirical results of the study (chapter 17-19).

Characterization of Telemedicine in General (Chapter 2-5)

Telepathology is a sub-specialty of telemedicine. Therefore, first of all I considered it as important to envisage how general developments in telemedicine affect the health care delivery system and by this influence telepathology developments, too. Beginning with the definition of important terms, the general history of telemedicine developments will be described and some areas and project in telemedicine are demonstrated, distinguished by location, fields, and activities of telemedicine utilization. To emphasize the importance of telepathology being integration in telemedicine developments, important organizations and some telemedicine projects are described.

Description of Telepathology (Chapter 6-9)

Embedded in the overall developments of telemedicine, the subspecialty 'telepathology' is regarded in detail. First of all I will exhibit the course of events. I will expose the history, organizational structures, kind of services offered, and point out the reasons for telepathology introduction. Then the different types of telepathology systems are explained. These are mainly static and dynamic-robotic telepathology systems. To expound the procedures in telepathology which will be later referred to, I have illustrated a typical telepathology examination process in a data flow chart. After telepathology has been described in detail, I will introduce several projects in telepathology by pointing out their background, equipment and utilization.

Explanation of Various Criteria of Telepathology Success (Chapter 10-16)

In chapters ten to sixteen I illustrate several areas which were named as problematical for telepathology success in recent literature. I illustrated these important aspects from different points of view. Doing so I will often refer to telemedicine in general. Yet again it is to emphasize that telepathology is a sub-area of telemedicine and therefore the situation is often identical for both terms. I assumed that factors of pitfall, which occur in other fields of telemedicine, for example in the further established field of teleradiology, could also have an impact on the success of telepathology projects and therefore should be considered in this study, too. One area where aspects are overlapping is characterized in chapter ten. There political factors, historical, geographical, as well as management criteria are commented. Since telepathology is strongly influenced by technology, critical aspects of

telepathology's system design and the equipment employed, as well as the advantages and disadvantages of different available networks are discussed. Telepathology services have to rely on a secure exchange of all personal and medical data of a patient. Therefore I have also investigated important security and safety factors in more detail. Another sector which occurs as critical for telepathology's success is efficiency. In chapter thirteen I have examined the overall efficiency of telepathology services within the health care delivery system, as well as financial criteria like investment costs or the cost amortization due to revenues and savings. Giving some examples of costs, these are converted into US-$. Yet, since prices vary frequently due to currency variations and changed prices, the given totals can only be taken as approximate values. Realizing that telepathology has to rely on a smooth and fast exchange of data and images, the problem of missing standards and unsatisfactory system integration are often mentioned as problematic in recent literature. Therefore I point out various areas where standards are desirable and refer to important institutions of standardization. Another very critical aspect of telepathology examinations is liability. Knowing that liability fines in health care can be very high, several legal points of view and critical areas are illuminated. Finally I have consider one of the most delicate criterion of telepathology's success - diagnostic accuracy. The discussion about diagnostic accuracy already led to various studies examining the accuracy of telepathology examinations. That is why I have worked out the most important factors of influence on diagnostic accuracy very detailed.

Illustration and Discussion of the Empirical Results of the Study (Chapter 17-20)

In the next chapters, seventeen to twenty the results of the empirical study executed in Constance are represented and discussed.

All results are accumulated in separate chapters, because it enables a comparison of the different ratings of factors. In addition it allows researchers, who know the problematic areas of telepathology, to look directly at the empirical results. Yet, for readers who are not familiar with the current research findings in telepathology it is to recommend first to read chapters ten to sixteen, since these chapters give valuable explanations to understand the concentrated considerations of the areas of difficulty in telepathology.

The results of the study can be subdivided into three main parts: a) factor analysis, b) users' and non-users' judgements, and c) judgements in relation to specific characteristics. The first part, the factor analysis, investigates statistical similarities within the examined criteria of telepathology's success. This way summarized factors can be built, which allow a more concentrated analysis of ratings.

At the users' ratings first of all I will depict the reasons and objectives of participating users for telepathology introduction. To trace the inquiry for different telepathology services, I further have analyzed the frequency of the actual telepathology service utilization. This utilization will be compared with participants' judgements about their interest of using various telepathology services in the future. In addition participants were asked about their recommended strategy for telepathology introduction. Whether they would prefer to focus on regional telepathology solutions or would like to follow international developments is also illustrated and analyzed.

After that I will discuss the ratings of the main factors of telepathology's success or rejection. If available, I have added comments of participants from interviews as well as written comments of the questionnaires to each factor. Then I have evaluated and interpreted par-

ticipants' ratings of the expected advantages and disadvantages. To regard telepathology from a broader point of view, participants were also asked about the situation and attitude of their colleagues towards telepathology. These results are interpreted by referring to the judgements of the factors of success and the dis-/advantages. All these ratings are divided in users' and non-users' judgements and analyzed in relation to each other.

Finally the interest in telepathology services, the ratings of the factors of telepathology's success, as well as all dis-/advantages were investigated with regard to specific characteristics of participating pathologists, such as age, computer experience, department size or the degree of specialization. Further the ratings of users were analyzed by referring to the type of system used and the qualification of the client. In addition, users were requested to estimate the meaning of aspects which could cause diagnostic inaccuracy. Again, the results are analyzed by referring to the system type.

The whole report ends with a final discussion and a summary prospect for the future developments in telepathology.

1 Objectives, Design, and Methods of this Study

1.1 Objectives of this Study

Over the past twenty years, there have been various demonstrations of advanced telemedicine service introductions. However, many projects have been of short duration. Considering telepathology applications, which this study is focused on, health care providers are reluctant in introducing telepathology services and the utilization rates of existing systems and services are often poor. There seems to be a lot of resistance at health care decision makers and pathologists do not rarely appear to be skeptical about telepathology.

Several research studies in the past have attempted to collect data on various aspects of telepathology systems, such as diagnostic accuracy analysis [see appendix VI and VII]. However, unfortunately there are no publications that have summarized the elements of success or failure of telepathology projects so far.

It is similar with other telemedicine projects [Puskin, 1995/(2), p. 129; Moore, 1995]. Many articles have been published, but mostly with a specific view of the author. To give some important pioneers and researchers who investigated telemedicine developments on a broader scale, Douglas A. Perednia MD (Portland, Oregon), Ace Allen, MD (Kansas City, Kansas), or Jim Grigsby (University of Colorado) often mentioned their opinion in the literature. Yet, most of their publications are also focused on several aspects but do not regard the full spectrum of difficulties. It seems that systematic evaluations of telemedicine systems and its impact on health care delivery systems are still an exception.

The aim of my study was to collect data about telepathology systems in a **standardized** manner in order to gather and **quantify** larger volumes of multi-faceted information in a **systematic** way. Therefore the key success factors of telepathology projects and service utilization have been examined. Doing so, areas which are often mentioned as problematical in the literature are thoroughly regarded. Differences related to the type of system employed (static / dynamic) are emphasized. Additionally, a fundamental matter of concern was to trace the meaning of different critical success factors. Opinion polls were executed, where users and non-users of telepathology were asked to rate various criteria with regard to the influence of telepathology's success or failure. Summarizing these criteria into groups of factors resulted in a simplified way of comparison and additionally showed a characteristically relationship within the factors. Furthermore significant factor differences related to the users' characteristics were carried out statistically by variance and correlation analysis.

1.2 Delimitation of the Research Study

In this study, telepathology is seen as the usage of information technology for direct interaction between individuals at geographical separated locations by involving an specialized expert on one side - in our case a telepathologist - and mostly a non-expert on the other side. Data and images of the patient and of his medical condition have to be transferred by using networks. That means that telephone, FAX and E-mail can be involved but the main focus is on the data interaction for especially exchanging video images, but also textual, numerical or graphical medical pathological data via networks. Special attention was

drawn to the execution of tele-diagnostics (primary diagnosis) and tele-consultations (second opinion), yet also tele-education, tele-discussion and other valuable areas concerning telepathology were included. I will not considered virtual reality systems, computer simulations (except for robotic microscopes), or investigations in comprehensive intelligent database system developments for tele-imaging.

The study was designed to consider the opinion of pathologists from all over the world, since telepathology systems have the advantage that they enable an international communication in telepathology and because this enables to work out country related differences. Yet due to the limitation of research money and time, the opinion pool of pathologists, who do not use telepathology was geographically restricted to Germany. The request of telepathology users was executed internationally. Most data was collected by using questionnaires. Since the amount of effort for participants had to be kept in an acceptable scale, areas of interest could not be regarded too detailed (still the questionnaires had five and seven pages – see appendix V). To still illuminate the broad meaning of various aspects of telepathology's success, experiences reported in the literature had been integrated and discussed. Doing so, there occurred the additional problem that factors, which depend on the special characteristics of a country (e.g. legal restrictions) could only be roughly considered by illuminating the main fields of difficulty. These factors should be further investigated in additional research studies.

Several articles of the literature were retrieved 'fulltext' from information databases. That is why the exact page number was not available. The same it is with sources retrieved from web-pages and Internet files. Comments of these sources are just give with author and year of publication. The rest of the quotations also includes the exact page number of the quotation.

Using pronouns in the text (mostly referring to a pathologist), only the pronoun 'he' is used instead of she/he. Feminists may excuse this behavior.

1.3 Study Design and Methods

The objective of this study was to gather comprehensive data about the critical key success factors and pitfalls of telepathology systems. For this the method of literature analysis, standardized questionnaires and interviews were employed.

The study started with an intensive literature analysis in information databases. First of all general literature about projects in telemedicine had been selected and considered carefully in order to investigate factors of success and failures. One study which delivered interesting inputs for this study was the 'ANARAD'-study (see chapter: 4.2.5.3) executed in Germany in 1996. Two-hundred radiologists were requested about their opinion related for example to their interest in different teleradiology services, their actually available communication infrastructures, or the obstacles of teleradiology services [Bolte, 1998, pp. 123 ff.; http://www.rzuser.uni-heidelberg.de/~n17/anarad.html]. Another study which also provided several vital aspects for this study was executed by Williams and Moore [Moore, 1995; Williams, 1995].

Specific literature about telepathology project had been investigated as well. Names like Weinstein, Nordrum, Dunn, Callas, Dusserre, Beltrami, Adachi just to mention some of the

pioneers in telepathology, reported about their experiences and problems they had to face when introducing telepathology systems. Further, to gain concrete and very detailed information about telepathology, one project was examined within a direct field study. Professor Oberholzer, telepathologist at the University Hospital of Basel (CH), was interviewed (narrative interviews in 1998) about his experience with his robotic-dynamic telepathology system. Mr. Oberholzer is using a hybrid telepathology application for frozen section examinations with a small hospital in Samedan, three-hundred kilometers apart from Basel (project description see: 4.2.7).

Field Study in Basel, Switzerland

Finally hypotheses about the most critical factors of success had been set up and all the collected information was put down to a guided interview manual [Schnell, 1995, pp. 238 ff.]. The advantage of standardized interviews in comparison to the questionnaire is that the specifications of a telepathology project can be collected more detailed and answers are more differentiated. This way decision processes for telepathology projects set-ups, the political background, organizational or human peculiarities, etc. will be gathered, too. The structure makes it possible that all areas of interests are entirely regarded. Since case studies demand a lot of time and money (travel fares, hotel), only the project in Basel was directly investigated. The other planned direct project investigations in Tromsoe (Norway), Udine (Italy), Vermont (USA), Tucson (USA) and Milwaukee (USA) were examined by questionnaire and e-mail contact.

The developed manual was used in May 1999 as the basis for the field study at the University Hospital of Basel. There detailed data about the telepathology approach of Professor Oberholzer was systematically collected[2]. Further two system developers were requested by telephone about their impressions regarding the factors of success of their system (Prof. Schwarzmann, system HISTKOM, Stuttgart/Germany; Mr. Hilgers, system DISCUS, Königswinter/Germany). Their comments were added to the results (chapter: 18.3).

Development of Standardized Questionnaires

The final questionnaires were developed based on the previous findings [Schnell, 1995, pp. 333 ff.; Friedrichs, 1990, pp. 209 ff.]. One was developed for non-users of telepathology systems (pathologists at hospitals and private offices in Germany) to discover their attitude towards telepathology developments, and another one was addressed to the users of telepathology applications (direct clients and consultants, that means that computer staff or system suppliers were not requested). The first one was in German, since only German pathologists were requested, the second one was in English (questionnaires see appendix V). Both questionnaires are in most parts identically. This way data became comparable. Yet, the questionnaire of users contained additional questions about their telepathology equipment, about the examined cases, diagnostic accuracy results, etc.

The method of standardized questionnaire had been chosen, because it enables the requested individuals to pick criteria out of a list, to rate various factors on a scale from zero to four, or to add comments about their attitude to a certain point. In addition, the method of standardized mail survey allowed to reach a huge amount of individuals without

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[2] Here I want to thank Mr. Brauchli,, the assistant of Professor Oberholzer, for the time he has spend at this field study.

spending a lot of money and time. The standardization and scale measures allow to do quantitative evaluation studies between the two groups. However questionnaires have several disadvantages. First of all, for not overtaxing the requested individual, the amount of questions is limited. Second, in comparison to narrative interviews, the content of the questions has to be kept simple. Multiple choice method was mostly used instead of open answers.

Questionnaires to Non-Users (Pathologists)

Since the number of pathologists, who do not use telepathology systems, was to high to request all of them, the study was geographical confined to pathologists in Germany. The addresses of these pathologists were selected by spot-checks form a list of the German Association of Pathologists. Five pathologists took part on a pre-test. Besides the request to fill out the questionnaire, these pathologists were asked about comprehensibility of questions, and about their opinion of missing criteria. Since one of these test persons is located at the hospital of Constance, he could have been asked directly in an interview about the weakness of the questionnaire and about his personal opinion related to telepathology. Finally the questionnaire was set up and mailed to 230 pathologist in July 1999. After two weeks time the pathologists, who did not answer, were either reminded by telephone to fill out the questionnaire or got a reminding letter. The comments, which were made at the reminding phone calls, were put down in a protocol and later added to the results as additional remark. Assuming that reminded pathologists will not call for an additional questionnaire in the case that the first one was lost, a copy of it was stored for downloading at the homepage of the University of Constance. Till the end of September 1999 seventy-two questionnaires had been returned to Constance.

Questionnaire to Telepathology Users

As a next step, pathologists who already use telepathology systems for consultation purposes were requested. The amount of telepathology users is not high. Often there is only one frequently used system per country named in the literature. Whereas static systems (kind of image sending e-mail system) are in the process of increased usage, robotic systems still seem to be an exception (distinction see chapter 2). Therefore this part of the study was not geographically delimited to Germany but kept internationally, and both type of systems were included. The addresses of participating users had been selected from the literature or discovered when talking to project leaders.

The design and content of the questionnaire was mainly the same as the one of the non-telepathologists, but it was expanded by specific questions about the used system. Due to the low number of telepathology users, a pre-test was only executed with Professor Oberholzer. Finally this questionnaire was sent to 140 telepathology users (in most of the cases tele-consultants, but also several clients). As at the study with non-users, after three weeks time the not answering persons got a reminding letter. In addition, at the 10th International Telepathology Congress in Aurich, Germany, in July 2000, several telepathology users were requested or reminded to fill in the questionnaire. Again, the questionnaire was also retrievable at the home-page of the University of Constance for down-loading. Till the end of August 2000 forty questionnaires were returned to Constance.

2 Definition and History of Telemedicine

2.1 Definition

Telepathology, which is examined in this study, is one of the subsets of telemedicine. That is why first of all a definition of telemedicine will be given. Then the more specified field of pathology and telepathology will be explained.

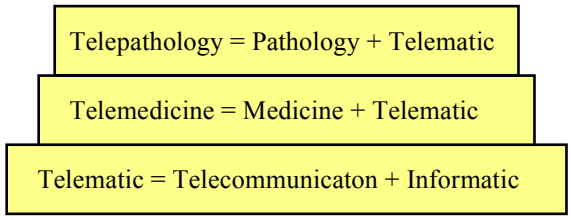

Figure 1: Definition of Telepathology [Hufnagl, 1999, p. 94].

Definition of the Term Telemedicine

The definition of the term telemedicine varies a lot. Some authors use a quite narrow description when they simply define telemedicine as the usage *"of real-time video conferencing*" [Moynihan, 1995], or when Bashshur explain it as *"a system of care that uses telecommunications and computer technology to substitute for 'face-to-face interaction' between patient, physician, and/or non physician providers*" [Bashshur, 1995, p. 82], or when it is characterized as "*a technology that enables providers to do two-way interactive video consultations, as well as transmit digital images such as X-rays and MRIs to other sites*" [Bergman, 1993/(1)].

Others give a broader definition. Williams defines telemedicine as "*the use of telecommunications technologies to facilitate health care delivery*" in general [Williams, 1995]. Another wider description characterizes telemedicine as "*the delivery of health care and the exchange of health care information across distances using telecommunication technology*" [Ferguson, 1995/(1), p. 35] or as „*the use of telecommunications technologies to provide medical information and services ... as shorthand for remote electronic clinical consultation*" [Perednia, 1995/(3)]. Kaiser points at the services and defines telemedicine „*as the practice of health care delivery, diagnosis, consultation, treatment and transfer of medical data and education using interactive audio, visual and data communications*“ [Kaiser, 1994]. Hufnagl even brings the definition down to a formula: „*telemedicine = medicine + telematic*“ [Hufnagl, 1999, p. 94]. The term telematic is defined as the alliance between the computer and the telecommunication technologies [Adeyinka, 1996, p. 21]. Within the whole discussion of the utilization of telematic in health care, there is already a paradigm change from ‘medical informatics’ to ‘health informatics’ [Rienhoff, 1997, p. 168]. This paradigm change consequently shifts the term telepathology in the broader context of the whole health care delivery system and has a strong influence on the actual design of telemedicine applications. The most simple and straightforward definition of telemedicine is „*medicine at distance*" [Houtchens, 1995, p. 93].

Definition of the Term Pathology and Pathologist

Pathology is the branch of medicine that analyses and studies the way diseases and illnesses begin and develop. It is the science of disease that is focused on the original causes of disease, and the anatomically organic changes due to sicknesses [Hartviksen, 1994]. In pathology the nature of lesions, such as benign or malignant, as well as histological typing of malignancy are diagnosed. Morphological alterations of intra- and intercellular structures are observed, described and classified [Kayser, 1993/(1), p. 331]. It is a medical discipline deeply based on the use of images, mainly coming from a microscope, but also from macroscopic examinations [Della Mea, 1995, p. 237].

Five different diagnostic circumstances can be distinguished in the daily work of a pathologist: autopsies, macroscopies, histological examinations (handling of biopsy / surgical specimens), cytological examinations (screening of cytological specimens / cells / smears, fine needle aspiration), and intra-operative frozen sections [Kayser, 1995/(1), p. 54]. Especially for intra-operative frozen section examinations telepathology systems have proved to be important. Such examinations are pathological ad-hoc analyses, mainly of tumor cells, performed under time pressure. The cell type of the tumor to be analyzed at a intra-operative frozen section examination is not known at the time of operation. The surgeon removes the tumor. Then he interrupts his operation and waits till the diagnostic result arrives. In general frozen section services have three potential uses. First the confirmation of the presence and nature of a lesion. Second the determination of the adequacy of surgical margins, and third the judgement whether the tissue obtained contains diagnosable material or whether additional sampling is indicated [Adachi, 1996, p. 440]. Based on the result of a frozen section examination the surgeon makes his decision about his further surgical strategy [Kayser, 1992/(2), p. 395].

A pathologist is someone who studies or investigates diseases, mostly by analyzing cell structures or tissue samples with a microscope. Pathologists are operating within a system of health care providers. Health care providers, as the name is already reflecting, are institutions or persons, who directly provide health care treatments to a patient, for example hospitals, doctors offices or nursing care offices.

Definition of the Term Telepathology

Telepathology involves „*the transmission and visualization of video images from tissue, fluid and related specimens for the purpose of rendering pathologic diagnoses*“ [Dunn, 1996/(2), p. 463]. Although in some definitions the term ‘telepathology’ was used for any medical application that involves the transfer of laboratory-generated data from one site to another with the use of a telecommunications system, the term has been applied specifically to „*the use of remote video microscopy by pathologists*“ [Weinstein, 1989, p. 40]. Most commonly telepathology is defined „*as the practice of pathology by visualizing an image from a distant location on a video monitor rather than viewing a specimen directly through a microscope*“ [Weinstein, 1987, p. 646]. It is characterized by „*the use of computers and telecommunications as an adjunct to, or to facilitate the usual practice of pathology and its subspecialties*“ [Galvez, 1998, p. 663]. Similar to other fields of telemedicine, telepathology systems can be used for primary diagnosis, consultation, quality assurance, proficiency testing, distance learning or even for staff meetings.

„*Telepathology is the process of transmitting digital pathology images over telephone lines or over a local/wide area network (LAN or WAN)*[3]“. These images may either be transmitted in real time video or as still images. That is why telepathology systems are distinguished in static and dynamic applications. In the static imaging mode, digitized images of microscopic slides are transmitted and viewed by a telepathologist. A modern static imaging system can be thought of as a video-FAX. Single static images are selected and sent at relatively slow speed to a consultant. They represent an application of chip-based image grabber board technologies. These devices provide a means to capture color video images and store them. Once stored, the images can be downloaded to another computer terminal and viewed at the convenience of the computer operator. In the dynamic mode, live video images of the microscopic slides are transmitted and visualized in real time. In addition, dynamic systems mostly incorporate color video and robotic microscopy so that the consultant is able to remotely control the specimen scanning process [Dunn, 1996/(1), p. 467; Weinstein, 1991, p. 512].

Core components of telepathology systems are namely a light microscope, a pathologist's workstation, features for motorized microscope control, a super high-resolution camera, two monitors - including a system control monitor and a high-resolution video monitor for viewing the specimen (located at a diagnostic institute or hub), and a (broadband) telecommunication linkage between the remote site and the diagnostic hub, with which the microscopical images are sent to the pathological specialist for examination.

Definition of the Term 'Critical Success Factor'

To place telepathology successfully, decision makers have to know the most critical success factors of these new types of tele-service. Critical success factors are those factors, which have an influence in the success or failure of a defined business or service. Although the success of a service or business is multi-causal and multi-dimensional, there are some central success factors, which have an elementary influence on the final result. Therefore, the objective of empirical research in success factor theory is, to examine the key-factors of success and the relation between different factors, either with empirical, hypothesis orientated approaches or with exploratorical data orientated methods [Effenberg, 1998, p. 46; Klein, 1996, p. 38]. This study follows the empirical approach by measuring different hypothetical factors and by asking people concerned with telepathology about their opinion.

2.2 History and Development of Telemedicine

The concept of telemedicine is not new, if it is defined as '*medicine at distance*'. Health care professionals have been using telephones to communicate directly with patients and among themselves since the turn of the century. „*When a patient calls his physician and is told to 'take two aspirin', this is an example of telemedicine; likewise, consulting with a colleague at a separate location is another example*“ [Weinstein, 1989, p. 40]. If telemedicine is seen in the context of professional health care support for remote facilities, it already dates back to the 1920s, when radio was used to link public health physicians standing watch at shore stations in order to assist ships at sea that had medical emergencies

[3] Anonymous, „Telepathology“, http://www.pathit.com/telepath/intro_1.html

[Williams, 1995]. Several years later in 1956, at the University of Nebraska's department of psychiatry further telemedical operations had been introduced. Interactive audio communication links had been evolved to link seven state hospitals to true telepsychiatric consultations, assuming that the isolation of the therapist from the patients had almost no effect on group sessions. At that time television and telephone as the available technology had been used to deliver health care to remote locations in a specialty that fundamentally required motion observation and interaction [Wyman, 1994; Müller, 1996, p. 9]. The offered applications had been very basically, but nevertheless they improved the health services for remote locations at that time.

In the early 1960's the National Aeronautics and Space Administration (NASA) developed telemedicine for biomedical monitoring and medical care for astronauts. Daily private medical video conferences between the crew surgeon and shuttle crew members allowed to monitor constantly the crew's condition on video. Data about EKG, heart rate, oxygen consumption, heat production, suit carbon dioxide levels, etc. were sent to NASA's Mission Control Center at the Johnson Space Center for examination [Ferguson, 1995/(1), p. 36]. In a next step, the medical findings with the space crew were adapted to other medical services, where physicians started to consult with their colleagues, view patients, access medical records and detailed X-ray, CT, scan and other imagery [Kukkonen, 1995, p. 268]. Soon NASA started to offer and use its medical capabilities and competence internationally [Goldin, pp. 9-14, 1995; Merrell, 1995, pp. 15-18].

Beginning in 1975, NASA provided S-band television, education, and support for health, search and rescue efforts, as well as for agriculture purposes in India, Canada, France, the Pacific Basin and the former Soviet Union by using the ‘Applications Technology Satellite-6’. In 1989, NASA was able to provide telemedicine assistance and educational opportunities for the medical community in the aftermath of earthquakes in Soviet Armenia with these health care applications [Ausseresses, 1995, p. 144; Llewellyn, 1995, p. 31; Grams, 1995, pp. 165-170; Rao, 1995, pp. 297, 299]. NASA further offer medical help via telemedicine at another earthquake in Mexico, at mud slides in South America, at a gas explosion and railway accident in UFA, Russia, or in the aftermath of the political turmoil in Moscow in October 1993 [Blanton, 1995; Ferguson 1995/(1), p. 36].

In the 1970s some other US-telemedicine projects were supported by the former Department of Health, Education, and Welfare (now Health and Human Services), the National Science Foundation, the former Office of Economic Opportunity, and the National Aeronautics and Space Administration. The objective of these projects was to improve health care delivery at an affordable price and with minimal disruption to the existing system of care. However most of these first generation telemedicine projects failed by poor planning and design of the system, limitations in technology and networks, poor standards, missing efficiency and quality, people's limited experience with them, missing incentives for physicians to use the offered equipment, and the absence of further subsidies [Bashshur, 1995, p. 84; Grigsby, 1995/(1), p. 19]. It is obvious that in the future it is important to avoid the repetition of the failures being made and to maximize the benefits which occur from new telemedicine systems.

Regarding the development of computing technology and the number of new telemedicine projects in the present, a major change can be recognized. This process can be traced down to the fact that computers became much faster and cheaper, and allow much better data processing, which is especially important for the exchange of images and sound. The possibility of communication via satellite and the digital transfer of data via ISDN-lines

improved the quality of information exchange, too. In addition, the Internet's[4] superstructured links among computer networks around the globe became available not just for researchers but also for a broad public, which further increased the development of telemedicine applications.

The possibility of an easy access to information and of a faster communication by using the Internet lead to a change in the way of people's thinking. Concepts for a closer cooperation between the health care providers were developed and the idea of telemedicine was more and more settled down in the mind of health care participants. Soon several federal agencies, e.g. in the USA the Health Care Financing Administration (HCFA), the Office of Rural Health Policy, or the US Department of Defense, begun with the introduction of telemedicine programs, often by using their own state's resources to build state-of-the-art telemedicine systems [Perednia, 1995/(3)].

In the seventies, 15 telemedicine projects had been introduced, but non of them survived due to bad technical equipment and efficiency. At the end of the decade on one hand a lot of money had been spend for expensive satellite supported analogue systems and on the other hand a lot of effort was put in the development of digital systems for the transfer of radiology images. These technologies became improved over the eighties, especially in USA, Canada, Italy, Norway, Finland and Australia [Müller, 1996, p. 10]. However, the elementary growth of telemedicine projects came with the introduction of high resolution scanners and cameras, and digital technology, which advanced the quality of the exchanged images. In addition faster and cheaper computers with more capacity in relation with satellite connections and ISDN-lines assisted the development of telemedicine projects, too.

In 1993 there were ten to fifteen operational telemedicine programs in the United States (excluding teleradiology). In 1994 twenty-five to thirty of such programs were already actively involved in patient care. In 1995 additional forty to fifty systems were described in various stages of development [Grigsby, 1995/(1), p. 23]. At the end of 1996 the introduction telemedicine applications already mushroomed [Perednia in Ziegler, 1995].

Telemedicine Networks

In the USA clinical telemedicine programs were set up in more than 40 states, and it is likely that many physicians will be directly or indirectly involved with clinical telemedicine by the year 2000. A similar development can be noticed in other industrialized countries all over the world. A lot of them are using or planning to use interactive video consultation, and it is estimated that at least 70 large electronic medical networks are currently under construction [Perednia, 1995/(3)]. This development is driven by the assumption that telemedicine will improve both, access to certain types of specialty care and the overall quality of the care provided. Comprehensive tele-health networks were established that could serve many functions, including the provision of diagnostic services of pathologists and radiologists at remote sites. Consequently the politics and economics of a managed care approach to health services delivery is now accompanied by telemedicine applications. Driven by the

[4] The Internet is a 'network of networks', linking thousands of universities, business, and individuals around the world [Swett, 1995, p. 598]. It was originally started by the U.S. Defense Department to exchange information quickly among researchers. In 1980, there were 200 computers on it, mostly at academic institutions. By 1991 there were 727.000 computer linked, and in 1995 more like 2 millions of users were already using the Internet for data transfer [Clements, 1995; ADA, 1995]. Today more than 25 million people are using the Internet, with an estimated growth rate of 10% per month, mostly in the United States, Canada, and Europe are using the Internet. The development of the Internet was one of the driving forces for the development of telepathology applications, since it is often used as the 'road' for the data and image exchange.

national effort to develop the electronic information highway[5] 'virtual medical networks' will emerge, in which each participant is able to exchange data and images or request medical information from other participants [Matthies, 1998, p. 99].

Some examples of national and international telemedicine networks may support the described developments. One of the first networks in the USA were the Eastern Montana Telemedicine Network, the West Texas MEDNET, the SYNAPSE system of Nebraska, or the Trans-American Medical Referrals (TA-MRI) of Miami, Florida. In Europe the French Communicable Disease Network was set up, and in the Netherlands the Dutch Health Service began in 1985 [Parsons, 1992, p. 431]. In Germany the Bavarian Government has developed and integrated the network „BAYERN ONLINE[6]" with several telemedicine pilot projects [Bär, 1998; pp. 55 ff.]. As soon as these telemedicine networks showed positive results, some commercial providers expected to gain new markets and started to set up telemedical network services, too. For example, the German network provider Telecom followed the strategy to link up all 110 000 private doctors, 18 000 pharmacies, 3.000 hospitals, 1.500 radiologists, 300 laboratories, and health insurance companies to a huge data exchange network. The interest of Telecom is obvious, since a network providing company earns money each time their 'wires are glowing' [Koch, 1998]. Similar networks to connect health care providers are in development by 'digital GmbH' and 'DGN Service GmbH'[7] [Lindemann, 1998, pp. 31 ff.; Fahlbusch, 1998, pp. 37 ff.].

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[5] The electronic information highway is a term which is used to describe the network of digital signal pathways that is replacing other types of electronic communication

[6] More details see: http://www.bayernonline.de

[7] digital Equipment GmbH, Niederlassung Hamburg, Bereich Gesundheitswesen, Kieler Str. 103, 22769 Hamburg; DGN Service GmbH, Heerdter Lohweg 35, 40549 Düsseldorf;

3 Telemedicine within the Health Care Delivery System

"Telemedicine is riding the crest of attempts at health care reforms." [Grigsby,1995/(1), p.22]

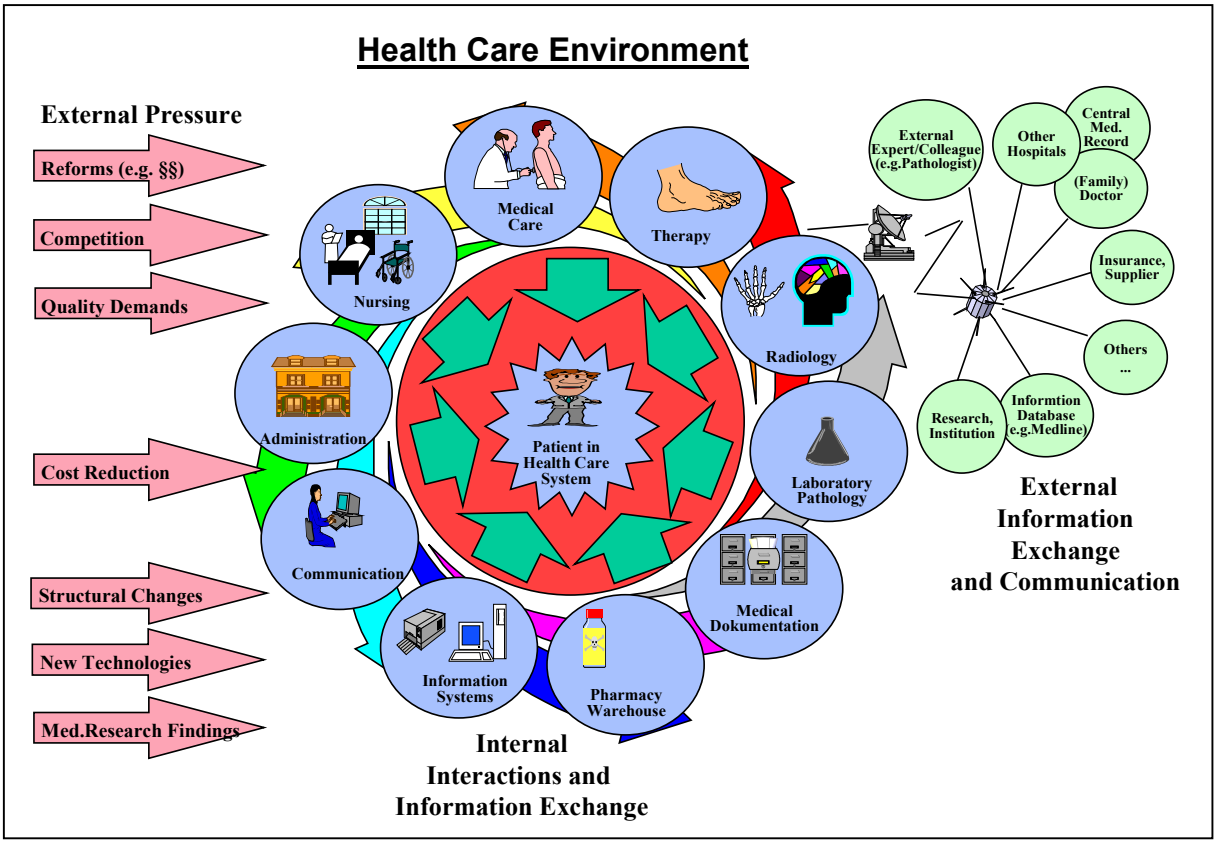

Figure 2: Illustration of information and data streams of a health care organization.

Health care delivery systems are facing a tremendous situation of changes (arrays on the left side). For several years now, the economical situation of health care systems is driven by increased costs. Reasons for this development are the advances in medicine, the demand of the society for high medical quality standards, a society with a higher average life expectancy and an increasing, extensive utilization of health services by the population, as well as permanent structural and policy changes. In addition people start to think that 'the most expensive service is just good enough' and 'to look at cost factors is inhuman' [Heinrich, 1996, p. 15]. This reflects that the population up to now does not want to do without highly specialized quality medicine [Diener, 1997]. It is obvious that this circumstances create high pressure to the health care systems, because they were tied down by their primary objective of improving the health of the population by preventing disease, treating illness, and ameliorating pain and suffering [Bashshur, 1995, p. 80].

As a consequence of the described situation, the costs for medical services increased from year to year and finally the ever-increasing insurance rates and medical expenses became almost world-wide a problem. One health care reform after the other tried to gain control of the cost explosion by still keeping the quality of the services on a high level. Legal restrictions were introduced. For example in Germany the 'Gesundheitsstrukturgesetz /1.1.93' replaced the compensation of the occurred costs system (Selbstkostendeckung) first by fixed increasing rates of budgets (Budgetdeckelung) and second by fixed prices for different types of diagnoses (Fallpauschalen). Similarly in Switzerland cost reductions were introduced by the SVG (Sozialversicherungsgesetz), the Swiss social insurance law. In parallel, the capacity of hospital beds were reduced, and a shift to ambulatory health treatment

started. In consequence, an enormous competition and sometimes even a fight for survival between the different health care providers began.

Necessarily the health care providers first of all started to think economically. Then they begun to plan their offered services more carefully by regarding the expenses and revenues, as well as the strength of their medical know-how. Optimizing resources and processes, building cooperation with other providers towards a 'Shared Care System', and getting the staff to be aware of cost factors, quality matters, and regarding patients as a customer instead of giving them the impression to have to be thankful of being treated are only some of the major facts, which underline the ongoing changes.

What role could telemedicine play in this turbulent surrounding? And which potential effects could it have on the health care delivery system? One fact of telemedicine is that it enables clients and providers to „... *bridge the distance and time barriers*" [Bashshur, 1995, p. 87] and that it tries to bring „... *equal and guaranteed health care at any place and at any time*" [Padeken, 1995, p. 70], especially to the inadequate provided population. It allows to distribute the newest medical findings via teleconferencing to remote physicians and to diminish their isolation. In addition, resources can be shared - technical equipment as well as the knowledge and the time of experts, which again could lead to higher medical quality and to a reduction of costs. And last but not least, telemedicine can improve the link between the inpatient and outpatient care activities, and by this maintain a better continuity and coordination of care. Double examinations can be avoided by offering access to medical records as an additional service of telemedicine.

However, to provide telemedicine networks over boundaries, several problems have to be solved by the health care participants and politicians. Problems of technical standards, of different languages, or social and cultural barriers. Further, political issues or legal restrictions as well as license questions of the involved physicians can cause problems, too. There are also questions about economic and geographic conditions to be solved, and regulations about reimbursement have to be set up [Ferguson, 1995/2, p. 122]. That these problems are not easily to overcome for health care and telemedicine network providers is obvious, especially if one keeps in his mind that *„different organizations have different ways of doing things*" [Bergman, 1994].

4 Areas and Projects in Telemedicine

Telepathology is a subspecialty of the overall term telemedicine. Therefore it is valuable to have a look at the overall situation and utilization of telemedicine systems before starting to evaluate the specific problematic of telemedical applications in pathology.

4.1 Locations of Telemedicine Consultations

During the last decades the increasing availability of communication infrastructures created new possibilities for telemedical applications. Especially the developments and research findings of industrial applications provided a vital input for the design of telemedical applications in various disciplines and locations of medicine. One sector which pushed telemedicine applications was already mentioned with NASA's use of telemedicine for building a space-bridge to space shuttles.

4.1.1 Telemedicine at Prisons

One important issue for using telemedicine has been the state's costs and risk in providing health care in prisons. For example, California alone spends US-$ 380 million per year on prison health care. However, to treat a prisoner in an inadequate way can lead to high compensations when successfully brought to court. In 1990, a prison inmate won a case against the state of Florida with US-$ 1-million compensation. Therefore, Florida began to introduce telemedicine at prisons on a pilot basis [Blanton, 1995].

Regarding the fact that on one hand transporting a dangerous felon to an outside specialist includes a security risk and on the other hand bringing the specialist to the prison would also cause problems, telemedicine seems to be a good solution to serve prisons with a broad range of health care services. The University of Texas Medical Center, Galveston, Texas for example has installed a link with a local prison that allows physicians to ‘see’ about 50 patients per week. Compared to the costs and risk of transporting 50 prisoners to a medical facility with the cost of video-conferencing such trials proved to be reasonable [Moynihan, 1995]. Another connection was created between the Texas Tech University Health Sciences Center in Lubbock, Texas, and prison hospitals at the surroundings under the supervision of the Texas Department of Criminal Justice [Shoor, 1994]. Following that trace, North Carolina's largest prison (Central Prison in Raleigh) contracted the East Carolina University School of Medicine for providing medical consultations with the prison. To give a diagnoses about the condition of the patient, the medical expert at the University is using a video console. He interviews the patient while directing the prison nurse where to point the camera. Finally he will give qualified advise for the course of further treatment [Blanton, 1995].

4.1.2 Telemedicine on Ships

Another area for telemedicine utilization is at ships, where injured mariners may find that the nearest medical facility is hundreds of miles and several days away. As a result, qualified medical care is not available and accidental death rate on ships are almost 30 times higher than by injured land-based workers due to not appropriate and to late emergency health care interactions. Similar to the situation at prisons, the vessel owner is responsible for the health of his crew members. If an individual is seriously ill or injured, the owner is

in a dilemma. He either can be very carefully and redirecting his ship to a harbor, which can cost for example by an oil tanker or a fishing boat during the high season hundred thousand dollars lost income and expenses, or he has to arrange an expensive helicopter evacuation for avoiding the risk of being sued for inadequate medical care. That is why 200 different organizations world-wide give tele-medical assistance to ships without a doctor on board.

In 1990, the **MHS** (Maritime Health Service), Seattle, initiated a health service in the North Pacific that enables medical officers on board of ships to communicate directly with a physician. In the beginnings, the Coast Guard was called via a single-side band radio for medical advise in an emergency case. However due to the lack of visual communication, the land-based physician could not be thorough and the patient had to rely on the experience and interpretation of the on-board medical staff.

As technology advanced, MHS enabled physicians to interactively examine patients on ships by using personal computers equipped with digitizing boards, high-resolution monitors, and data links over standard telephone lines and satellite communication systems. **MedNet** (Medical Consolation Network), a video communication application based on a video-conferencing system was introduced, which combined a small video camera with video digitizing, compression board and software. This way, appropriate and immediate assistance to medical situations could be offered for saving money and life. In addition, a central database contained information about the on-board personnel's level of medical expertise and about the inventory of medical supply on the spot, which enabled the consulting physician to access the available resources on board for treatment [Jarris, 1994].

Another very experienced organization is the **CIRM** (Foundation Centro Internazionale Radio Medico), located in Rome (Italy). Starting in 1935 with simple Morse code communication, nowadays highly developed continuous (24 hours a day) telemedicine assistance is offered. CIRM employs 10 physicians, who can contact other specialists if necessary via net [Amenta, 1998, pp. 44-45]. A further European project is '**Moebius**', which evaluates the use of satellite and ISDN connections to give medical support to a polar expedition ship [Detken, 1996, p. 102]. Even though telemedicine assistance cannot guarantee the same medical quality as this would be the case ashore, it essentially will improve the health care on ships.

4.1.3 Telemedicine at Airports

The first telemedical application in the flight business was tested at an airport. In 1968, an interactive television connection linked Boston's Logan Airport to Massachusetts General Hospital. This way emergency patients could be seen by doctors by means of video cameras [Blanton, 1995; O'Brien, 1998].

In general, the situation of airline companies is similar to that of ship owners, because both are dealing with the transportation of passengers or goods. The affordability of world-wide travel and the increasing tendency for families to be widespread globally, coupled with the upsurge in multinational commerce and associated business travel lead to the situation that many passengers are not in the peak of health or physical fitness due to their age or medical condition when they fly. In short, more older and sick people are travelling by air. In addition, the amount of air-travelling people increased, too.

For example, each year British Airways (BA) transports over 30 million passengers to over 165 destinations in more than 75 countries. However, it comes as a big surprise that the number of in-flight medical incidents on British Airways requiring professional assistance is as few as 1 per 55.000 carried passengers (in total 600) in 1994. Lufthansa reported about 37 so called 'unscheduled safety landings' due to dangerous emergency cases. 50 % of them occurred due to heart problems in 1998. Although these numbers do not seem to be very high, the general public and the media are hungry for stories about medical dramas. That is why the on-board life-saving operation, using improvised surgical equipment on a flight from Hong Kong, received world-wide publicity and led to renewed media interest in the provision of in-flight medical emergency and first-aid equipment. Such reactions force the highly competing aircraft companies to take action. BA answered with a 24-hours telephone advisory service. An aircraft captain is able to communicate via a high-frequency radio link with a BA-doctor 'on call' to get advise for the treatment of sick passengers. All crew members are trained and regularly reviewed to a very high standard in first aid and intermediate life support. Aircrafts carry comprehensive medical and first-aid equipment, like EKGs or electric shock devices. Doing so, telemedicine services are examined for exploring ways in which the efficiency of the delivery of in-flight medical assistance can be improved [Bagshaw, 1996, p. 36; Stahr, 1998].

4.1.4 Telemedicine on Islands

One example for the use of telemedicine on islands is the project of the **CATAI** Association (Catedra Anatomia Patologica) at the University of La Laguna, Faculty of Medicine, in Tenerife, Canary Islands, Spain. CATAI is testing regular video-consultations in cytology, pathology, radiology and mammography [Ferrer-Roca, 1995/(2), pp. 151-163; Ferrer-Roca 1996, pp. 13-23]. Since the experts in Tenerife tested their carried out examinations with regard to diagnosis accuracy in pathology, this project will be described in more details at a later chapter, too (chapter: 4.1.3.6).

Another example is a telemedicine project in Portugal. Telemedicine services like telepathology, teledermatology, telecardiology, tele ORL (endoscopy), telepsychiatry, telematernal and foetal medicine are provided to the Azores Islands. These islands are approximately 760 sea miles apart from Lisbon. They have a total area of 2.335 km^2 and 250.000 inhabitants. The telemedicine project is intended to create a network between nine Azores Islands. If necessary, all tele-physicians are able to tele-consult with the medical experts of the major University Centers of Lisbon. In 1992 telepathology as frozen section services had been introduced between Lisbon and the Hospitals of Faro, Beja, and Castelo Branco [Goncalves, 1995/(2), pp. 285-287].

4.1.5 Disaster and Emergency Medicine, Telemedicine for Special Events

Telemedicine can play a fundamental part in disaster medicine. It's necessary to assess the disaster damage, to quickly define the overall effects of the disaster's impact, to specify health care needs and available local resources, and to collect other valuable data as fast as possible to start with an efficient emergency interaction [Noji, 1995, p. 172; Young, 1995, pp. 175 ff.].

However these carefully designed programs and efficient tele-applications in predisaster, acute, and postdisaster rehabilitation are necessary to extend the coordination of routine and preventive health services. Since disaster medicine cannot exist in a vacuum but must

be integrated with other disciplines and the participants involved, the ongoing medical needs and requirements have to be critically estimated and balanced with the preventive interactions and emergency care plans [Houtchens, 1990[8]]. Designing disaster and emergency programs and systems is not easy, because of its high complexity. Many activities have to be regarded precisely. For example problems have to be solved such as the recording of available material resources, the consideration of cultural, social, economical, political and organizational characteristics, or problems caused by incompatible and not standardized technological systems. The capabilities and skill demands of individuals involved have to be determined, too. This allows to develop efficient education and training programs for all involved emergency health practitioners [Llewellyn, 1995/(1), pp. 30-31].

All the mentioned problems above become most obvious in emergency situations in less developed countries. There telemedicine is either non-existent or only rudimentary, as are capabilities to respond to large scale emergencies and disaster situations.

> *"Less developed countries often have neither the telecommunications infrastructure, nor the medical resources necessary to effectively employ telemedicine as part of their national disaster response strategy." [Ferguson, 1995/(2), p. 121]*

For offering a satisfying disaster telemedicine service, the requirements to be met are similar to other telemedical health supports, but perhaps more difficult to accomplish. In 1992, to meet the challenges posed by catastrophic disasters, the US-government developed, under the leadership of the Federal Emergency Management Agency (**FEMA**), a unified all-hazards response and recovery plan - the **Federal Response Plan**. The aim of this plan is to coordinate and integrate local, state and federal emergency responders to a network, which allows to answer emergency needs by bundle up all available resources in an efficient way. This was the foundation of the FEMA telemedicine emergency network [Yound, 1995].

Another project, which puts special effort in the development of a telemedicine emergency infrastructure, is the G7 Global Healthcare Applications Project (**G.H.A.P.**). A group of the seven most industrialized nations in the world (G7) came together for establishing a transnational and multilingual health emergency system for the improvement of promptness and effectiveness of interventions and service management through telematic interconnections of the emergency points of care and of all actors and services involved[9]. Other EC-project, which are focus on emergency medical services, are **GETS** (Global Emergency Telemedicine Services), and **MERMAID** (Medical Emergency Aid through Telematics). Both offer a 24-hours multilingual and multidisciplinary telemedicine surveillance and emergency service around the world. And as a last example, the EC-project **HECTOR** (Health Emergency management and Coordination through Telematics Operational Resources) has the goal to fill the actual gap of an integrated and interoperable emergency network, which is able to react promptly and efficiently to any emergency situation[10] [Detken, 1997, p. 72].

Telemedicine systems could not only be appropriate at emergency situations, but also at situations caused by specific events. For example, a teleradiology and two-way video link connected the medical facility of the Yale-New Haven Hospital emergency department in

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8 http://www.it.hq.nasa.gov/~kmorgan/telemed_blue/references/disaster.html

9 More details see: http://www.ispo.cec.be/g7/projects/g7rep596.html

10 More details see: http://www2.echo.lu/telematics/health/gets.html / mermaid.html / hector.html

Connecticut, USA, with the Yale Field House during the 'Olympic World Games' [Swett, 1995, p. 599]. Such mobile telemedical systems seem to be appropriate for many other events, too, which demand health care support just for a certain period of time.

4.1.6 Telemedicine for Developing Countries

Over 75% of the world's population is located at third-world countries. This population is suffering from serious shortages of resources and capital, lack of trained manpower, large scale illiteracy, and an explosive growth in population with an inadequate support of health care services. Furthermore, natural disasters have not rarely contributed to the misery of these countries. The idea of establishing a global telemedicine operational system came up.

Therefore a cross-cultural understanding has to be developed between the global partners, no matter whether a national mobile telemedicine service is established or a cooperative link to an expert at a medical center in America or Europe is created. Telemedical services have to be made affordable to the developing countries, and the tendency to apply a rich man's solution to the poor man's problem should be avoided. It is necessary to develop universal telemedical solutions, which are appropriate, adequate, and cost-effective for the medical demands of participants [Rao, 1995, p. 300]. In addition a solution for the coordination (who will coordinate which activities? - set up of responsibilities) and reimbursement (who will pay for which services?) for such third-world telemedicine services has to be found. In most developing countries the user does not pay for the telemedicine service so that in most countries telemedicine services have to be subsidized by the government or another party [Wright, 1997]. For this reason in 1994 the International Telecommunication Union established a study group, the European Telemedicine Collaboration Group, to investigate telemedicine feasibility, to quantify the benefits, and to create recommendations and guidelines with particular reference to developing countries [Wootton, 1997/(2), pp. 23-26].

One special project which aims to promote the development of regional networks between universities of the developing countries and their European counterparts is the **FOMTA** project (Fundamentals of Modern Telemedicine in Africa). Using broadband technology, telediagnosis, teleconsultation, and other telemedicine services will be practiced to eliminate time-delaying due to the lack of infrastructures [Adeyinka, 1997]. Besides the activities of FOMTA many other projects between first and third world countries are in the process of introduction.

4.2 Medical Fields of Telemedicine

Maturity - most experimental	**--->**	**Maturity - most mature**
Telepathology	Telepsychiatry Teledermatology Telecardiology Teledialysis Neurosurgery Decision support	Teleradiology

Figure 3: Overview of maturity of telemedicine applications [Wootton, 1997/(1), p. 394].

4.2.1 Telepsychiatry

The very first applications in telemedicine were introduced in psychiatry. Already in 1959 Wittson and his colleagues employed two-way interactive television for medical purposes when they use a microwave link for telepsychiatry consultations between the Nebraska Psychiatric Institute in Omaha and the state mental hospital 112 miles apart [Perednia, 1995/(3)]. Nowadays telepsychiatry consultations are carried out using standard videoconferencing equipment. There is no consensus about the minimum required video quality for telepsychiatry, yet in Norway, Australia and the USA even low quality (128 kbps) equipment has proved to be sufficient for telepsychiatric consultations. The telepsychiatry applications are one of the most mature applications for teleconsultations, since the actually available technology is very appropriate to communicate with the patient on a regular scale without travelling for hours. Videoconferencing systems help to avoid transportation cost and improve access to services for psychiatric patients in rural areas [Wootton, 1997/(1), p. 395]. That telemedicine applications in psychiatry are very appropriate proved the comprehensive telemedicine project in Norway. There the mental health professionals made up the largest proportion (approximately 1000 patients in 6 month) of health works using videoconferencing facilities [Elford, 1997, pp. 14-16].

4.2.2 Telemedicine in Dialysis

> *„I am available to patients [in Giddings/USA] on a continuous basis", Moncrief says. „It's not like I'm there for a flash and then gone. It's just like me being in town all the time." [Moncrief in Bergman, 1993/(3)]*

The nephrologist talks about overcoming the three-hour round trip from his Austin, TX, office to check on dialysis patients at a clinic in Giddings, by using a camera and TV monitors instead of travelling. Jane Preston, president of the American Telemedicine Association and director of the Texas Telemedicine Project in Austin, does not just introduce interactive video consultations for dialysis at her medical center. She also installed other telemedical services to communities that do not have medical experts and specialty services, for example teleradiology analyses of x-rays and MRIs. In dialysis a patient should be under permanent successive control of a physician. Again, telemedical equipment may help to bridge huge distances in a comfortable way.

4.2.3 Teledermatology

Dermatology is another specialty that relies heavily on visual examination. Thus it is well suited to the transmission of video images [Grigsby, 1995/(1), p. 22]. Most groups who have employed real-time teledermatology use videoconferencing equipment, usually with an additional video camera for obtaining close-up pictures of dermatological cases and specimens, e.g. at the project in Norway [Elford, 1997, pp. 4-6]. One can distinguish prerecorded teledermatology and real-time teledermatology. Still images (digital images and conventional photographic images) are transported by computer disk or by e-mail for subsequent interpretation. Such a system was introduced at the University of Miami, School of Medicine, Department of Dermatology, or at the University Hospital of Connecticut [Swett, 1995, p. 597]. The used Picasso Still-Image Phone System (Union, NJ) allows live audio communication between all participating physicians [Berman, 1997, pp. 27 ff.]. In addition, the real-time teledermatology system, is currently tested for example within the UK-Multicenter Teledermatology Trial. It is about a teledermatological real-time approach between four centers world-wide: Belfast, Craigavon, Manchester and New Zealand. Some

users, like the Queen Victoria Hospital in Morecambe (UK) even execute trials with portable digital imaging systems in dermatology [Lyon, 1997, pp. 81 ff.]. Results to date suggest that the accuracy of teledermatology is sufficient for being used as a possibility for specialist dermatological consultation [Wootton, 1997/(1), p. 395; Loane, 1997, pp. 73-75]. Several other successful trials in dermatology are described in recent literature [Phillips, 1998, pp. 5-9; Lewis, 1999, pp. 57-58; Bittorf, 1997, pp. 195-198; Kok, 2000].

4.2.4 Telemedicine in Neurosurgery

The Clinic for Neurosurgery in Greifswald, Germany, is located in the rural area of Mecklenburg/Vorpommern. At this thinly populated part of Germany, only two hospitals are treating neuro-surgical patients - the clinic in Greifswald and the clinic of Schwerin. Therefore the situation is characterized by a chronically inadequate provision in this specialty, which affects emergency cases in a special way.

Referring to the community medicine, injuries of the central nervous system take up place two in the causes of death, and even place one in the case of disability with following entitle to a pension. Most of the prognoses of fractured skulls and brain injuries show that there is a significant statistical dependence between an immediate neuro-surgical help and the long-term condition of a brain injured person. This made the clinic think about, how to use the small capacities as efficient as possible. Telemedicine was the answer.

If a neuro-surgery emergency case is admitted to one of the hospitals around the center, the first diagnosis is carried out there. Then clinical relevant images (for example CT-, MRT- or angio-images), as well as descriptions of the symptoms and other data of the patient are transmitted via telecommunication to one of the two medical centers. The specialist at the medical center is now able to decide how critically the condition of a patient is. If necessary, he can give medical ad-hoc advises via tele-consultation. However, most important, the expert is able to judge whether this patient can stay in the clinic were he is, or whether the injured has to be immediately transported to the center for intensive care. Since the medical center has all information about the patient, as soon as the patient will arrive, mostly by helicopter, the waiting physician team can start with the treatment.

Using telemedicine in Greifswald has helped to avoid unnecessary and for the patient risky transportation. Previous required courier services are replaced by electronic data transmission. Time and costs are saved, double examinations are avoided, and the capacity at the center is used much more efficiently [Müller, 1996, pp. 7-13; Burchert, 1997, p. 20-22].

Similar to the project in Greifswald, at the Hospital München-Bogenhausen (Bavaria, Germany), Department of Neurosurgery, a telemedicine systems is employed to give fast access to high quality neurological expert know-how. CT-images of the head of an emergency admitted patients are transmitted to the center in Bogenhausen so that therapy advises or an emergency transportation to the neurological center can start at once. The requirements of equipment and costs are low. Just a personal computer (200 MHz, 64 MB memory, 2 GB hard drive), a 17 inch monitor, a modem or adequate feature to access the network, and a device to digitalize images are needed [Wolf, 1998, pp. 129 ff.; Heckermann, 1997, pp. 23-24].

4.2.5 Teleradiology

Teleradiology is „ *...a technique that involves the transmission of digital radiographs between institutions using a telecommunications network as the transfer medium*“ [Wootton, 1997/(2), pp. 23-26]. „*In radiology, seeing a patient face to face has never been the issue*“ [Sheldon in Anonymous, 1995]. The personal contact between the radiologist and the patient does not have a huge impact, but the discussion between the treating physician and the radiologist is important. That is the reason why the exchange of medical signals, text or images via telecommunication networks is especially appropriate for radiology. The transfer of X-rays, MRIs, and other radiology scans already proved to be sufficient for radiology diagnoses, second opinion consultations, education or central case archiving for several years [Engelhorn, 1996, p. 29; Schwab, 1997].

The trial of transmitting radiology images for examination goes back to 1959. At that time Albert Jutra pioneered teleradiology by interlinking two hospitals in Montreal, five miles apart from each other, with coaxial cable to transmit videotaped telefluoroscopy examinations. His vision was that a special telecommunications network should be established interconnecting hospitals' and physicians' information [Weinstein, 1987, p. 649]. Some years later, in 1970, images had successfully been sent by using microwave transmission and amateur band television transmitter of low power. However, the system was described as insufficient [Grigsby, 1993]. By 1980, due to significant technological improvements, the first satisfying teleradiology networks were established. Unfortunately, the employed new technological achievements were expensive and therefore they were not acceptable on a broader scale. That is why another 10 years went by till cost efficient teleradiological solutions were available on the market. Some examples are given in the following:

4.2.5.1 Teleradiology-Projects in Germany

The teleradiology system MEDICUS is used as a viewing station, which supports the input, retrieval and export of radiology images and data[11]. The project MEDICUS runs by the German Cancer Research Center (DKFZ), Division of Medical and Biological Informatics and the technology transfer company 'Steinbeis Transferzentrum Medizinische Informatik', both located in Heidelberg[12]. It is funded by TeBerkom (a subsidiary of the German Telecom). Starting in 1995, more than 15 radiology departments in university clinics, small hospitals, doctor's offices, and research institutes are participating. MEDICUS works on ISDN lines as well as in a local area network. Designing the system, high attention was given to the user interface, data security, integrity and authentication. Special concepts for data transfer reliability and data security were developed, to ensure a controlled access to data storage and to all involved systems, and to manage a secure input, manipulation, transfer and output of data [Engelmann, 1997/(1), pp. 26 ff.].

Even if the user is not familiar with computers, MEDICUS is so easy to handle that he/she is able to work with the system within a short time. To reduce the effort for the user, implemented exportation functions support an automatic data transfer between the MEDICUS

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11 More details see: http://mbi.dkfz-heidelberg.de/mbi and http.//imsdd.meb.uni-bon.de/gmds

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workstations. From there, cases - or parts of cases - can easily be retrieved by patient, study, series, or case data to be sent to other communication partners. The data and information flow is faster than before and due to this the diagnostic and therapy efficiency is higher.

The heart of the teleradiology-system MEDICUS is the special viewing-station CHILI. With the CHILI workstation university clinics as well as small hospitals and physicians are able to create their own mini-PACS archive. Users are able to select parts of cases for minimizing the amount of images and with this the time for the data transfer. The system further supports remote tele-consultation, where physicians and radiologists can view images and discuss cases at the same time. Resources can be shared such as expensive equipment or radiology staff. Because CHILI is based on the DICOM standard protocol, it allows to integrate running applications without additional programming efforts or to download data for further manipulation. Experiences show that with this radiology system the workflow and the routine activities of radiology departments are optimized and prove to be more efficient in reference to costs and time [Engelmann, 1997/(2), pp. 96 ff.].

Another teleradiology system is KAMEDIN (Kooperatives Arbeiten und MEdizinische Diagnostik auf Innovativen Netzen). It is tested between the University of Luebeck[13] and the University of Rostock [Handels, 1996, p. 33]. Using this system, the radiologists at both ends are able to discuss images of radiology cases. As a next step, the system will be hooked up to a database, which will help to identify medical anomalies [Koch, 1998]. A further teleradiology-system, which was developed at the Medical University of Luebeck, Department of Medical Informatics, is called CYPRIS. It is based on the programming language Java and pursues the objective, to ensure radiological image transfer and teleconferencing without restrictions by operating systems and hardware components. The system supports networks, which are based on the TCP/IP protocol, like ISDN, Intranet or Internet. This way it enables a low cost telecommunication [Klaiber, 1998, pp. 146 ff.]. Based on RATEMA the University of Ulm, established a telemedical connection to the Research Center of Radiology at Tscheljabinsk, Ural, for supporting their Russian colleagues in the treatment of victims of the nuclear industry at this region. And finally, the Medical Center of Krefeld has set up a ‘Healthcare-Network-Architecture’ within their integrated hospital information system. This network includes a RIS/PACS-system[14] combined with tele-radiology functions for the tele-support of the hospitals of Kaevelar, Emmerich-Geldern, Dinslaken and other clinics at the region of ‘Niederrhein’ [Schröder, 1997, pp. 15 ff.].

4.2.5.2 Special Centralized Service Centers for Teleradiology in USA

Teleradiology Associates, in Durham, N.C., offers a full range of radiology services to clients in 20 states. The clients are mostly rural hospitals and clinics, which cannot afford to hire full-time specialists and therefore seek expert radiology interpretation skills 24 hours a day, 365 days a year [Forsberg in Anonymous, 1995, p. 52]. Another example is offered by the University of California at Los Angeles. Local radiologists of California are able to transmit electronically any CT scan, MRI, ultrasound or x-ray that relates to a potentially serious condition to the experts at Los Angeles for viewing [Ziegler, 1995].

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[13] More details see: http://www.medinf.mu-luebeck.de; Institut für Medizinische Informatik, Ratzeburger Allee 160, 23538 Lübeck

[14] RIS = Radiology Information Systems; PACS = Picture Archiving and Communication System

All these radiology projects show that most of the telemedical applications were successfully introduced. Often the projects started with a single connection, for testing radiology applications, and then additional diagnostic specialties were attached. Sometimes even robotic equipment for online surgical operations are added, like it happened at the German RATEMA project in Ulm. Other health care providers, like the Hospital of Krefeld, started with a comprehensive concept for an internal integrated hospital information system (HIS) with centralized electronic medical records and PACS-archives, and then began to increase their number of examinations by adding telemedicine services. Doing so, they put an eye on the direct integration of exchanged data into the information systems (HIS/RIS) of participants, so that data only had to be entered once.

4.2.5.3 ANARAD-STUDY

In 1996 roughly 200 German radiologists were requested for their opinion about teleradiology in the ANARAD-Study[15] [Bolte, 1998, pp. 122 ff.]. This study showed that in Germany the actual interest for teleradiological applications is not very high. The main areas of usage are seen in emergency cases, and for teleradiological background services like specialty support in difficult cases (second opinion). One step towards telecommunication support in radiology has turned out to be recognized in the internal use of RIS and the use of PACS. Since radiology has a central position within medical diagnostics, characterized by a high communication demand to other clinical specialties, a high degree of technical and computer utilization is essential to guarantee the efficiency of procedures. The study also showed that radiologists favor the use of PC-based systems, followed by PACS with extended teleradiology functions.

Radiologists would preferably choose asynchronized offline systems or mixed offline-/online systems. They first transfer the images together with textual questions and then in a second step discuss the case at the monitor by using videoconferencing features. Doing so, it is important that the teleradiologist gets all diagnostically relevant data of a case and that he is able to attach these information exactly to the right patient. One of the biggest obstacle is the clarification of legal questions, like the prohibition of digital image retention (§ 28 RöV[16]), how the contact with the patient has to be (personal, or is online sufficient), or the settlement of responsibilities for teleradiological errors. As further important factors the requested radiologists mentioned the quality of images (resolution, color, contrast), the standardization of the data transfer protocols and data/image formats, the compatibility between the systems of attending partners, the security of systems, data and passwords, and the reimbursement of teleradiology services [Bolte, 1998, pp. 123 ff.].

4.2.5.4 Differences Between Teleradiology and Telepathology Applications

At many teleradiology systems static monochrome images are transmitted in a batch mode. However, pathology is based on moving images scanned at a microscope. Therefore the idea of telepathology applications associates moving images in full color, transmitted in real time. Comparing radiological images with pathological ones, there is much more in-

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[15] Extensive description of the anarad study and results are published on the www: http://www.rzuser.uni-heidelberg.de/~n17/anarad.html; contact address: bolte@ikr.ma.uni-heidelberg.de; study was designed by the German „Arbeitsgemeinschaft für Informationstechnologie der Deutschen Röntgengesellschaft (AGIT) and by the „Berufsverband der deutschen Radiologen.

[16] RöV = Röntgenverordnung; German regulations with special liability aspects in radiology

formation in a single light microscopic field of a tissue section than in a computer tomographic scan image. The monitor capacity was not sufficient to offer satisfying tissue sample images. Because of the improved quality of monitors this limitation decreased. Since in pathology moving images are desirable, network capacity and transfer time needed for each image are a problem. Digitized images require a vast amount of storage capacity and very broad bands for transmission of full-color images at high resolution. In addition, to get a higher diagnostic accuracy, bi-directional communication is required. Firstly for the communication between the partners, and secondly for the control of the microscope and stage movements if a off-site robotic microscope is used [Weinstein, 1987, pp. 647, 649]. That is why telepathology has received less attention compared to teleradiology. (Further explained differences see chapter 2.2.2 please).

4.3 Activities in Telemedicine

4.3.1 Telemedicine for Diagnoses - Teleconsultation

4.3.1.1 Primary Teleconsultation - „Telediagnosis“

Distance Treatment in Georgia

At the Medical College of Georgia (MCG) Telemedicine Center in Augusta, Ga., specialists are linked with physicians at Dodge County Hospital, 130 miles away in rural Eastman, Ga.. Patients are tele-examined and specialists tele-cooperate with physicians at the rural hospital since 1992. Using high-resolution cameras for transmitting images, X-rays and CAT scans, the specialist can see whatever his colleague at the remote location sees. In addition, electronic stethoscopes, otoscopes, and laryngoscopes enable the specialist to examine a patient's heart, lungs, eyes, and throat. This way about 83% of the patients could have been treated locally instead of they had to travel to the MCG for diagnosis or therapy. Soon five other remote sites connected to the MCG network [Shoor, 1994].

Video Consultation as a Regular Service

Similar to the NASA telemedicine activities, the Telemedicine Center in Walter Reed Army Medical Center, Washington, D.C. offers world-wide telemedicine services in surgery, radiology, and pathology. Doctors from Kuwait, Haiti, Bosnia-Herzegovina, Somalia or other locations around the world are sending compressed digital resolution images and clinical information to the medical center in order to receive consultation. Digital cameras, portable telecommunication terminals and a satellite modem are necessary to transmit all necessary case data for example via an Inmarsat high-speed data satellite to Walter Reed. Recommendations for treatments can be outlined immediately, medical records are completed and if needed text information can be downloaded to the doctors on the spot. If required, a face-to-face video-conference can take place. The service is offered 24 hours a day [Gomez, 1995].

4.3.1.2 Second Opinion Consultation – ‘Teleconsultation’

A very common use of telemedicine is to call a specialized physician for an immediate second opinion. When travelling into rural areas, very soon one will meet a shortage of specialized physician’s support. That is why for example the Kirby Hospital in Monticelle,

Illinois, is now linked to the next medical center by a telemedicine system for requesting second opinion diagnoses [Kaiser, 1994].

Unfortunately the possibility of executing teleconsultations for primary and secondary diagnoses is not used very often. Regarding telemedicine utilization on the whole, in almost every project teleconsultation accounts less than 25% of the use of the system. The majority of on-line time is used for medical education and administration [Perednia, 1995/(3)].

4.3.2 Mobile Health Services and Patient Monitoring

> *„The requirements for (tele-)medical services are the same, independent of whether they have to be provided within a clinic (local area), between clinics and general practitioners (regional or metropolitan area), or on the wide area, international scale." [Padeken, 1995, p. 70]*

Serving Mobility of Citizens

About 15% to 25 % of the United States' population can be considered to live in rural or non-metropolitan regions. Especially 'frontier' regions, like the Western and Great Plains States often show a population of six or fewer people per square mile. Such residents do not differ significantly from the urban population. Yet, many chronic medical conditions (e.g., arthritis, hypertension, diabetes, heart disease), or the rate of death from accidents are more prevalent among persons living in rural areas. Especially for elderly people, with their great burden of functional disability, chronic illness, and health service needs, mobile health care, enhanced by telemedicine features, is a efficient possibility of medical support [Grigsby, 1993[17]] .

Mobile health units are transportable, modular diagnostic or clinical facilities that are generally equipped to provide a specific medical service (e.g. CT scans, HIV control) or a limited set of services (e.g. primary health care). In some cases, such units travel from one site to another on a fixed schedule, while in other cases, the itinerary is variable, or in emergency cases, a mobile health care station will be located at the patient's place as long as his medical condition is demanding it [Grigsby, 1993]. Generally, the objectives of such mobile health care services are, to support the communication between the patient and his/her physician, independent of the patients present location (i.e. at home, travelling or as a guest staying in a foreign country). Physiological parameters can be transferred to the attending physician by using mobile physiological monitors combined with mobile communication systems. Often, such mobile units are placed at the patients side, for monitoring by itself certain parameters. If it detects violations of predefined limits, it establish automatically a communication link and releases an emergency call. If the patient is staying in a foreign country and needs medical service, the health care providers in the host country will be able to assess the status of the patient by real-time monitoring of physiological parameters or by getting a direct communication link with the patient's home physician or clinic. International standardization of health records for trans-national exchange and utilization becomes an important issue. At present, there are research studies in mobile patient monitoring done at the Pediatrics Clinic Porz/Cologne and at the Neurological Clinic of the University of Aachen, both located in Germany [Padeken, 1995, pp. 69-71].

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[17] Text retrievable at: http://med.mc.ntu.edu.tw/~somed/teletea/engwww/teletea/document/telemed_report.txt

Teleprotection - Monitoring of Newborn Infants and Pregnant Women

In 1991, at the Children's Clinic Porz, Germany, in cooperation with the University of Brussels, Belgium, a project for monitoring new-born infants had started. The reason for this was the realization that intensive prevention activities can reduce the most frequent cause of death by infants - the so called 'Sudden Infant Death', which occurs by almost 60% of all cases between the 2nd and 12th month of life. Infants with neurological symptoms the malfunctions/failures of the cardiorespiratoy control system are significantly high, such endangered infants are controlled by polysonographic home monitoring systems. Data like breathing movements, heart rate, oxygen saturation, temperature, etc., are measured. If data are beyond given limits, an emergency auto-dialing starts. Parents are trained in using the technical equipment, for assessing the physiological status of the child, and in reanimation. If necessary, they are able to activate a second link for voice communication with the treating physician. As a result, the death rate of 29 in 1991 was decreased to 12 in 1993 [Padeken 1995, p. 72]. Another monitoring trial took place at the University of Giessen, Germany. There a digital ambulance home care competence network for children cardiology was established. It is used for the transfer of expert know-how and for monitoring congenital heart- and circulatory trouble [Marquardt, 1998, pp. 150 ff.].

At Philadelphia's Pennsylvania Hospital a similar system is in use. As part of the hospital's prenatal home monitoring program, a computerized home monitoring system for tracking patients with high-risk pregnancies was introduced. This system automatically places calls to patients at a predetermined time each day and led them through a series of questions to monitor changes in their conditions. Patients respond to the questions by pushing buttons on their phone, which are recorded. If the status of a woman becomes critical, medical care activities can start at once [Lumsdon, 1992]. A similar tele-system for tele-ultrasonic scanning in prenatal diagnostic and therapy is available at the University Hospital Charité at Berlin, Germany (Universitätsfrauenklinik und Poliklinik der Charité). Images are sent to the center for an early and high quality diagnosis, and for fast medical advises at critical medical situations [Nguyen-Dobinsky, 1997, pp. 17 ff.].

Another project for monitoring cardiac rehabilitation patients took place at St. Vincent Charity Hospitals in Cleveland, Ohio. Patients recovering from heart attacks can ride their stationary bikes at home and data of the electrocardiogram are transferred to the hospital's specialists via simple telephone lines. This service can be expanded by cable channel settings to build up a visual contact between the patient and the hospital staff. The experience with this type of cardiac rehabilitation was so successful that it became a model for other projects for example in Nashville, Tennesse, or Greenville, North Carolina [Blanton, 1995]. Other projects for heart disease and pregnancy control were introduced in Bavaria, Germany within the state supported program BYGN (Bayerisches Gesundheitsnetz) [Deutsch, 1996, p. 792] or with the EU-projects UMTS (Universal Mobile Telecommunication System) and the project Hermes [Detken, 1996, pp. 103-104; Detken, 1997, pp. 72-74]. At the Telepathology Congress in Aurich another trial in cardiology was reported from Kyiv, Ukraine [Lazaretnik, 2000].

Taylor assumes that if such systems prove to be adequate, in some cases patients could leave the hospital sooner, since continued home health care support is guaranteed. For this reliable monitoring telemedicine systems at a reasonable price are needed, if possible based on multimedia technology [Taylor, 1994]. Again, this would reduce a hospital stay. Consequently clinical expenditures would be reduced, too.

Online-Exercising and Monitoring of Neurological Patients

In 1996, Professor Schoenle at the Clinics of Schmieder, Allensbach, Germany, started a test project by monitoring neurological patients. Patients got equipment to do their daily medical exercises at home. Data about the patient's medical condition and improvement were collected and statistically analyzed. Patient's liked the system, because it saved travel cost and effort [Bebber, 1996].

4.3.3 Telemedicine for Education and Medical Advises

Primary care physicians in rural areas are often stressed and usually carry a higher than average patient load. Although they are good, solid doctors, they have problems in catching up the newest know-how in medicine and therefore need support [Kaiser, 1994]. Telemedicine applications seem a good solution to overcome the isolation of these doctors.

One example for this is demonstrated at the Green County Medical Center. This Center is linked with a rural hospital in Jefferson, Iowa, to demonstrate a simultaneous examination of a patient by the rural physicians and the specialists in Jefferson. In addition, continuing education sessions are conducted [Shoor, 1994]. Such educational and advisory telemedicine demonstrations have already proved to be very useful and the number of users is continuously growing. In the following some examples for tele-education are given.

4.3.3.1 Online Information, Bulletin Board and Online Discussion

The Montana State University in Bozeman, Montana created at its Virtual Medical Center an electronic bulletin board system (BBS) that provides clinical support and educational courses to callers nation-wide as well as to foreign countries (Canada, UK, Mexico, Sweden). The access is very simple. The physician only needs a personal computer, a modem, and the BBS software. Than he is able to participate in case discussions, to access the medical library services, to download education courses or other resources of the University of Montana's School of Pharmacy via e-mail or to receive the latest available public health advisories and information [Shoor, 1994].

Another good example for bulletin boards, online discussions, and educational activities are the online services of the American Dietetic Association (ADA). In 1995, the ADA formed the American Dietetics Online (ADO) by linking up to the Internet service provider America Online. ADA offers all kinds of information for its members. All these services are free of charge for its members. You just have to connect ADO by e-mail or by subscribing to America Online. One of ADA's services is the monthly newsletter with ADO information, discussion topics and schedules, and issues encountered in traversing the information network. Another service is the ADO Journal Club. For this club an interactive 'chat room' format is used, similar to a telephone conference. Current issues are discussed related to published articles. The intent is to give doctors working in rural areas the possibility to discuss topics with their peers in larger urban centers and to ask for medical advise. There is the Journal Club Meeting. The discussion subjects of the meeting are chosen out of suggested topics on a Bulletin Board a month before each meeting. At the beginning, an expert will introduce the problem of the topic and afterwards the discussion is opened. Average sessions run from 1 to 1 ½ hours of discussion, followed by one hour of continuing education. Each participant can log on and off at his/her convenience. The mentioned ADO Bulletin Board System allows members to exchange information, share successes

and failures, to post messages, questions, requests, and announcements for any America Online subscriber to read. And last but not least, a RD Idea Exchange is held. Similar to the Journal Club, but perhaps a little bit more controversial and political orientated, wide ranges of current issues that affect dietetics practice, education and research, health care reforms or dietetics' marketing strategies are discussed [ADA, 1995].

4.3.3.2 Internet Health Advisory Desks

Another interesting tele-care service introduced by insurers in USA (Blue Cross, Blue Shield, Medicaid) is the Personal Health Advisor at Portland, Oregon. This is a telephone access system, where a registered nurse helps patients determine appropriate care based on their symptoms [Conklin, 1994]. A similar 'hot line' service is offered by the National Jewish Center's (NJC)[18] [Braly, 1995/(1)]. Such an advisory desk could also be accessed via Internet. The advisor may be able to retrieve health care resources from participating health care providers (e.g. information about free bed capacity of hospitals) or to delegate the patient to an expert for further treatment. An example for such an advisory Internet telemedicine service is already established in Denmark, where patients can contact a 'net-doctor' for medical advises [Scheifele, 1999]. Another example is the Interactive Online Global Health Center, where voluntary medical doctors offer online consultation services and information to the public all across the world [Smith, 1996, p. 34]. Such Internet medical advise desks could also be employed to increase the communication between physicians in rare and difficult cases.

4.3.4 Medical Online-Information

If the term 'telemedicine' is defined in a broader sense, also medical information on the Internet could be added to this subject. Some examples may show the advantages of such easily accessible information.

4.3.4.1 Project Medicine Online

'Medicine Online' offers medical information on the Internet for professional users like physicians, pharmacists and other people working in health care in Germany. Created in 1996 by MED medicine online GmbH, Cologne, in cooperation with the GMD (Gesellschaft für Mathematik und Datenverarbeitung mbH), the German Telecom AG, DeTeBerkom GmbH, and the MAI Deutschland GmbH, multimedia data in digital format are transferred terrestrial on radio and display. The front-end interface has a clear design and is divided in four headings - actual information, forums, contacts and advises. Under the menu 'actual information' one can find information about new developments, research results and other useful information about medical topics. Forum offers the possibility to attend online consultations. Users can ask questions, which are answered by experts, experiences are exchanged and discussed. 'Contacts' allows to get useful addresses and 'advises', and it gives information about medical journals, medical exhibitions, conferences, etc. In addition, the user has access to the Internet and can use the e-mail service[19].

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[18] http://www.njc.org

[19] Information Brochure from MED medicine online GmbH, Department of Public Affairs, Bremsstr. 12, D-50969 Köln, not published; <med-koeln@t-online.de>

4.3.4.2 Health Online Service

'Health Online Service' (HOS), a subsidiary firm of the Burda Medien GmbH, located in Munich, Germany, created a complex multimedia open system, which is connected with other partners all over the world. It guarantees a security system, based on the coding technology used by the Pentagon that allows a secure medical data exchange. Equipped with a PC, a modem and a software with a well designed interface, physicians are able to use the comfortable, inexpensive, time saving HOS services 24 hours a day. Services are for example the support of international communication between colleagues, attending online conferences and forums, data retrieval from medical databases (MEDLINE), access to therapy and diagnostic databases, to book references (Pschyrembel, red list) or address lists (emergency addresses), downloading of education classes for different specialties, or the availability of information about products and about companies in pharmacy and medical technology with the option of direct online ordering. In addition medical records can be exchanged via e-mail. Access to the Internet is available and some other useful services like financial hints, calendar of events or even travel information are presented. In summary, Health Online Service[20] offers similar services as Medicine Online, but is orientated internationally [Sachse, 1996, p. 25].

Another telemedicine information service, originate from the project ODIN (Oncological-Haematological Data- and Information Network), is the service MultiMed (Multimedial Communication Systems in Medicine). The objective of MultiMed is to make actual, high-quality information available to physicians independent of time and location [Matthies, 1997, pp. 29 ff.].

4.3.4.3 Medical Internet Information

Other sources of information for health care practitioners are the WWW medical home pages. Such pages often lead to very actual information or case databases. Information is mostly available free of charge, since it is often sponsored by universities and hospitals [Braly, 1995/(1)]. Again, physicians are able to access medical advises from informal Internet chat services and user-groups. They also can participate at medical discussion groups, where they are able to post questions that may be answered by other participants. Commercial information resources like 'MEDLINE' are accessible free of charge. Sponsored by the National Library of Medicine, a subset of the National Institutes of Health in the USA, physicians can search through the titles and summaries of over seven million articles published in medical journals. One only needs a computer with a modem, and a searching software, which can be ordered by the National Technical Information Service[21] for a small fee (ca. US-$ 35). The modem can also be used to access the 'Med Help BBS', a service office which processes research queries of customers (physicians) in MEDLINE and other medical databases for ca. US-$ 25, including copies of relevant articles. In addition, Med Help offers access to a library of medical information, available on the Internet for free downloading [Churbuck, 1994].

Fortunately, all these services are not just accessible by physicians, but by all users of the Internet, too. Nowadays patients are able to retrieve various information about their sick-

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[20] Information Brochure from Health Online Service GmbH, Arabellastr. 17, D-81925 Münchern, not published; <hf@hos.de>

[21] National Technical Information Service - 800-423-9255; Med Help BBS - 516-423-0472

ness[22], about diagnostic and therapeutically treatment alternatives or about preventive behavior. This way telemedicine information may help to improve the patient's responsibility for his medical condition [Köhler, 1998, p. 173].

4.3.5 Telemedicine Databases for Research Purposes

Each telemedicine application has a database in its background, where all case data and images are stored. With the computer's assistance, a physician can analyze cases more precisely and with a higher productivity. For example, if there are images available from a specific organ of a patient taken at different times, the physician is able to identify the patient and to document his progress quickly.

If telemedicine systems are combined in a network with linked data storage, additional valuable information and expertise will be gathered. Data are retrievable for research and scientific findings. For example, as a value added effect of linked telemedicine databases one can learn about the characteristics of abnormalities by looking at many images to discover what is routine and normal, or respectively investigate which deviations are abnormal. This way 'neuronal networks' can be created for the adoption of human sensory systems into mathematical models that are being applied to a wide variety of problems, including image analysis, pattern recognition or improvement of treatment paradigms. [Kukkone, 1995; Hanwehr, 1995, p. 222].

The University of Bremen (Germany) is actually designing the interactive multimedial image database '**Mevis**', which allows to reconstruct three-dimensional vessels, and to visualize and analyze bone tumors [Detken, 1997, p. 71]. Another example is the project **ENN** (European Neurological Network). ENN has the objective to collect expert's know-how from different specialized centers in Europe in a database, to analyze and to offer it to practitioners for diagnostic support and educational purposes [Penzel, 1997, pp. 136 ff.]. A further network, which was designed to collect valuable data about unwanted effects of medicine in a database was introduced by the German Government's Department of Drug and Medical Products, together with the Institute of Medical Information Science, Biometry and Epidemiology at the University of Munich, Germany [Swoboda, 1997, pp. 33 ff.]. A similar database was designed by the toxically information centers in Freiburg and Munich, Germany, within the project TOXINFO-2. In this database valuable information about toxicological products are retrievable [Horsch, 1997, pp. 55 ff.].

4.3.6 Telemedicine in the Context of Robotic Applications

The digitalization of images led to the development of numerous applications for diagnostic support. Yet, the improvement of imaging technology also goes along with new methods for therapy. With sensory apparatus or 'smart gloves' to a remote location through robotics, a user from a distant site can see, feel and even touch objects in the real world. A physician in one location could have a similar hand control, visualization and touch as if he is actually at the operation site performing his procedures [Ziegler, 1995]. This technology

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[22] Examples for medical information in Germany:

- For medical information : www.medizin-forum.de;, www.meine-gesundheit.de, www.arztpartner.de [Hottelet, 2000, p. 13]. For medical advises and self-helf groups: www.arzt-auskunft.de; www.gesundheitsscout24.de, www.yavivo.de
- For addresses of physicians: www.lifeline.de; www.glaxowellcome.de; www.gesi.de/infocare/medserver.htm
- For medical publications: www.ncbi.nlm.nih.gov/PubMed

has already found its place in pathology diagnostics. A pathologist has immediate access to a remote controlled robotic microscope, which enables him to examine a slide of a patient's biopsy at a distance. This is called 'virtual microscopy' or 'virtual reality technology' in pathology [Felten, 1999, p. 477; Okada, 1999, p. 525; Rovetta, 1998, p. 79; Grimes, 1997/(2), p. 319].

One of the most revolutionary thoughts in therapy is the use of robotic components to improve surgical activities, the 'computer assisted surgery' [Gasser, 1997, p. 37]. For example, robotic features can be used for educational and training purposes like the simulation of virtual operations [Detken, 1996, p. 102]. Based on digital CT-images robotic features were developed, with which the specific demands of patient's surgical implants can be measured. A surgeon then is able to select quickly the appropriate standard implant from a catalogue and to adapt it to the specific needs of the patient. Moreover, the surgeon can to navigate a virtual scalpel or other robotic instruments in millimeter precision through the patients body. Each movement can be followed on the monitor [Kukonen, 1995; Hanwehr, 1995, p. 221; ZVEI, 1997, pp. 31-32]. With these computer assisted features surgeons will work more precisely and even faster.

Another example is executed at the Heart Disease Clinic in Leipzig, Germany, by Professor Friedrich Mohr. He uses a robotic endoscopy for bypass operations on the beating heart. He employs a 'telemanipulator-system' developed by 'Intuitive Surgical' (USA), which consists of two elements, a master console and a three arm tele-manipulator, the so called operational robot. Only three 2 cm diameter openings at the left side of the patient's thorax are necessary to insert the instruments and the high resolution videoscope, which makes it possible to see the inside of the body in excellent 3-D quality. The cardiologist guides the scalpel 'virtually' with two sticks, so that he does not have to touch the patient at all. The arms of the operation robot are following smoothly the instructions of the stick in trebly reduction right to the millimeter. Each movement can be seen on the monitor in tenfold magnification. Doing operations this way, the body stressing procedures of the heart-lung-apparatus will not be necessary any more. Currently, the robotic machine is located just five meters away from the surgeon. Even a fast direct conventional procedure is possible in case it is needed. Since the console and the operational robot are connected online, such operations could also be done at a longer distance. The whole system costs about 4 million US-$. In 1999 at least 40 operations were executed in Leipzig. Professor More expects that this number will increase during the next decade [Konrad, 1999].

Satava names five areas that contribute to the realism of such virtual simulations: fidelity (high resolution of the graphics), organ properties (deformation from morphing or kinematics of joints), organ reaction (such as bleeding from an artery of bile from the gall bladder), inter-activity (between objects such as surgical instruments and organs), and sensory feedback (tactile and force feedback) [Satava, 1995, pp. 275 ff.]. Experts expect that robotic features will improve the quality in medicine and reduce the risk in surgery.

4.3.7 Meta-Medical-Record in Telemedicine

A lot of health care professionals are involved in the treatment of a patient. This will even increase, if telemedicine applications are used. All treating physicians are collecting data so that finally there exists a lot of redundant paper based information in various formats and at various locations. Unfortunately, there are numerous heterogeneous information systems in use, which are not compatible with each other. This makes an automated data exchange almost impossible [Bethke, 1998, p. 105]. Facing the situation that several physicians are

involved in a patient's treatment process or that nowadays 'mobility' of people increases permanently (holidays, flexible labor market), it would be from high value for physicians if they were able to review the medical record with all previous data and treatment descriptions of a patient [Sandberg, 1995]. Today a single physician has only access to his self-collected patient data. Not rarely he/she spends a lot of time gathering information by reviewing voluminous paper charts and tracking down patient information on the phone or in various parts of the hospital or at other locations [Steiniger, 1994]. This is no surprise, since the term computer-based patient record is still used in the narrow sense of automating today's paper records and the vision for future clinical computing seems to be limited to clinical data repositories [Amatayakul, 1995].

The effect of such paper storage is that a lot of space and time for sorting, archiving, and retrieval of data is needed. The documents are often in different formats, unreadable, redundant, incomplete or disappear at all [Löbus, 1997/(2), pp. 13-14; Detken, 1996, p. 101]. A fair amount of time is further required for patient records to be dictated, transcribed, and sent to referring physicians [Williams, 1995]. This situation frustrates physicians and make the treatment of the patient and the health care delivery system inefficient. To allow an instant access to any health data about an individual, several institutions and projects have to be active in developing computer-based patient record.

Projects for the Design of Medical Records

One project is designed by the Pacific Bell Health Care Market Group, which is expected to be used by half of California's health care providers. As a backbone, a virtual computer-based patient record system will be implemented. Once the whole system is ready to use, physicians are able to take advantage of clinical messaging applications, they can transmit and receive orders and results, and eventually discharge patients [Braly, 1995/(2)].

Another project started in June 1994, when Europe's first independent academic medical center, the Health Care International Medical Center (HCI) in Clydebank, Scotland, started its work. As an approach to health care for the international community, the key-objective of this medical center is, to make high-tech, specialized care more accessible and affordable, regardless of resources available at the patient's locale. The goal of world-wide medical consulting is, to convey patient information to specialists for consultations, treatments and follow-up care without the restriction of time and space. The core of the service is the electronic creation, transmission, amendment, storage and retrieval of patient information in a central electronically database. The data of these medical records is collected at all points within the health care system. This way information from various departments and points of patient contact can be integrated, which leads to an almost paperless environment[23]. Patient's information like electronic images, assessments, documentation, medications, tests and procedures, etc., is up-to-the-minute available in admissions, at the bedside, in ancillary departments, operating theatres, in physician offices and even at physician's homes [Mariner, 1995].

The Los Alamos National Laboratory works on a concept for virtual patient records, which are available through references (analogous to hypertext links of the World Wide Web) and are only brought together on demand by the end user. The idea behind that is that physicians generally access components of a record rather than the entire patient record

[23] The only paper documents stored are released forms signed by patients.

[Forslund, 1996]. Further, employing multimedia features, the University of Pittsburgh has embarked on a venture called the Image Engine Project, which has the objective of perfecting a multimedia electronically medical record [O'Brien, 1998, p. 154].

In Germany, the 'BERMED' project between the heart center of Berlin, the Rudolf Virchow University Berlin, and several other hospitals and physicians around Berlin is pursuing the aim to integrate distributed patient data in a object-orientated multimedial electronically medical record database constructed on the client server principles. But it is difficult to overcome the problem of different document qualities and formats. An integrated medical application with a well designed graphical user interface helps the physician to easily access patient data, to carry out data retrieval, to generate diagnostic results, to manipulate digital images or to support desktop conferencing [Deutsch, 1996, p. 793]. Another approach is designed by the DLR (Deutsches Zentrum für Luft- und Raumfahrt, Institut für Luft- und Raumfahrtmedizin) in Cologne, Germany. The DLR discovers how to tie already existing date sources to an electronic medical record for telemedical services [Dethke, 1998].

A good survey about institutions in the USA, which consider the questions of medical record standards, are listed by Houtchens [Houtchens, 1995, p. 98] and Detmer [Detmer, 1994] and will be examined more detailed in chapter fourteen (14.2.1). I just want to name some of the most important standard setting bodies: The American College of Physicians, the Institute of Medicine, the American Hospital Association, the Computer-Based Patient Record Institute, or the federal government's Work Group on Computerization of Patient Records.

It is obvious that the developments in the standardization of medical records affect telemedicine, since physicians or other legitimate users all over the world are involved in the procedures of telemedicine and they all need the data of the patient to give up a qualified statement. Of course, questions about data protection and security, legal restrictions, tenability of storage media, etc., have to be answered before such a system can be used on a regular basis. On a long term basis, electronic medical record systems should become an essential part of the integrated health care delivery system and provide valuable information for statistics and medical research, for clinical decision-support systems as well as for other medical knowledge bases. By this way an almost paperless, more patient-centered and clinical process orientated computing environment will be created.

Smart Cards

As long as easy accessible integrated medical records are not available, so called 'smart cards' or 'patient chip cards' were developed. Such cards contain for example administrative patient data (cardholder identity, insurance information, private insurance data and person to call in emergency), patient medical data (history, specialist doctor's names, stay in hospital, data about examinations), biological data (blood analysis, blood group, and agglutination), as well as pharmacy data (current treatment, prescription, and delivery) [Güler, 1998, p. 407; Lischka, 1996[24]].

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[24] More information see: http://www.kp.klr.de; „Telemedizin - Stand und Ausblick"

4.4 Telemedicine Regarded by Interacting People

If telemedicine activities are considered under the point of view 'who is involved' in the interaction, one can distinguish several individuals and institutions [Deutsch, 1996, p. 788]:

- **Doctor to Doctor; Doctor to University**
  This communication link has the aim to get an expert's opinion or diagnosis from physician, who is located at another place. All online-data of a patient can be downloaded by the external physician, so that he is almost able to treat the patient as if he was present. As a consequence, diagnosis and therapy of patients can be improved and with this the quality of medical care. In addition, using the equipment of video-conferencing, valuable education and training classes can be accomplished. The connected physician can ask questions, which will be answered by the experts.

- **Emergency Department with Clinic Facilities** (capacity check)
  Another valuable communication link can be created between the ambulance service and the hospitals in the environment of an accident [Sandberg, 1995]. The ambulance can check, whether a hospital has enough capacity and necessary expertise to attend the injured person. If there is already a medical record at the clinical database available, data can be retrieved and added.

- **Patient with Doctor/Clinic** (homecare, accessing medical information)
  Several projects also pursue the aim to use telemedicine for the improvement of home care. Telemedicine links are employed to monitor high risk patients, for example the monitoring of heart attack patients. Furthermore, individuals can create links to the hospital via Internet for retrieving information e.g. about reactions in the case of poisoning, about new medications or just information about hospital services stored on the WWW.

- **Clinic/Doctor with Statistic Centers**
  If medical data is available in an electronically format, as it is in telemedicine, it can be put together in a central database and be used for medical research analysis. Telecommunications will become a important tool in the improvement of medical research findings.

- **Online Industry with Doctor** (product information, direct order entry)
  Such links are used for direct order entry with the suppliers or to get immediate information about products and medications. In the case of telemedicine, needed medication can be retrieved and ordered quickly.

- **Insurance with Doctor**
  The online connection with the health insurance supports a fast exchange of patient and reimbursement data. Since several individuals and organizations are involved in the treatment of a patient, reimbursement is quite complicated. With direct data exchange the billing-process can become simple, complete and fast.

5 Important Organizations and Telemedicine Projects

5.1 International Activities

5.1.1 TRC - Telemedicine Research Center

The TRC, a Clinical Telemedicine Cooperative Group, located in Portland, Oregon, is a non-profit public service research organization incorporated in March, 1994. The TRC was introduced by the dermatologist and medical internist Douglas A. **Perednia** MD, who is known for his experience in telemedicine applications, such as digital and computer imaging and data delivery. The TRC board includes internationally recognized leaders in telemedicine like Ace **Allen**, MD., Director of the Telemedicine Evaluation and Research Center in Kansas City, Kansas, or Jim **Grigsby**, Ph.D., Director of the Center for Health Policy Research at the University of Colorado. The TRC is funded by dedicated telemedicine research and evaluation grants, and contracts with government agencies like the National Library of Medicine (NLM), the Office for the Advancement of Telemedicine (OAT), or the Center for Health Policy Research (CHPR). The objective of TRC is to provide a mechanism for pooling data from many telemedicine projects simultaneously and for evaluating telemedicine activities. It promotes telemedicine research and the creation and management of telemedicine related issues [Perednia, 1995/(4), p. 291]. Further coherent strategies for coordinating federal telemedicine activities are developed [Puskin, 1995/(1), p. 64]. The TRC also maintains a list of telemedicine programs and sources of funding on the Internet[25] [Weinberg, 1996/(1), p. 834]. Currently the TRC is involved in four projects: the 'Telemedicine Information Exchange' (TIE), the 'Rural Telemedicine Grantees Evaluation', the 'Telemedicine Outcomes Study', and the 'Telemedicine Activity Survey'[26].

5.1.2 TIE - Telemedicine Information Exchange

TIE[27] is a completely independent source of telemedicine information. Continuously up-dated, it provides the most comprehensive computer library database on telemedicine in the world with a collection of international quality-filtered resources of information about telemedicine and telemedicine-related activities. Internet access is given to the TIE's bib-liographic database with over 4.000 citations about telemedicine issues, to information about important telemedicine-focused meetings, to current issues discussing journals, to current information about telemedicine projects, research, funding sources, products and services. A main input for this database are journals like the 'Global Telemedicine Report', the 'Journal of Telemedicine and Telecare', the 'Telemedicine Business Newsletter', the 'Telemedicine Journal', 'Telemedicine Today', or 'Telemedicine and Telehealth Networks'. Another objective of TIE is to help people to create successful telemedicine programs by providing answers to questions that are frequently asked. Therefore, questions are presented together with answers or published articles from experts in various telemedicine fields. In addition lists about funding sources for telemedicine activities, as well as information about over 200 vendors of telemedicine equipment are presented. The TIE's content continues to increase and new services are continually added.

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25 Retrievable from the TIE on-line database: http://tie.telemed.org; a list of US telepathology sites (1995) and US sources of funding for telemedicine and telepathology is also given by Weinberg, 1996, p. 834

26 More information see: http://trc.telemed.org/about/background.as; Telemedicine Research Center; 7276 SW Beaverton-Hillsdale Hwy; Suite 404, Portland, OR 97225; fax: (503)-494-6736; voice: (503)- 221-1620; e-mail: trc@telemed.org, or ctcg@telemed.org

27 More information see: http://tie.telemed.org

5.1.3 ITC - International Telemedicine Center, Inc. Consulting Services

The ITC in Huston, TX, is a telemedicine consulting and training supplier with the aim of mentoring U.S. and international telemedicine initiatives. The reason for doing so was the realization that inadequate planning and training are major reasons why telemedicine programs fail or do not attain their potential. Therefore the ITC provides a full range of services starting from strategic and operational planning support up to user training and evaluation services. Consulting activities can be arranged by contacting the ITC's office via mail, phone, or email[28]. Like TIE, the ITC in addition provides information about publications in telemedicine (e.g. the Telemedicine Journal, Journal of Telemedicine and Telecare, Telemedicine Business Newsletter, Telemedicine Today), or about meetings and conferences where not rarely ITC staff is active participating as conference speaker or as workshop participants.

5.1.4 ACP - American College of Physicians

The mission of the ACP is the enhancement of health care quality and effectiveness by fostering excellence and professionalism in the practice of (internist) medicine. It has over 83.000 members in the USA. That is why the ACP's opinion about telemedicine has a huge influence on telemedicine acceptance. The ACP sets up standards and practice guidelines for the delivery of high quality care and offers a wide range of medical education courses. The ACP develops policies and programs for the improvement of clinical care and medical education through the use of information systems and new technologies. It gives support for managing and integrating medical information and knowledge and helps to satisfy the information needs of internists. Electronic consultation services in form of forums and bulletin boards are offered, where experts provide responses to queries and new research findings. Further the ACP is involved in the development of digital databases for diagnostic and therapeutic decision-support, added by features which allow to measure clinical outcomes. And the ACP has a major influence in the design and development of electronic medical record systems. The ACP puts a lot of effort into the design of user-friendly interfaces. It also drives forward the improvement of interdisciplinary communication for physicians and consultants being able to view data and images simultaneously [Blonde, 1995, pp. 131-137].

5.1.5 IMIA - International Medical Informatics Association

In 1989 the IMIA was established. The IMIA is a non-governmental organization with 35 national members and 18 corresponding members, and with special relations to the World Health Organization (WHO). The objective of IMIA is to promote the specific needs in the application of information science and technology for medicine, health care, and biomedical research. For that reason it serves international cooperation, supports the development of medical applications such as telemedicine systems, subsidizes the dissemination and exchange of information, and organizes the annual World congress on Medical Information Technology [Ferguson, 1995/(1), p. 44].

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[28] http://int-telemedicine.com/consulting.htn; International Telemedicine Center, Inc., 7580 Fannin - Suite 101, Houston, TX 77054-1991; Fax: (713)-797-0461; Tel: (713)-799-2555

5.2 International Activities Across Boundaries

5.2.1 GHNet - Global Health Network

The GHNet was introduced due to the wish to provide international preventive medicine and public health information. It also offers preventive medicine training and is involved in various health educational activities world-wide. For this, several organizations are collaborating: the NASA Johnson Space Center in Houston, Texas, the University of Pittsburgh, the Third World Foundation of North America, and the Pan American Health Organization. Within this collaboration, the Third World Foundation of North America is interested in the development of telemedicine programs with Africa and India, whereas the Pan American Health Organization is focusing its interest on the development of a disaster preparedness and telemedicine network in Central America, South America and the Caribbean [Ferguson, 1995/(1), p. 37].

5.2.2 DOD - Projects of the Department of Defense

The Office of the Assistant Secretary of Defense Health Affairs is working with a number of federal agencies and industries to develop a Military Health Services System offering telemedical services and computer-based patient records for the support and connection of military treatment facilities. Several vital inputs for these developments came off the Defense Modeling and Simulation Initiative, which was designed by the DOD to provide advanced distributed simulation war-fighters in geographically distributed localities. Lessons learned from this distributed simulation network concerning architecture, standards, protocols, interoperability, information sharing, and distributed data bases were later used for the design of telemedicine systems [Lilienthal, 1995, p. 213].

One medical center that is using the systems of the DOD is the Tripler Army Medical Center based at Hickam Air Force Base in Hawaii. It offers a telecommunications system for medical information support, electronic diagnosis and consultation services within the project ‘Akamai’. Telemedical advises are given to diverse military and civilian user groups, which are often more than one million miles away throughout the Pacific. The Akamai project has features for PACS, telemedicine, teleradiology imaging, digital patient records, new tele-surgery, and telepathology technologies [Ferguson, 1995/(1), p. 38; Tangalos, 1995, pp. 281 ff.]. A second figure of the Akamai project is the digital imaging network system, investigated at the Georgetown University. This network will offer diagnostic imaging support and computer aided diagnosis. In addition, research and demonstration programs are tested with which pathways should be discovered for the development of the most appropriate utilization of telemedicine capabilities [Mun, 1995, pp. 161, 163].

5.2.3 International Telemedicine Service Providers

Several other health care providers started to offer telemedicine services all over the world. For example, the Massachusetts General Hospital, Boston, has created a for-profit subsidiary that, for a fee, reads radiographs transmitted from hospitals and clinics in the Middle East. The Mayo Clinic, Rochester, Minnesota, has built a telemedicine clinic in Amman, Jordan. A multinational venture, the Health Care International Hospital in Glasgow, Scotland, has been established to function as an electronically integrated hospital capable of providing care via telemedicine to patients anywhere in the world. Currently it is targeting international clients from Italy to Saudi Arabia to participate at its network [Perednia, 1995/(3)].

5.3 Projects of the European Community - Telematics for Health Care

The European Community realized the potential of telemedicine services for the health care sector. Therefore approximately 80 research and development programs, with a volume of more than 100 million ECU (approx. US-$ 350 million), are introduced by the EU[29] [Dietzel, 1996, p. 21]. These projects support various advanced communications and telematic applications in preventive medicine, diagnostic, therapy, after-care, research, as well as for administration and statistics. At the same time some projects investigate the standardization of electronic information creation, retrieval and storage to enable an efficient information exchange between all health professionals. Some of these project are introduced in this chapter or listed in appendix III. Unfortunately, although many projects are supported by the EC, many of them have their focus on detail solutions and show shortcomings in generalization [Detken, 1997, p. 75]. That is why for the development of appropriate telecommunication applications in health care and for the assistance of a common service policy standardization is desirable. Doing so, liberalization and regulation aspects, interconnection and interoperability of networks and services, as well as questions about communication security and universality of services have to be carefully examined right from the beginning of a project. One approach to do so and to guarantee the interoperability of international and national standards is the project FEST.

5.3.1 FEST - Framework for European Services in Telemedicine

The objective of the EC-funded project 'FEST[30]' is the development of a framework which provides support to different types of individuals interested in establishing and operating a telemedicine system. Thus the task of FEST is to guarantee that national telemedicine activities are conform with international standards. The framework is intended to provide assistance in planning and evaluating the potential for particular services for the specific needs of the questioner. It also supports the development and installation of telemedicine applications, up to the assistance in correcting problems in an existing service [Detken, 1997, p. 75]. Tools are available, which help to identify and to address various factors of influence of particular telemedical service types. Several questions have to be answered by the users of the framework. For example questions about the organizational structures, about roles and activities, relationship of the service to its environment, information flows, or technological and engineering considerations, etc. This way the user is led by an interface through the main areas which should be considered at his telemedicine service. In addition users get assistance in answering critical question in form of a set of rules and advises. Further the user is asked to look at so called 'aspects', which were developed to guide him through another set of factors and to regard his service from another point of view.

5.3.2 EHTO - European Health Telematics Observatory

The objective of EHTO is, to collect, analyze and present information about the developments in health telematics, to support the development of health telematic applications and to improve the standardization of them in Europe. For this know-how and experience is

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29 More information see: http://www2.echo.lu/telematics/health/health-proj.html

30 More information see: http://www2.echo.lu/telematics/health/fest.html

classified into categories corresponding to the needs of the different actors of a sector. EHTO aims to helps in the definition of requirements for specific applications. It supports decision makers in their choice of selecting telematic solutions, and influences the industry to deliver more appropriate products.

5.3.3 HEALTHPLANS

The project HEALTHPLAN is a concerted action to support national and regional health authorities in developing plans for the introduction of health care telematics. National key health care authorities and decision makers are put together to share requirements, priorities, information, experiences, methodologies and plans for the establishment of health care telematic services. Doing so one objective of HEALTHPLAN is to raise the attention of influential national decision makers on the potential of health care telematics. Another important goal is to foster the development of coherent plans for the implementation of telemedicine applications at local, regional, national and international levels.

5.3.4 HERMES - Telematic Healthcare - Remoteness and Mobility Factors in Common European Scenarios

Several islands of telemedicine activities were created in Europe. The project HERMES therefore seeks to provide a proto-platform to an agreed European specification for quality assured telemedicine services. Its focus lies on the harmonization of medical and technical standards, and on the introduction of methods for service and technology developments. The initial HERMES services also include a set of urgent response activities such as a 24-hour on-call services for home-based services and for ambulatory-care services, as well as the development of a portable vital-signs monitoring system. All activities of HERMES go align with the G7 telemedicine activities. As soon as the initial backbone structure is in place, other services will be added and made interoperable for all citizens throughout Europe.

5.3.5 ISAR-T - Integration System ARchitecture - Telematics

The goal of this project is to continue care by means of telematics between a hospital and its partners. For this ISAR-T[31] will identify, prototype, and evaluate a kernel of telematic applications geared at providing services within hospitals, between hospitals, and between hospitals and general practitioners. This way ISAR-T supports the continuity of care by simultaneously enhancing treatment quality and cost control.

5.3.6 ISHTAR - Implementing Secure Healthcare Telematics Applications

The objective of the ISHTAR project is to address the problems of health data protection and health information systems security within telematic applications in a horizontal way. For this programs of action are employed to improve the level of security awareness within health care establishments across Europe. Legal and societal issues raised by telemedicine and networking in health care are identified and analyzed. An advisory panel of experts

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[31] More information see: http://www2.echo.lu/telematics/health/isar-t.html

was built to answer legal, medical and technical questions of data protection in health care. Expert assistance is also given for implementing, validating and maintaining existing guidelines on health data protection.

5.3.7 PROMPT - Protocols of Medical Procedures and Therapies

The aim of PROMPT is to build an integrated care station, which combines several operational technologies, like electronic patient record systems, software for clinical decision support, or protocol-based care. That is why PROMPT technology aims to offer a wide range of services centered around the provision of high quality health care. It is based on standardized guidelines and protocols. One specialty where the PROMPT care station is particularly useful is in cancer medicine. Based on the newest research findings, standardized protocol-based decision support applications are employed to improve diagnostic and treatment quality in oncology. Since the technologies of PROMPT are generic it is not just applicable for oncology, but also for other specialties in health care.

5.3.8 G7-Glophin - Global Public Health Information Network Feasibility Study / Accompanying Measure

The activities of the G7-states already started in 1994 with the Global Health Care Applications Program for the harmonization of national and international telemedical activities. One effect of this program is GLOPHIN. As the name is indicating, this is a project which wants to prepare the ground for a multilateral, multipurpose, GLObal Public Health Information Network. Doing so, an important task of GLOPHIN is to define technical obstacles for telecommunication within the EC (Brussels, Luxembourg), WHO (Copenhagen, Geneva), and the G7 member countries. Canada, Japan and USA are contributing as sponsoring partner. A concept for an information network is designed together with appropriate regulations and guidelines for the support of an international data exchange in the areas of communicable disease surveillance and vital statistics.

5.3.9 Summary or European Projects

The European Community has introduced various project, dealing with problems in telemedicine. Some project are focused on a very specific specialty of health care (e.g. radiology, diabetes, oncology), others are focused on a specific subject like integration, technical restriction or the solution of security questions. It is important that there is a strong information exchange between the different activities, since it does not make sense that projects like HERMES or HEALTHPLAN are dealing with harmonization in health care telematics, but do not communicate with each other. However that seems to be a challenge. Application trials in telemedicine are almost mushrooming and often the decision makers and acting persons prefer to use the ‘try and error’ system instead of developing time consuming concepts, which perhaps anyway will be overcome by the newest technology developments. Nevertheless, it makes sense that participants of telemedicine projects keep an eye of the ongoing activities of other national and international telematic projects in health care. To avoid a waste of time, effort, and money, at least projects funded by the EC have to be carefully coordinated.

6 Description of Telepathology in General

6.1 History and Telepathology Projects

The trend to introduce **graphical workstations** in pathology goes back to the late sixties. After graphical applications like CAD (Computer Aided Design), CAM (Computer Aided Manufacturing), or CAE (Computer Aided Engineering) with graphical tools for 2D and 3D element input and display proved to be valuable for the industrial world, medical institutions became interested in these tools, too. Several trials started for the utilization of workstations for image access, display, treatment and archiving to improve the working condition in pathology. In parallel to this, **video-microscopy** was re-discovered for pathology. Since many years this technique has already been used for the demonstration and discussion of histological slides with colleagues. Yet the Internet communication offers a much wider distribution and utilization of case demonstration images [Eide, 1992/(1), p. 405; Weinstein, 1987, p. 646]. Finally the first telepathology applications for microscopical image exchange were developed.

One of the first tests of telepathology took place at the **Logan Airport in Boston in 1968**. Video microscopy was used to transmit live black-and-white images of histological sections from surgical specimens and stained blood smears to the department of pathology at the Massachusetts General Hospital, several miles away [O'Brien, 1998; Weinstein, 1991, p. 511]. Although this early system did not provide color images, and did not allow the consulting pathologist to directly manipulate the slides mounted on the microscope, accurate diagnoses were achieved. Another trial took place between a hospital in Brazil and a hospital in Washington DC in 1974. Referring to this trial, it was the first time that still images of microscopic slides were transmitted via satellite communication [Eide, 1994, p. 881].

In 1983 a local telepathology network for the transmission of full-color frozen section images was installed in **Chicago**. The network was a test for telepathology utilization and connected ten operating rooms of the Rush-Presbyterian-St. Luke's Medical Center with its laboratory building, the Chicago-based Central Pathology Laboratory [Weinstein, 1987, p. 647; Weinstein, 1996, p. 99]. This attempt was part of the US-National Bladder Cancer Project. The director of the project was Ronald Weinstein, who later was involved in the establishment of the Arizona-International Telemedicine Network (AITN). Weinstein[32] is well known and has a leading role in the environment of telepathology in the United States.

Based on this successful trial, the first **dynamic-robotic telepathology system** was developed in **Chicago** in **1986**. It was successfully used for breast biopsy frozen section examinations over a huge distance. Images were transmitted thousands of miles from the Fort William Beaumont Army Medical Center in El Paso, Texas, to Washington, D.C., via the SBS-3 COMSAT satellite using a 30-MHz transponder [Dunn, 1997/(1), p. 8]. Frozen sections examinations, where the specimen is prepared and processed at remote sites, like it was the case in Fort William, soon became a main item for dynamic telepathology trials, since the time and distance problems are most obvious considering frozen sections. In 1986, the first commercial prototype of a robotic color video telepathology system was constructed by **Corabi International Telemetrics, Inc.** (Atlanta, GA), as part of a corpo-

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[32] Actual address: Ronald, S. Weinstein, University of Arizona Medical Center, USA; e-mail: ronaldw@u.arizona.edu

rately funded joint venture between USA and Japan. This system included the use of high-definition television and a fully remote controlled microscope [Weinstein, 1991, p. 511]. In 1990 the Emory University Hospital, Atlanta, the Mayo Clinic in Rochester, Minnesota, and in Scottsdale, Arizona, started further trials with robotic telepathology systems [Krupinski, 1993, p. 66]. Robotic systems were also introduced in Burlington (Vermont/USA), Milwaukee (Wisconsin/USA), Basel (Switzerland), Kyoto (Japan), and Tromsoe (Norway).

Soon whole networks, based on telepathology communication were established. In 1989, **the first static-image telepathology network** was set up in France. At the beginning six laboratories in the region Dijon were linked over standard telephone lines to a consultation network. This network was expanded into a national network linking commercial laboratories with academic departments. Finally the network connected 32 workstations at different sites, including one system at Martinique and at the Guadeloupe Island [Weinstein, 1997/(3), p. 2]. Similar networks were set up in Italy (Udine), Sweden (Uppsala, Linköping), and Japan (Sapporo, Yonago/Tottori).

In the USA, telepathology is already offered as an international medical online service by the **Armed Forces Institute of Pathology (AFIP[33]),** located in Washington, D.C.. Originally, the AFIP provided telepathology services in the form of diagnostic consultations to remotely located Army, Navy and Air Force pathology laboratories. Since 1993, teleconsultations and various tele-education programs are offered to civilian laboratories and pathologists all over the world. In Europe, the project EUROPATH[34] (EUROpean Pathology Assisted by Telematics for Health) plays a vital role for the development of telepathology. Twenty-five partners of different European countries are participating in the development and improvement of telepathology applications. A more detailed description of further projects and telepathology activities is given in chapter nine.

With the availability of digital image capturing features, image storage and compression tools, teleconferencing systems, telecommunications infrastructures (e.g. optical fibre cable) and networks, as well as digital telecommunications services like ISDN, the wish to provide adequate healthcare via networks to rural and medically under-served areas increased continually. This development was further pushed by the improvement of Internet technology and Internet access. Since communication technology became cheaper and computer performance improved continually, the number of projects in telepathology and the request for telepathology applications started to rise increased grow [Weinberg, 1996/(1), p. 831]. Subsequently, investigators all over the world began to engineer static and dynamic-robotic telepathology systems.

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33 http://www.afip.org; contact address: T. J. O'Leary, Department of Cellular Pathology, Armed Forces Institute of Pathology, Washington, DC 20306-600 [Becker, 1993, p. 909].

34 http://www2.echo.lu/telematics/health/europath.html; see also: Allaert F.; Dusserre L.: "Europath work groups - guidelines for telepathology practice", http://europath.image.fr/EUROPATH/Path_W...th/Path_TelepathPractice/practice1.html

6.2 Organizational Structure of Pathology

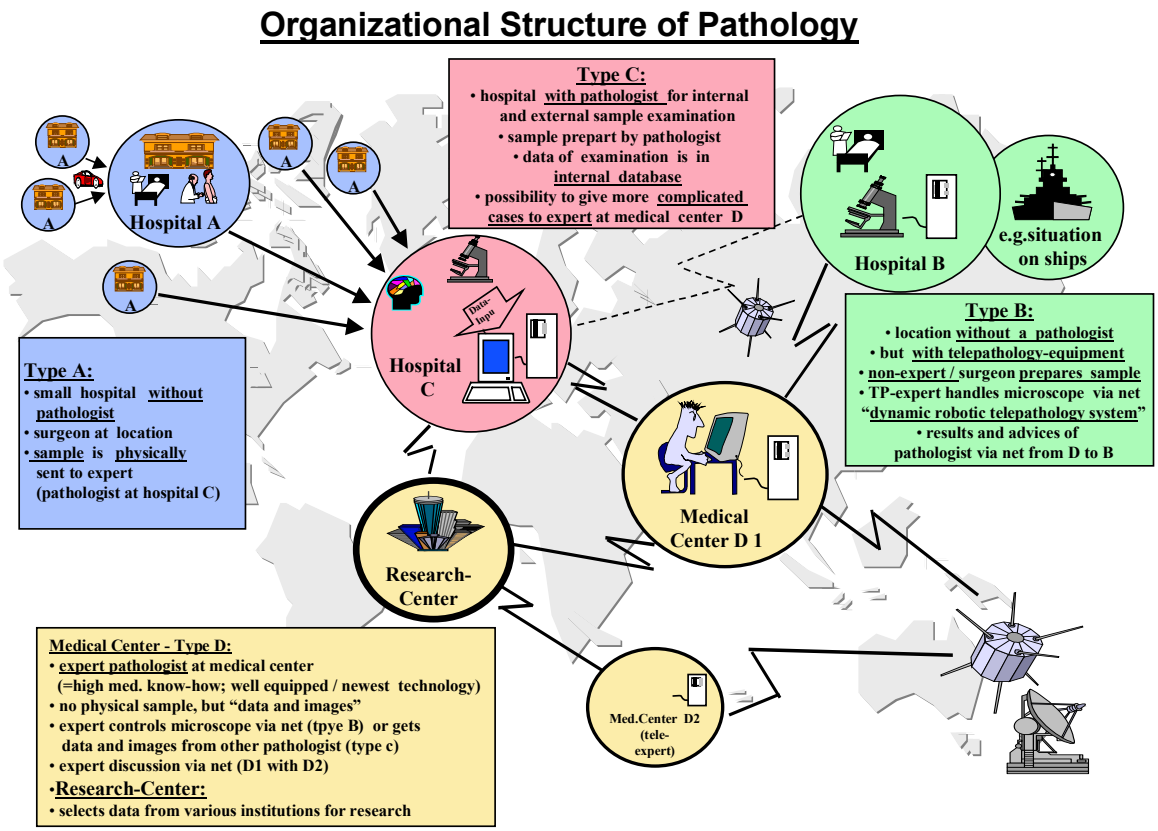

Figure 4: Graphic about examination structures (primary and secondary) in pathology.

Conventional Method
(Hospital A without a pathologist - hospital C with a pathologist)

After the surgeon has removed the tissue sample at hospital A, the sample will be transported by car / train / helicopter to the expert pathologist in hospital B. There, the sample will be first prepared (frozen, cut in thin pieces, stained, and put between glass) and then microscopically examined. The result report is sent to hospital A via mail or via telephone.

Telepathology Method for Primary Diagnosis (Telediagnosis)
(Hospital B without a pathologist - hospital C/D with a pathologist)

The tissue sample is removed at hospital B. Then the pathological expert at hospital C/D is contacted by telephone. An online connection is created between B and C/D via net. By using a camera at hospital B, the pathologist is able to examine the sample (macro-examination) and advise the non-expert how to cut and prepare the specimen. As soon as the sample is prepared and put under the microscope at hospital B, microscopical images are sent to the pathologist at C/D for examination (micro examination). If the expert is using a dynamic robotic telepathology system, images can be scanned and selected from the distance by himself. At a static system the client is selecting the images. The diagnostic results are sent via e-mail and telephone. Currently, for reassurance of this new process of treatment, tissue samples are examined conventionally (direct light microscope examination)

again later. A habit, which is anyway common with frozen section diagnoses. Frozen section specimens are mostly sent to the pathology laboratory for a final diagnosis based on more accurate and time consuming techniques.

Expert Conversation - Second Opinion

As soon as specimen images are available in an electronically format, an expert conversation about rare or complicated cases can take place without additional effort.

Central Data Storage

All kinds of electronically available data and images can be stored in a database and used for scientific research studies.

6.3 Different Kinds of Pathological Services

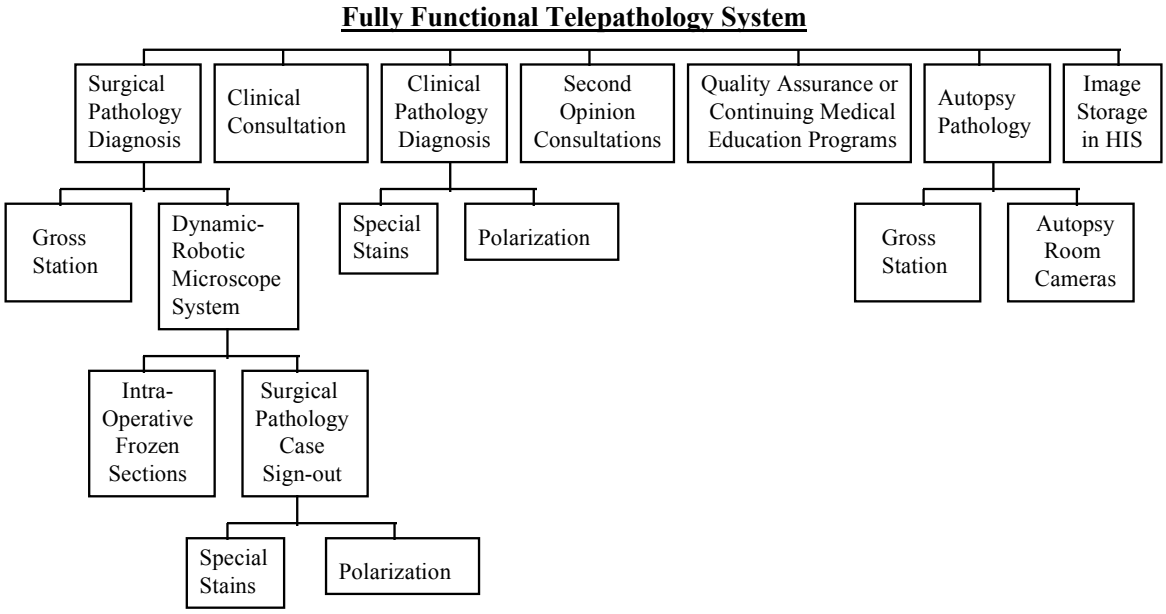

Figure 5: Services which could be delivered by telepathology [Weinstein in Dunn, 1996/(2), p. 464].

The figure above shows the main services, which may be served by telepathology. They can be briefly characterized as follows:

6.3.1 Tele-Diagnostics

Primary Diagnostic (Telediagnosis)

One area of telepathology is the utilization of telepathology systems for **primary diagnostics**. This service is often called '**telediagnosis**[35]' or '**telepresence**' [Nelson, 1997, p. 176A]. In the figure above telediagnosis is demonstrated by the first three boxes - surgical pathological diagnoses (including intraoperative frozen section examinations), clinical consultation and clinical pathological diagnoses (e.g. cell examinations). Primary diagnosis it

35 At the AITN the term 'telediagnostic' is used for second opinion diagnoses. In opposite in most of the literature and in this study, it is used for primary telepathology diagnoses.

meant to be the **first diagnosis** that is directly executed by telepathology. Such a diagnosis has immediate therapeutically consequences. Primary case examinations are either done for a specific single case or for a set of multiple 'en bloc' cases from different patients in a sequence without any break. Yet, telepathology is actually only performed for single case diagnoses [Kayser, 1996, p. 475].

Primary tele-diagnostic is mainly used between hospitals without pathologists and outside pathology laboratories. Often primary telediagnoses are limited to frozen section examinations, like in Basel (Switzerland) or Tromsoe (Norway). One of the few locations where telepathology is not just used for frozen section examinations but on a **routine basis** for primary diagnostic is in Vermont, USA. All tele-diagnoses are confirmed by direct light microscope examination later.

Second Opinion Consultations (Teleassistance, Secondary Diagnostic)

Pathology has evolved towards enormous complexity. It is a vast and changing field of the medical art, which makes it very difficult for a pathologist, even impossible, to acquire and maintain a keen knowledge in all the fields of organic diseases. It is already impossible for general pathologists to handle the increasing sophistication of diagnostic methods and to cover the entire spectrum of specialized and sub-specialized diagnostic services, e.g. cardiac, dermatology, liver, gynecology, breast, neurology, etc., or even to examine cases outside their designated subspecialty area. Therefore pathologists become interested in helping one another in providing accurate diagnoses [Martin, 1995, p. 192]. To **ask a colleague** to have a 'second look' on a rare or difficult specimen or to refer cases to subspecialists, to confirm, to infirm, to modify or enrich a diagnosis is a common procedure in pathology. Not rarely a pathologist is not sure about the stage and grade of a certain disease process, e.g. grading malignancy or estimating degrees of tissue destruction from chronic inflammation or other degenerative processes, and wishes to confirm or clarify his result [Allaert, 1995/(2), pp. 599, 600; Kayser, 1995/(1), p. 54; Olsson, 1995, p. 235].

However it is quite time consuming, if there is no second pathologist at the face. The glass microscopic slides together with documentation on the patient's clinical history and investigation have to be packaged up and send by mail. This means that the average turnaround time by using traditional routes is 1-2 weeks, depending on the distance between the referring and expert's institution. In addition, not rarely slides get damaged or lost, or there is a contentious issue of the return of the material to the referring pathologist, which may cause problems [Eusebi, 1997, p. 13]. Tele-expert-consultation may be a solution to overcome these difficulties.

> *"It is difficult to compute the **benefit in diagnostic assistance** which relies to a high degree on the diagnostic knowledge of the partners and clinical task of the surgeon; however, rough estimations calculate that substantial additional information was achieved in about 35-40 % of cases." [Kayser, 1995/3]*

> *"Frozen section diagnosis are not regarded as the major potential application of the technology. **Expert** on-line **consultation** in difficult cases may be a more important application." [Weinstein, 1987, p. 648]*

Telepathology systems have proved to be an accurate and cost effective way to support second opinion advises between pathologists. They allow to reduce the risk of generalists to take responsibility for diagnosis and treatment. If they are not certain about a diagnostic outcome, they can easily request an expert for an 'online' second opinion. Specimen

images and case information are sent via the Internet to a consultant pathologist. Then in an interactive situation, the two physicians converse by telephone, showing each other the part of the lesion they find necessary to discuss. Using telepathology systems, pathologists are able to easily communicate and work with colleagues or small professional groups without compulsory links with major hospitals [Allaert, 1995/(2), p. 596].

One can distinguish **second look** consultations ('horizontal' consultation for supportive chats with colleagues), and **second opinion** consultations or **reference consultations** with board examination centers ('vertical' consultation with experts), where a highly specialized pathologist is contacted [Busch, 1992, p. 430]. At second look consultations the responsibility for cases remains at the requesting side. In opposite to second opinion consultations, where the judgement of the consultant has legal impact (see chapter 15.1.2).

Reference consultations are executed by pathologists, who are highly specialized in the examination of specific organs. Consequently the reference pathologist carries the responsibility. This is already a routine process in pathology. If a diagnosis is not conclusive or if the diagnosis has drastic therapeutically consequences, the whole specimen is sent to this specialist for a reference diagnosis. This takes in average one to two weeks until the result is available. Since waiting time is lost time for the patient and surgeon, telepathology will speed up this process [Hufnagl, 1999].

6.3.2 Continuing Medical Education and Discussion Groups

Telepathology systems are often employed for **online education lessons** on a distance, for computerized training and proficiency testing, or for the establishment of discussion groups. They support the access to databases with rare and interesting registered cases. This way they help to increase competence. Getting access, the pathologist at the periphery has the possibility to take part at the newest research findings and education programs. In the past pathologists discussed difficult or rare lesions by looking through one or more multihead bridge microscopes. With telepathology a color TV camera is linked to a high-quality color TV monitor for image capturing and demonstration. All electronical images can be used for teaching and training. Based on such video images, various **experts** at different locations can communicate and work on difficult cases that have been prepared through formalized telepathology systems. Telepathology applications will also improve **interdisciplinary cooperation and communication,** because colleagues can easily be contacted and case information can be exchanged quickly. Fortunately, pathologists already start to recognize the new communication and training multimedia tools in pathology as a new feature to communicate more effectively with colleagues. They also enjoy the continuous education and training lectures that are offered online [Azumi, 1996, p. 451, Rienhoff, 1998, pp. 7-14; Allaert 1999; Brebner, 1997/(1), pp. 10-12; Brebner, 1997/(2), pp. 48-52; Diebold, 2000].

One example for online-teaching in telepathology had been executed by the Office of Academic Computing for the Pathology Departments of the New York Hospital Cornell Medical Center and the Sloan Kettering Memorial Hospital. Students and teachers telecommunicated in groups, supported by a free Internet conferencing software (CU-SeeMe in connection with AppleScript). Low bandwidth high-resolution images were exchanged over the Internet. Students just had to click on images, manage pointers, manipulate image placement and zooming and were able to download cases [Stensaas, 1996, pp. 484-485]. Similar online-education features are available in Bosnia-Herzegovina and Germany

[Seiwerth, 2000; Leiner, 2000[36]]. At the Medical University of Beijing, China, a menu-driven MBES-Pathology system had been introduced for individualized, interactive multi-media self-paced learning. The system has improved the comprehension of learning and teaching in pathology compared to traditional methods [Gong, 1996, p. 486]. And as a last example, at the Department of Pathology at the Robert Wood Jonson Medical School (New Brunswick/Piscataway, NJ, USA) 'TelemEDUcation' provides biomedical information, computer-based learning tools for medical education and medical practice support via Internet [Trelstad, 1996, pp. 453-454].

6.3.3 Computer-Aided Diagnoses, Quality Assurance and Research Data

Computer-Aided Diagnoses and Standardization of Exams

Pathological case data, especially rare and difficult ones, can be archived and processed at a (centralized) scientific visual data storage. If such registered diagnostic case data is available, it could be used for diagnostic purposes in the **classification** of benign and malignant tumors. Remote pathologist are able to access reference cases for a double-check of a diagnosis decision. They will be alert of any possible abnormalities in the images. Merely conventional telephone lines are sufficient to send visual information of a case to the database. There the original images could be matched with the images stored in the visual database. Then the most congruent one and its diagnosis could be retrieved [Kayser, 1993/(1), pp. 331, 332]. Doing so, highly complex computer image analysis systems are used to screen specimen independently or automated quality control re-screening is offered to compare the patient's images with reference images [Grohs, 1998, p. 166; Klossa, 1998, p. 209; Martin, 1995, p. 192; Mun, 1995, p. 158]. Computer-aided diagnosis systems with artificial intelligence technology and artificial neural networks for decision support could help to improve the accuracy and consistence of diagnoses, almost as having a second pathologist for double reading at the place. In addition, case databases may become a forcing factor to standardize exam processes and could provide clear guidelines for quality assurance.

To give an example, in a project at Oxford, UK, 'gold standard' images are stored in a database, which is accessible via Internet by non-experts as reference point and analysis feature for diagnoses [McGee, 1995, p. 34; Joel, 2000]. Another database of this kind was designed in France[37] for hematology [Flandrin, 2000]. The ENAA telematic system (Electrodiagnostic Neurophysiological Automated Analysis) at the Bristol Hospital, UK, is an additional example. It also can be accessed for requesting diagnostic support [Papakostopoulos, 1996, p. 30]. Thinking about executing quality performance tests of pathologists by using 'virtual cases', the research approach of the University of Trento is from value [Demichelis, 2000]. Images could be captured and transmitted to all pathologists instead of the real slides have to be mailed. Another useful effect of telepathology in the context of quality assurance is the creation of protocols. Cancer research associations, such as European EORTC, already access telemedicine processes to define and monitor therapeutic protocols. For the future it is to assume that **computer-aided diagnostic assistance** tools become a very important component in telepathology.

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36 www.mi.med.uni-goettingen.de/PathologieLehre/

37 web: www.adicap.asso.fr; standardized image database for hematology, contact address: 1. ADICAP, Hopital Charles Nicolle, Laboratoire d'anatomopathologie, 76031 Rouen Cedex, France; 2. CRIHAN, Parc technologique de la Vatine, 32 Rue Raymond Aron, 76130 Mont-Saint-Aignan, France; CRIHAN = Center de Ressources Informatiques de Haute-Normandie; ADICAP = Association pour le Développement de l'Informatique en Cytologie et en Anatomie Pathologique

Technical Diagnostic in Pathology

There are already pathologists who use cell automatic recognition and who generate computer-aided diagnoses by automatic cell counting to improve and maintain diagnostic quality [Marsan, 1995, p. 342]. Volume reconstruction are generated through section piling, and computer-aided diagnosis and statistics are created by 3D applications [Allaert, 1999]. Such technical procedures were introduced to gain a more detailed or specific diagnostic statement. Procedures such as immunohistology, DNA analysis, ligandohistochemistry or PCR are summarized under the term '**technical diagnostic pathology'** [Kayser, 1996, p. 476].

As soon as images get a digital format on the computer, **morphometric information** can be extracted on a distance and diagnostic accuracy can be improved by '**telequantification'** of images [Phillips, 1995, pp. 288 ff.; Phillips, 1996, pp. 231 ff.]. For this, images are sent for quantitative **DNA-cytometry analysis** or quantitative immunohistochemisty to specialized centers. 'Analytic or **quantitative cytology** is already widely employed to measure ploidy on Feulgen-stained specimens or to assay clinically tumor markers, such as estrogen receptor protein on immunohistochemically stained specimens. If such standardized quantitative measures are online available, specimen evaluation, diagnosis and reporting will be improved [O'Brien, 1998, p. 153; Kunze, 1998, p. 141; Kunze, 2000]. Institutions which do not have experience or the necessary equipment and manpower can submit images of their case slides to others who are willing to perform the measurement [Kayser, 1993/(1), pp. 332, 333]. This is already practiced in Dresden (Germany) and in Tenerife (Spain) [Woziwodzki, 2000; Ferrer-Roca, 1995/(2), pp. 154 ff.].

Quality Assurance

Diagnosis validation (to which second opinion consultations belong to), quality assurance activities, and personal performance tests are compulsory for several specialties in pathology. By this quality assurance is defined as

> *"... a procedure that ensures a constancy of high-quality diagnosis or therapy in space and time ... it should assist all involved partners to reach the best and most reliable diagnosis within a limited period. Telepathology can be considered a technical procedure to assist assurance and maintenance of high standards in diagnostic pathology." [Kayser, 1996, p. 477].*

Quality assurance tests are often performed during post-university continuous education, or during various meetings and congresses. Currently such tests are organized by national and international specialized pathology associations like the CAP (College of American Pathologists), the RCP (Royal College of Pathology), or the AFAQAP in France [Allaert, 1999; Della Mea, 1995, p. 237]. The CAP for example developed criteria for the assessment of continuous quality improvement and investigated the degree of accuracy of pathology services. These criteria already helped to confirm an error rate in surgical pathology diagnoses of less than 1% for its non-telepathology practice [Bhattacharyya, 1995, p. 12]. With telepathology such quality assurance activities could be expanded, standardized, and simplified. For example, test tissue samples which had to be mailed in the past, could be distributed as a digital image together with a question/answer file to evaluate the examination quality of pathologists. Post-graduate training with proficiency tests could also be executed online [Martin, 1995, p. 192; McGee, 2000; Slodkowska, 2000].

Science

As soon as cases are diagnosed and coded by thesaurus (e.g. SNOMED, ICD, ADICAP, RESINTEL) and stored in telepathology databases, statistical output through data sort is immediately available for epidemiology studies [Allaert, 1999; Flandrin, 1997/(1), p. 97; Flandrin, 1997/(2), p. 104]. To easily retrieve data from local databases, again it is important to speed up the standardization of pathological medical records. Such records or images of a scientific archive can easily be used for quantitative research analysis of images, for documentation of diagnostic findings at clinical conferences, as well as for the creation of shared teaching materials.

6.3.4 On Call Services

Another interesting effect of telepathology services is the creation of 'on call' cooperation between pathologists, e.g. for weekend services, or even for the establishment of **'on call' service centers**, offering 24-hours pathological consultation services. Such centers also could be contacted, if second opinion examination is needed. And as a vision, they could help to optimize medical resources between diagnosis provider countries (Europe, USA) and diagnosis requester countries (third world, medically emerging countries such as India, Africa).

An example for such a service center is the AFIP in Washington/DC. A similar service was created in Arizona - the Arizona-International Telemedicine Network (AITN), or in Berlin - the UICC (see chapters nine, 9.1.1.1 and 9.4.3). Cases are tracked through this network to subspecialists, who will help the referring pathologist [Bhattacharyya, 1995, pp. 9 ff.; Weinstein 1995].

6.4 Reasons and Objectives of Telepathology Introduction

The limited availability of pathologists in rural locations is often a bottleneck in health care delivery systems [Weinstein, 1986, p. 433]. That is, why similar to telemedicine services in general, the driving force of telepathology introduction was the idea to transfer the highly qualified know-how and the experience of pathological experts at medical centers to peripheral hospitals and doctor's offices by using telecommunications technologies. Knowing that the major issue of pathology is the interpretation of images, the basic objective was to transfer the knowledge and experiences in the interpretation of images from the center to the peripheral site [Oberholzer, 1993, p. 1078]. In other words, instead of the patient moving to the expensive medical center for treatment, or instead of pathological experts having to travel to the periphery, only the data and images of a patient and the expert opinion are travelling along the wires of telecommunications networks. Participants of this study were also asked to write down their reason for telepathology introduction. The results can be found in chapter seventeen (17.2).

7 Types of Systems

In general telepathology systems can be distinguished in **static still-image systems** or so called store-and-forward systems, and **dynamic live-image** systems with simultaneous voice communication also known as real time systems.

7.1 Static Still-Image Systems

At a still-image system, microscopic images are captured in a digital format on an image grabber board at one end and transmitted singly to a computer workstation, where the receiving telepathologist is able to view the images at the monitor at the other end. Typically, the selection of microscopic fields for transmission to the consulting pathologist and the control of all microscope functions are at the transmitting site. For the exam process the referring pathologist is sitting in front of his workstation color video monitor for manipulating the microscope optical controls, and the glass slide positioning on the stage. When he is satisfied with the image quality (microscope parameters control including zoom) and image relevance (glass slide position of adequate regions of interest), he captures these images, which are automatically stored in the patient's file. Before sending this file, the client usually adds some comments, signs it for security and liability reasons, selects the address of the pathological teleexpert, and transmits the file to him. If the consulting pathologist requires more images, the client again selects images and transmits them to the telepathologist [Allaert, 1999; Weinstein, 1992, p. 399; Weinstein, 1997/(1), p. 34].

> *"Our experience was that the majority of diagnostic questions raised in our telepathology consultation practice were solvable by static imaging". [Weinstein, 1995, p. 224].*

Since the usage of still image systems starts to increase, a work group for **guidelines in still image telepathology practice** was built[38] in Europe. Yet, many telepathologists prefer to keep control of the imaging scanning process at the microscope. Such pathologists ask for dynamic telepathology solutions.

7.2 Dynamic-Robotic Imaging Systems

In comparison to still-image systems, a dynamic imaging system implies real-time transmission with practically no delay in transmission time. A dynamic telepathology application is a kind of specialized video conference system. Yet, in addition to two-way audio and video, which is part of all video conference communications, a dynamic telepathology system further has to establish a data connection to control the remote video switch, to coordinate microscope control tools, the light for the macro camera and to display the remote cursors at both locations. All images of the sample and specimen slides moved about on the microscope stage are viewed live and in real time by the consultant.

First a camera mounted on a grossing stand is capturing gross images of the tissue sample. The telepathologist is able to follow the gross-examination and to advice the client. Then the sample is prepared. As soon as glass slides are ready, the client precisely mounts them on the specimen stage of the robotic microscope, at precalibrated X- and Y-coordinates. In the image of the glass slide at the expert's monitor a cursor indicates the position of the

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38 http://europath.imag.fr/EUROPATH/Path_W...th/Path_TelepathPractice/practice1.html

microscope's objective lens, thus the precise area of the slide being visualized. The cursor can be repositioned with the mouse at the host workstation. Then the software for the robotic features repositions the motorized stage of the robotic microscope to the X- and Y-coordinates represented by the repositioned cursor. Target areas of interest can be selected proactively. Dynamic-robotic imaging systems allow that the specimen can be viewed by panoramic scanning and zooming, and objectives can be changed and manipulated directly by the telepathologist. That is why dynamic image systems are also called '**master systems**'. The remote observer is the master of all robotic features, of selecting diagnostic fields and adjusting focus magnification, instead of being a slave of the system and dependent on the client's image selections [Azumi, 1996, p. 447; Krupinski, 1993, p. 67; Weinstein, 1997/(1), p. 34].

7.3 Dynamic Imaging System Without Robotic Features

Such systems are also live systems, but the microscope functions are under the control of a local system operator at the transmitting site. Although there is no direct robotic microscope control, two-way audio conversation enables the interpreting telepathologist to instruct the transmitting client to change microscope objectives or to return to a particular sample field. One can say that it is a mixture between a static and dynamic-robotic system. It is a kind of compromise between a less expensive static-image system and a more expensive, technologically more complex, completely remote controlled dynamic robotic image system. However the lack of microscope control by the consulting pathologist could result in some of the same difficulties encountered with static-image systems.

7.4 Hybrid Systems

Several telepathology programs use equipment that integrate dynamic imaging, static imaging, and robotic microscopy into single systems. Such systems are called 'hybrid systems'. In general hybrid systems are incorporating both: a) low-resolution video is used for scanning the entire tissue selection in real time with dynamic imaging and remote robotic control of the microscope, and b) high-resolution static digital images that are employed for capturing and transmitting conspicuous diagnostic fields. Mostly codec and live video conferencing are used. Telecommunication is usually done with T1 or ISDN linkages. Hybrid systems overcome the problem of sampling and are less constrained by wide band telecommunications requirements. They are already in use for example in Norway, Japan, USA and Switzerland [O'Brien, 1998, p. 152; Weinstein, 1997/(3), p. 3; Weinberg, 1996/(1), p. 833].

7.5 Advantages and Disadvantages of Different System Types

Cost

Robotic systems are relatively expensive. They often have the difficulty to ensure compatibility among different telepathology systems, because of the complexities of standardization in controlling the remote microscope. Because they are very complex, dynamic systems demand a higher effort to become familiar with their usage (training effort). The great advantage of dynamic systems is that they are suitable for hospitals which do not have a pathologist (saving of pathologist's salary rate at the client's side), because the whole pathological process is under remote control of the consultant.

In contrast, static systems have the advantage of low equipment costs (capital and running costs). The low bandwidth requirements also tend to make still-image systems far less expensive. One has to keep in mind that in many rural and under-served areas, where telemedicine services are most desirable, convenient high-speed links are often not available - and if, not at a reasonable price [Perednia, 1995/(3); Becker, 1993, p. 909]. Static systems are also more simple, so that less time is needed to learn how to use them. Already e-mail applications could represent a way for doing static telepathology, proved by trials in Italy and other countries. Such systems have the advantage that a physician even does not need to switch to and learn to use a particular system [Rosenthal, 2000; Kuakpaetoon, 2000; Della Mea, 1995, p. 238; Della Mea, 1996, p. 26; Della Mea, 1997/(2), p. 636; Della Mea, 1997/(3), p. 17; Della Mea, 1998/(1), p. 20; Beltrami, 1998, p. 146; Nagata, 1998, p. 286; Oka, 1999, p. 205; Okada, 1999, p. 525; Szymas, 1998, p. 133; Szymas, 1999, P. 37; Rovetta, 1998, p. 79; Boudier, 1999, p. 133; Slodkowska, 2000; Szymas, 2000(1)]. However, there is the limitation that skilled personnel is needed at the client's side to handle the specimen and to capture appropriate images. Therefore, the client has to be a pathologist (high salary by mostly low operating rate), or the client's personal has to be specially trained (high pathological training effort).

Bandwidth

Dynamic systems require access to broadband telecommunications channels for optimal manipulation of a motorized, robotically controlled light microscope. Because each microscopic video image contains a large amount of information (approximately 0.1 to 1 MB), very wide bandwidth transmission capability is required to achieve a satisfying high-speed image transfer [Becker, 1993, p. 909; Weinstein, 1997/(2), p. 25; Weinstein, 1997/(3), p. 1; Kayser, 2000]. In opposite, static imaging telepathology systems use 'store-and-forward' digital imaging technology. Because these systems are less dependent on bandwidth, they can already be executed by using conventional, old telephone lines [Swett, 1995, p. 593].

Organization

The advantage of still-image systems is that they obviate the need for simultaneous availability of the consulting parties. Images selected by the client can be downloaded to a distant workstation at any hour by a telepathologist for reviewing at a convenient time. This asynchronous data transfer makes transmission time and speed less important. Neither sender nor receiver need to wait while the case is transferred from one site to the other [Perednia, 1995/(3); Weinberg, 1996/(1), p. 833; Eusebi, 1997, p. 16]. In opposite, dynamic systems demand a set up ahead of time between the referring pathologist and the expert or between experts. Client and consultant have to build a team with a good cooperative relationship [Kayser, 1995/(1), p. 55; McGee, 1995, p. 34].

Accuracy - Field Selection

With dynamic-robotic telepathology, the teleconsultant views all sections on all glass slides in their entirety. Doing so he is able to control all microscopy functions in real time including stage movements and field selection. That is why dynamic systems achieve high levels of diagnostic accuracy.

This is in contrast to static-image telepathology, in which the receiving telepathologist has less control over the sampling of tissues and selection of microscopic fields for diagnostic

interpretation. At static systems the referring pathologist just captures a small set of digital images which are then transmitted to the consultant, who views them on a video monitor. Therefore the accuracy of static imaging is highly dependent on the experience of the referring pathologist in field selection [Eusebi, 1997, p. 16].

Referring to a trial with a non-robotic telepathology system in Vermont, USA, inappropriate field selection for example was a problem. Invasive areas of samples were missed because affected area of the tumor were simply not shown by the referring pathologist, who had not noticed them [Callas, 1996, p. 327]. That is why the AFIP (chapter 9.4.1) recommends for systems without robotic features that the referring pathologist has to be competent enough to choose representative areas of a specimen for adequate diagnosis. Images should be provided in a manner similar to the standard examination of a microscope slide. First a low-power view to provide a general overview and then progressively higher powers [Berman, 1997, p. 31].

Summary

Several researchers suggest that high bandwidth combined with real-time transmission of images and remote control over the sender's microscope system is the solution. Other believe that electronics will never replace the present way of practicing pathology. Most experts studying these issues believe that the solution lies somewhere between these extremes and that the specific situation of the user is very important, when making a decision [Mullick, 1996, p. 192]. At a study in Sweden, 67 % of the users of a static system would have preferred a dynamic imaging system; 18 % a hybrid system and 0 % would have chosen a static system. Paradoxically even a static system was identified as too expensive by the same users [Olsson, 1995, p. 240]. These results reflect that most pathologists want to keep control over the pathological image selection process, but as soon as costs are discussed, they refuse to invest in systems at present.

That is why Weinstein recommends that first of all, decision makers may choose to buy the static imaging modules of full-feature telepathology systems separately as stand-alone, entry level systems. This would give the advantage that the system is affordable at a reasonable price and that it could be incorporated into dynamic systems, when dynamic features seem to be more appropriate or the user is ready to step up to the next level of commitment to the technology. The selection of static imaging systems that are upgradable into full feature static-dynamic telepathology systems, and that are compatible with dynamic system specifications, might be considered as an approach to introducing telepathology into one's practice [Weinstein, 1991, p. 513]. However, unfortunately many dynamic systems do not incorporate separate static modules. Yet, this may change with user requests for such systems.

Regarding the characteristics of the different system types and the services being used, it is obvious that consultations between well-qualified pathologists do not necessarily require access to robotic microscopy. If a pathologist selects the images, or if malign tumors are clearly to recognize (specimen type), static systems seem to be appropriate. Static systems may also be sufficient for quality assurance or for diagnosis validation settings such as to send images for quantitative evaluation of the morphological and cytological features of tissue samples to laboratories [O'Brien, 1998, p. 155; Della Mea, 1996, p. 26; Eide, 1994, p. 886]. They are obviously appropriate for educational purposes and discussions between experts. To summarize, one can say that still images are adequate when the client is experienced in image selection, and for diagnostic problems which do not require the transmis-

sion of many images. For example, to give a pre-diagnosis in ophthalmology or dermatology (see chapter 4.2.3) often it is already sufficient when a static image of the eye or skin deformity is available. It is further atvantageous if static images are available for documentation of the case after the tumor has been replaced [Schaller, 2000; Kok, 2000]. Static systems are already broadly used, especially for expert consultation, for example in Belgium, Croatia, France, Hungary, Portugal, Sweden, and Germany [Kayser, 1996, p. 476].

However, dynamic system usage increases, too. Employing dynamic systems, expensive staff resources can be optimized and locally under-served regions can be supported. The final decision is always dependent on the specific user's expectations and needs.

8 Procedures in Telepathology

8.1 Procedures in Telepathology

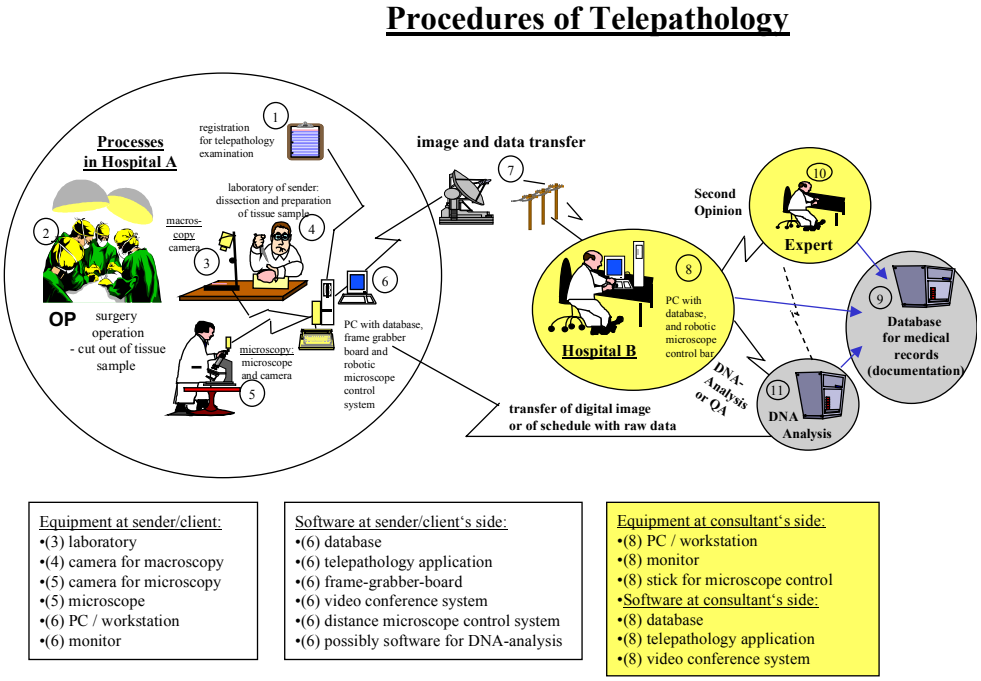
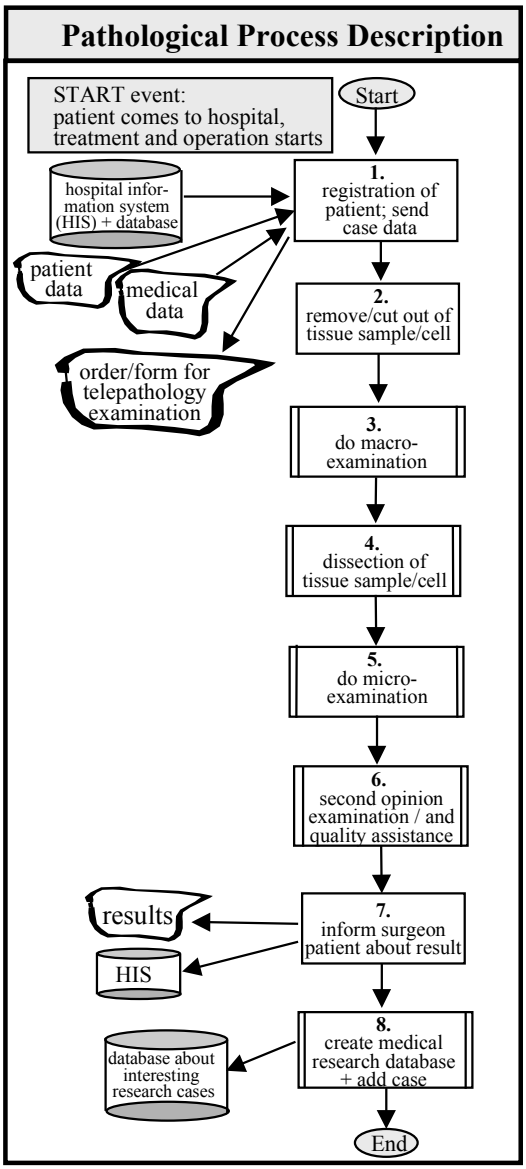


Figure 6: Telepathology Consultation Procedures.

The illustration above demonstrates the procedures of telepathology. The order of activities is represented by the numbers in the circle. On the left side the activities done by the client can seen. The patient is recorded for telepathology examination (1). The data of the patient are sent to the telepathologist over the network (7). The surgeon removes a tissue sample or takes samples of cells (2). Then the specimen usually is brought to the pathologist to be examined. With dynamic telepathology macro-examination is executed under control of the telepathologist (3). Therefore images of the specimen are captured with a video camera and sent to the telepathologist (7). The telepathologist tells the client by a light-marker where to cut the sample. After that a laboratory technician prepares the removed tissue sample for microscopy according to standard procedures (4). As soon as the glass slide is under the microscope, the micro-examination can be started (5). The specimen is scanned first by low microscopical magnification to get an overview. Then suspected areas are scanned with higher magnifycations. With robotic telepathology systems, this is done by the telepathologists (8) using robotic microscope control tools. At static systems the client has to select images of conspicuous sample areas. For capturing the glass slide images, a video camera with a frame-grabber board is centered on the microscope. Microscopical images are observed and are digitally captured simply by using the computer's mouse (6). At the dynamic examination process, the pathologist is able to discuss the case with the client on the monitor. At static examinations, images are captured and sent on block to the telepathologist. The pathologist examines the specimen images and makes his diagnosis, or defers the case. He informs the surgeon about his result. If the expert is not sure, he can consult another expert (10), or he can execute quality assurance features for the quantification of morphological variations or DNA-analyses (11). For security reasons, most specimens executed by telepathology are later

transported to the pathologist, who examines the specimen a second time directly at his light microscope. Each case is documented in an electronical medical record (9).

The following data flow diagrams will explain the procedures more detailed[39]. At the heading of each data flow diagram, one find the name of the process, which will be described in the diagram. Each procedure is caused by an event, which is given in the start field, directly under the process header. In the rectangles, the processes are explained in short words. If a rectangle has a double line frame, this process is extracted in further, finer activities, which will be described in a separate data flow diagram. For orientation, in the header of each diagram one finds the name and number of the process which will be explained. A similar process as the following is described for the robotic dynamic telepathology system in Norway by Elford [Elford, 1997, p. 6].



START: A patient is committed to the rural hospital of his region. Personal and medical data of this patient are recorded in the hospital information system or in a printed file. Former records are fetched from the archives. Then the preliminary examination tests are done, and the entrance diagnosis is taken. The surgeon discovered a tumor. However, because there is no pathologist employed at the small hospital, an external telepathologist is contacted.

1. The administration records patient and case data and sends them to the telepathologist. The telepathologist checks the transferred data and prepares himself for the later examination (especially if he is requested to do immediate intraoperative frozen section examinations).

2. The operation starts. The patient is under anesthetization. The surgeon removes the tumor and passes it for the macro-/ and micro-examination (alternative in cytology, cell samples are taken).

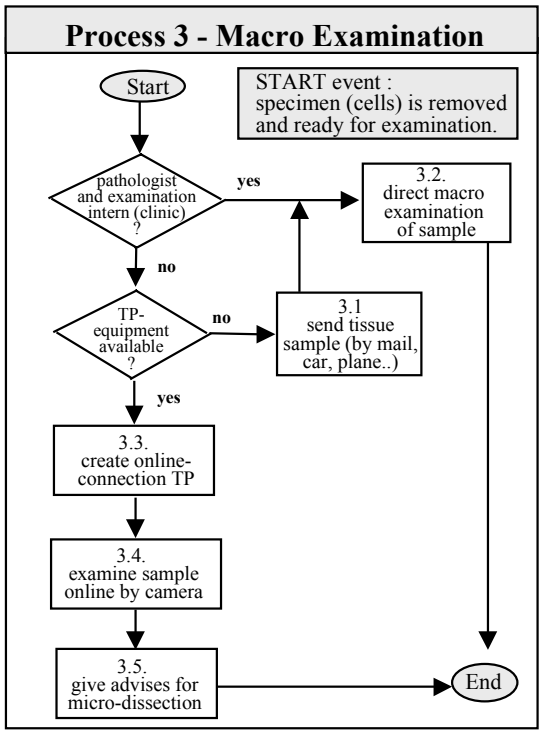
The processes 3-6, and 8 are described in a more detailed data flow diagram.
3. Macro-examination
4. Dissection of tissue sample
5. Micro-examination
6. Second opinion examination and quality assistance
8. Creation of medical research database

[39] A further description of the telepathology process is given by Weinstein, 1987, pp. 648-649, Schmid, 1996/(2), p. 930, and Schwarzmann, 1996, p. 18.

7. The pathologist has finished his examination. The result is documented in an electronical medical record and sent to the rural hospital. In the case of **intraoperative frozen sections**, an immediate result is given to the surgeon by telephone. This practice has the advantage that the surgeon knows how to continue his operation (patient is still under anesthetization), and that the patient can be informed about his diagnostic result and about further therapy activities as soon as he awakes from anesthetization. As a continuation of telepathology, the specimen is transported to the central hospital for a second 'security' examination under the light microscope. A detailed final report is mailed to the client. The case is stored in the telepathology database or even better, added to the medical record at the central hospital information database (HIS).

Process 3 - Macro Examination

Process 3.1 and 3.2 describe the common processes of macro examination. Process 3.1: There is no pathologist available, and no telepathology equipment at hand at the rural clinic. Therefore the tissue sample of the tumor is transported to the expert pathologist in the common way (road / rails / airway). Disadvantage: long transportation time.
Process 3.2: The rural hospital has its own pathologist to whom the tumor sample is brought. The pathologist directly checks the specimen and decides where to take the specimen sample from for the glass slides. In both cases a skilled pathologist is doing the examination directly.



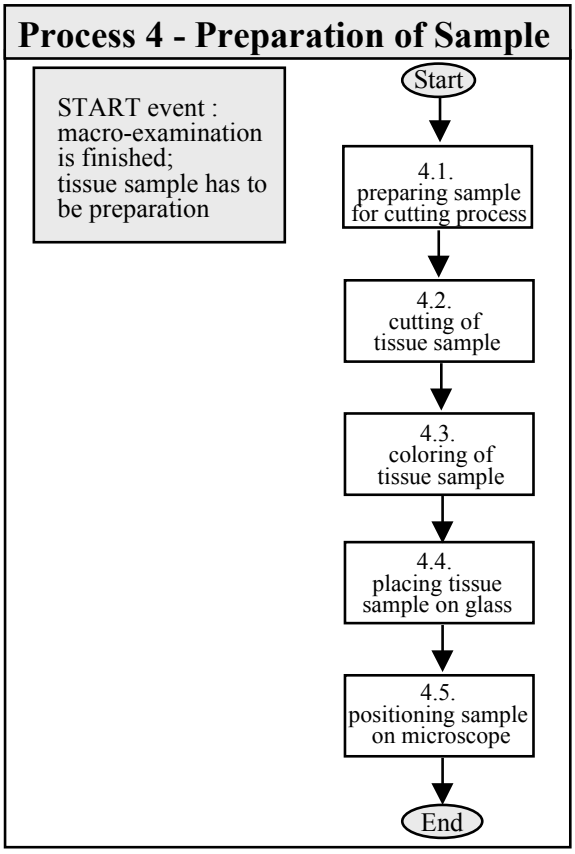
3.3. Dynamic Telepathology: The telepathologist is informed by telephone that the macro-examination will start. An online-connection is built up between image sender (client) and receiver (expert).

3.4. The specimen from the organ is put under a macro camera. The surgeon/client describes the consistency of the specimen and reports unusual appearances (discussion via videoconference system). The client regulates the macro-camera for a clear image on the monitor. The expert views the sample on the monitor.

3.5. The pathologist then instructs the surgeon with a light marker where to make a slice for the specimen (= where and how to cut the sample).
At static telepathology, the client has to do the macro-examination without the visual guidance by the telepathologist.

Process 4: Preparation of Sample

The laboratory technician prepares the removed tissue for microscopy according to standard procedures.



4.1. The sample will be frozen, which makes it possible to cut extremely thin sample slides.

4.2. The sample is cut at the place, where the tumor cells are located -referring to the expert is recommendatial (3.5.). At cytology, cell samples are taken.

4.3.The sample slide/cells are stained mostly by using the haemotoxylin and eosin stain. Normal pathological samples are almost both, colorless and transparent, when they are firstly obtained from disease tissue. If left as is, the sample cannot be diagnosed since its cell structure cannot be seen. This means that prepared samples must be created by using special dyes to produce color.

4.4. The prepared slides are placed on a glass slide.

4.5. The glass slide is positioned under the (robotic) microscope in a special holder.

Process 5: Micro Examination

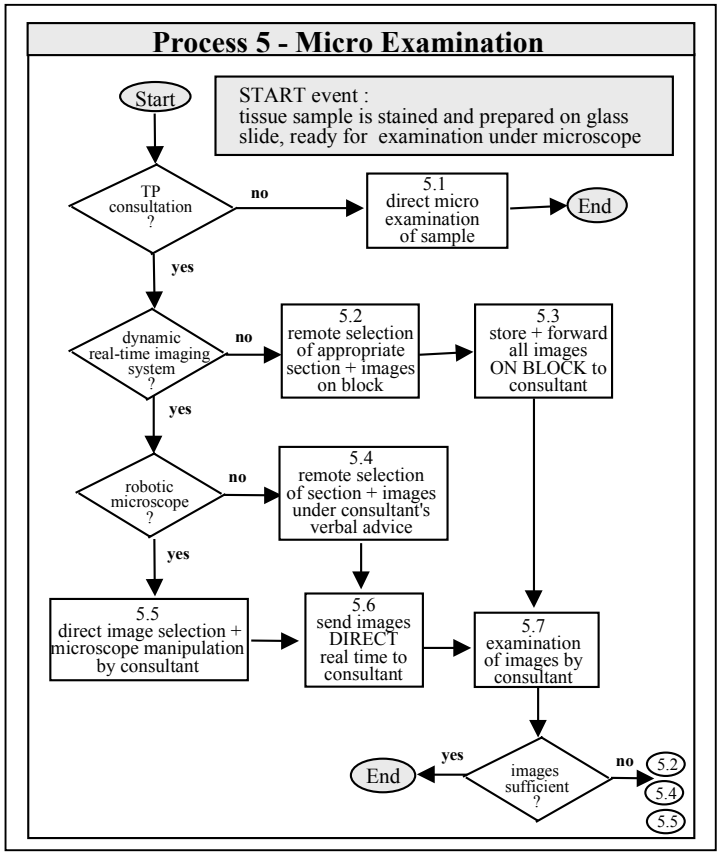
5.1 Conventional method: As continuation of process 3.2., the micro examination is done **directly** on the light microscope at the local place of the expert.

5.2 Static telepathology: The examination is done off-line with a **store and forward system**. For this, the client selects images from the sample (field selection) at different magnifications. Images are captured and stored.

5.3. Static telepathology: The selected micro-images (all at once) are transferred to the expert's computer for examination (process 5.7). The consultant does not have to be available (asynchronous data transmission - comparable to e-mail). If images are not sufficient, the expert will call the client and request additional images until he is able to make his final diagnosis.

5.4. A **dynamic (real-time) system** is used: However the microscope is not robotic. Therefore the expert has to rely on the help of the client in manipulating the microscope, in changing objectives and in keeping the orientation of the tissue sample sections. Nevertheless he is able to follow and to direct the image selection process in real-time.

5.5 Use of a **dynamic system** combined with a **robotic microscope:** With such a system, the expert is almost able to manipulate the microscope at the remote side like a light microscope at his place. He can change x- and y-coordinates, objectives, and focus the image.



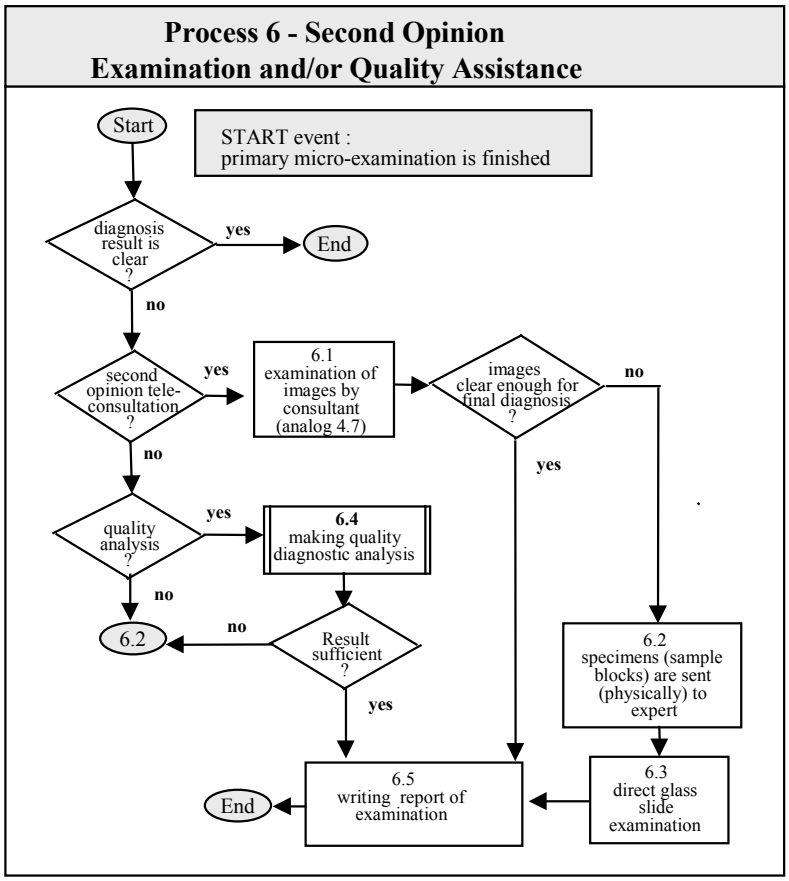
Description of the dynamic process between 5.5. and 5.7.: In general, first the pathologist looks at the specimen and then takes a snapshot of the whole specimen, which is mostly placed in a corner of the monitor as a sample orientation map. Both, the pathologist and the surgeon are able to point at the video image with each other's cursor. The cursors are shown at both places simultaneously. The pathologist then scans the specimen by using of the robotic microscope with a small magnification. Then he regards suspect areas of the specimen with higher magnification. The remote microscope is controlled with a special cursor (e.g. a super-mouse or a big button), with which movements, speed, illumination, lens changes (magnification) and optical zoom are controlled. While moving and scanning the specimen stage, a mark in the 'map' at the corner of the monitor shows the actual position. Often the pathologist may mark suspected position while he is scanning the specimen. The location of the marks is shown on the 'map' and he may go back to this position by pointing and clicking the mouse on the marks. Images from interesting areas are saved on the computer's hard disk and are mostly shown as small images at the monitor.

5.6 Each image of process 5.4 and 5.5 is sent directly to the expert (real-time). The expert is able to examine each image in real-time (process 5.7) and to control the process of image selection and objective changes until he has all images available for an accurate diagnosis.

Process 6: Request for Second Opinion Examination

If the telepathologist is able to make a clear diagnosis, he reports the result to the client e.g. surgeon (6.5). Yet, if the telepathologist is not sure, he is able to quickly request an expert for his/her second opinion:

Since images are already electronically available (captured for the primary tele-examination), they can directly be forwarded to the expert. If this is not the case (because the tele-equipment is only used for second opinion discussions, but primary diagnostic is executed by the common direct method), images have to be captured first, before they can be transferred to the expert.



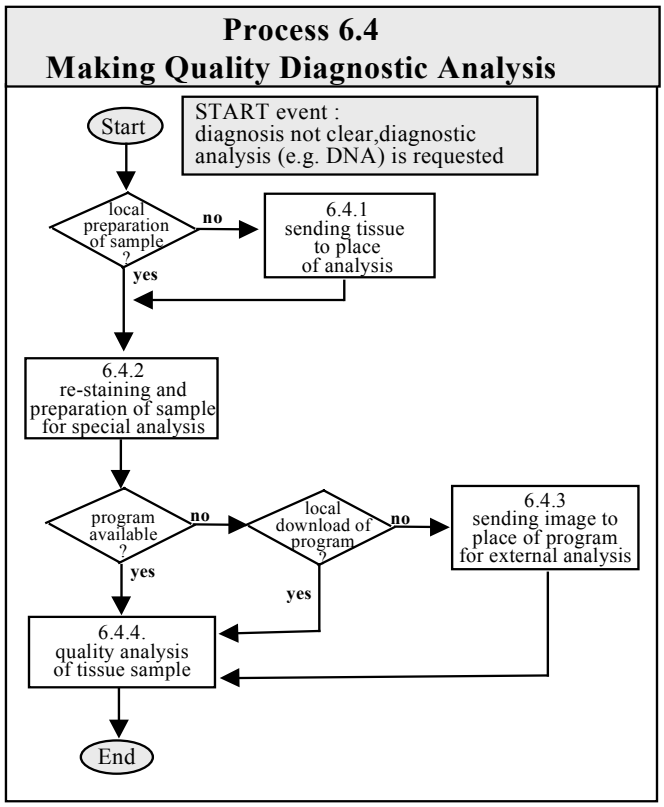
6.1 The expert is examining the images on the screen. If he comes to a diagnostic result, he is reporting it to the requesting client (6.5). Yet, if the expert is not able to come to a conclusion, he may first ask the client for sending additional images.

6.2 If the tele-images are not sufficient to render a final diagnosis, the expert will ask for the physical sample. The sample is transported physically to the expert.

6.3 The expert is preparing and examining the specimen directly at his location.

6.5 The final diagnosis is rendered. The examination is documented and a report mailed to the client.

Process 6.4: Quality Diagnostic Analysis



To improve diagnostic certainty, pathologists often employ quantitative measuring tools for DNA-analyses or immunohistochemisty procedures. If such examinations are not executed locally, the physical sample has to be sent to a place, where quantitative measuring tools are available (6.4.1).

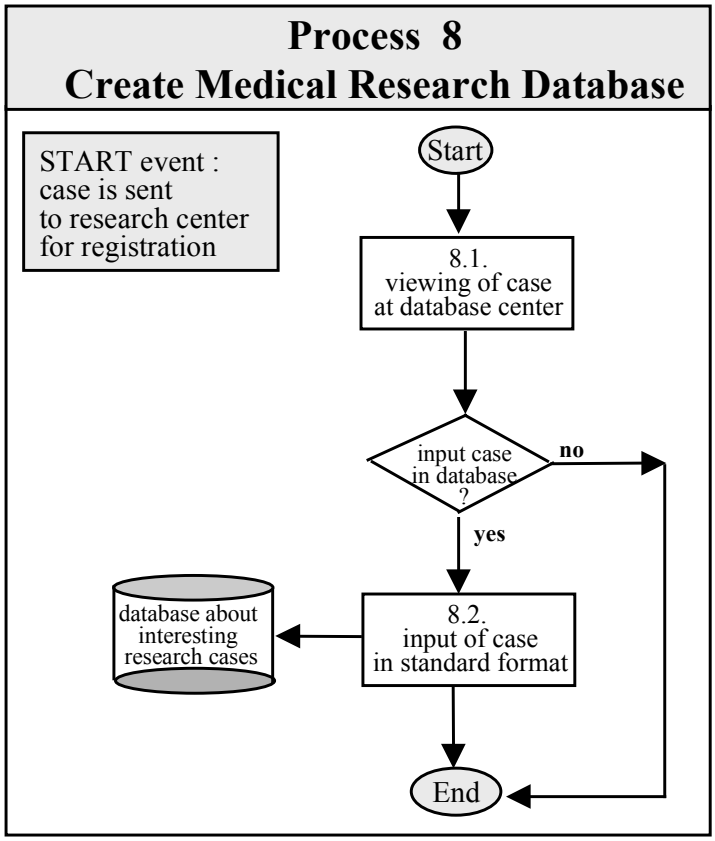
6.4.2 For most qualitative measurement procedures, the specimen has to be specially prepared and re-stained.

6.4.3 If the analysis program is not available at the client's place, it can either be downloaded from a central location or images are sent for analysis to the specialized center.

6.4.4 Images are analyses by a special analysis program.

6.5 The results are documented and reported to the requesting client.

Process 8: Create Medical Research Database



Cases are sent to a central location, which is responsible for managing a research database.

8.1 The administrator of the research database views all arriving cases. He checks them by criteria like reliability or completeness.

8.2 The administrator decides to register the case or not. The selection is executed by specific criteria dependent on the objectives of the database, e.g. only rare and interesting cases should be stored, or only cases of a certain disease. Then he/she brings the case in a standardized format (if necessary – see chapter standardization) and creates a new file in his database.
In this way cases are available for research investigations and educational purposes.

8.2 Example of a Telepathology Interface

The most important features of a telepathology system are demonstrated in the following picture (examples are taken from the SAMEBAS system of Basel/CH).

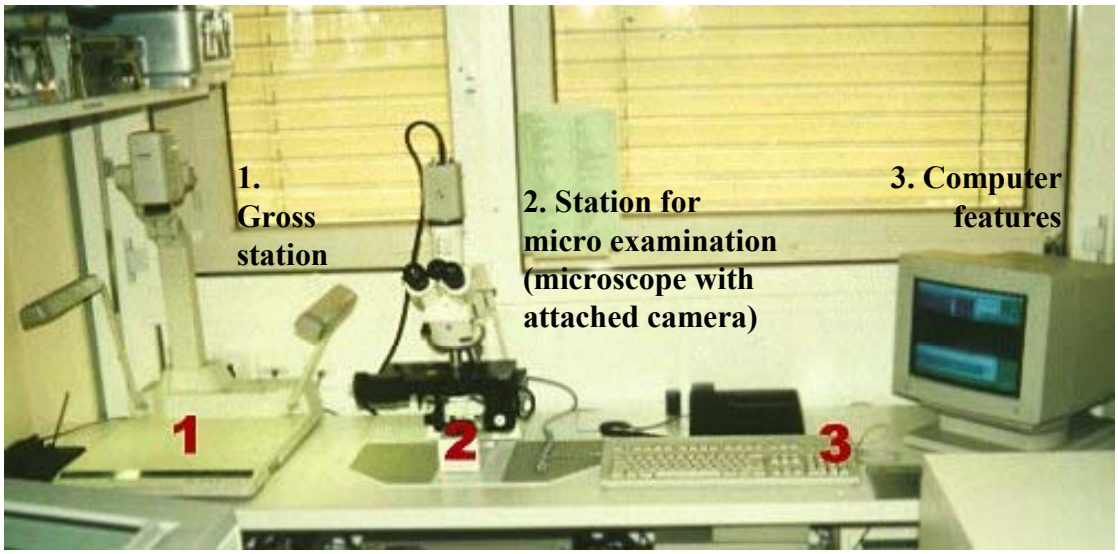


Figure 7: Infrastructure of a telepathology system.

8.2.1 Forms for Order Entry and Documentation

Most telepathology systems use an order entry form, which is used to collect all necessary data of a case. The data in the form are stored in a database.

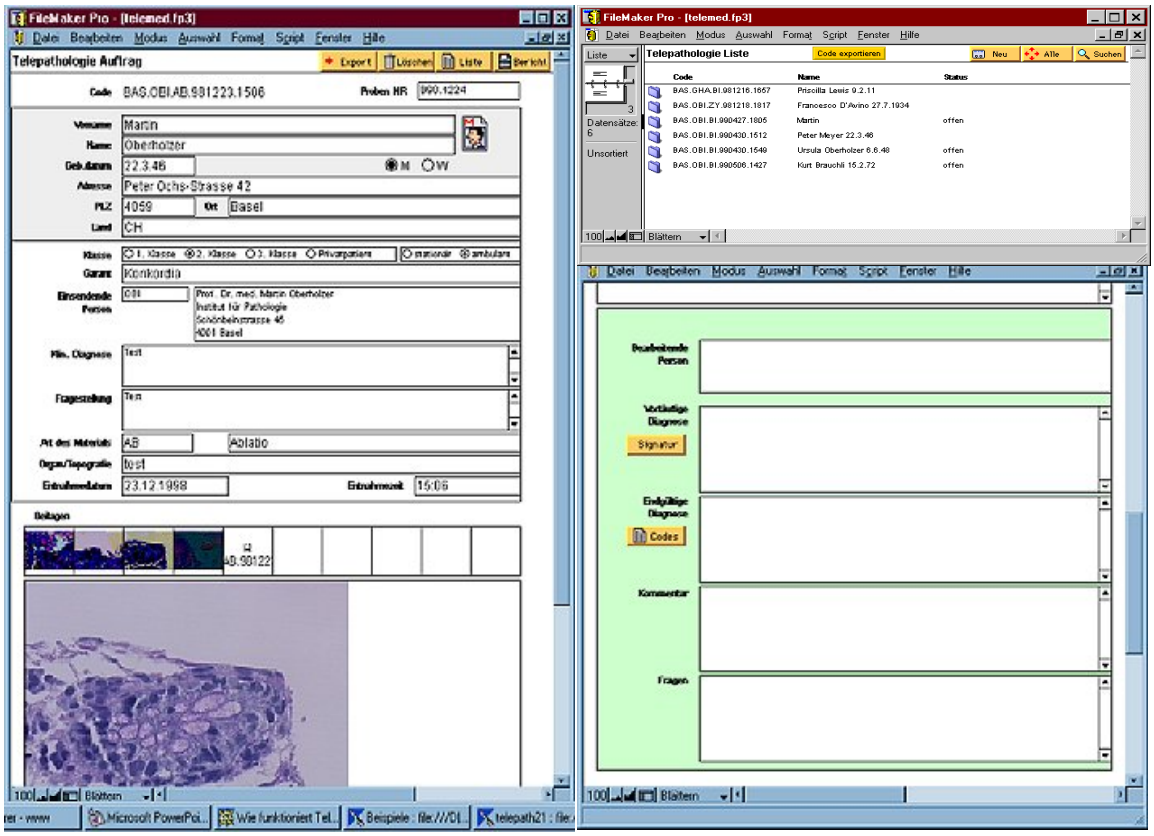


Figure 8: Entry form, list of cases and documentation form of a telepathology system.

The entry form in the given example contains data of the patient (name, address, birth date, insurance information), the name of the treating physician at the clients side, as well as medical data (history, information referring to the diagnosis).

The image on the left side gives a list of cases, which are currently in the diagnostic pro??cess. At the end of each examination process a report is generated and mailed to the client. The data of this report are also stored in the database and can be retrieved if needed. It contains the name of the expert, a field for the ad-hoc diagnosis and the final diagnosis, as well as comments and a field for open questions.

8.2.2 Features for Image Manipulation

Each system offers features to manipulate images. Some use a supermouse to move the cursor in an image, others use buttons on the screen.

Figure 9: Manipulation features of a telepathology system.

9 Introduction of Telepathology Projects

In the following, several telepathology projects are introduced. Since telepathology is a highly IT-orientated field, the new developments are fast. That is that some given information may already be out of date, although it had just been published (e.g. change from Pentium I to Pentium II computers, or from Windows 9x to Windows NT, etc.). Nevertheless the following descriptions contain valuable information about the kind of systems used, the objectives of introduction, political settings, and other interesting aspects.

9.1 Projects Using Static Systems

9.1.1 Projects in the USA

9.1.1.1 Telepathology in Boston

[Source: Balis, 1997, pp. 245-261; Kayser, 1999, p. 153; Weinberg, 1996/(1), pp. 831 ff.; Weinberg, 1996/(2), pp. 111 ff.; Weinberg, 1997, pp. 229 ff.; http://path.mgh.harvard.edu/; contact: dweinberg@partners.org]

Participants of the Project in Boston:

Expert: Massachusetts General Hospital (MGH), Harvard Medical School; Brigham and Women's Hospital, Boston

Client: Wake Forest University, Bowman Gray School of Medicine

The Massachusetts General Hospital (MGH), Harvard Medical School, became well known in telepathology. Already in 1968 the very first telepathology trials took place at the MGH with the Logan Airport [O'Brien, 1998; Weinstein, 1991, p. 511]. Currently the MGH is executing telepathology with the Bowman Gray School of Medicine of the Wake Forest University, 60 miles apart from Boston. In addition the MGH and the Brigham and Women's Hospital, both located in Boston, take part at the telemedicine program of Partners HealthCare. This telemedicine program aims to build up an Internet-based telemedicine service, which will also include telepathology. Medical director of Partners HealthCare is Dr. David S. Weinberg, one of the pioneers in telemedicine.

9.1.1.2 Telepathology in Connecticut, USA

[Swett, 1995, pp. 594-602].

Participants

Expert: Yale-New Haven Hospital, Connecticut, USA

Client: West Haven Veterans Administration Hospital, Connecticut, USA
King Faisal Hospital in Riyadh, Saudi Arabia

Background

The Yale-New Haven Hospital, Telemedicine Center[40], Connecticut, is an institution in the USA, which is strongly involved in several telemedicine approaches. For several years the Department of Pathology of the Yale Hospital and the West Haven Veterans Administration Hospital enjoy an operational telepathology link by using a static system. The Yale Telemedicine Center has telepathology equipment, which can send, receive, and store histological images. Plans are underway to enlarge the service firstly to a state-wide, and secondly to an international network. There also exists a dedicated connection to Saudi Arabia, which enables physicians in Riyadh, at the King Faisal Hospital, to send pathology slides to Yale for consultation in less than five minutes. In parallel to telemedicine consultation services, there are running several educational programs.

Services

The Yale-New Haven Hospital offers consultation services by using a static telepathology system. Services will be expanded internationally. In addition, several educational programs can be accessed.

Equipment

For the improvement of telepathology, the Yale Department of Pathology is cooperating closely with the Roche Medical Imaging Group to develop a full-featured telepathology workstation that will enable very thigh-quality pathology image archiving, remote consultation, and remote reporting. It is also an aim that image data are smoothly integrated into the medical record of a patient.

9.1.1.3 Telepathology in New York, USA

[Eusebi, 1997, pp. 13-16; Kayser, 1999, p. 157; http://hed.info.apple.com/cornell.html].

Participants

Expert: Memorial Sloan-Kettering Cancer Center in New York, Department of Pathology

Client: University of Bologna

Background

The ‘Pathmaker’ still image system was installed in June 1995. It is used as part of the ‘Cornell Doctors TelePathology Network’. Initiator of the project is Dr. Steven Erde. Pathmaker is mainly used for test purposes between the participating hospitals. In the period from June 1995 to May 1996 thirty-six cases were examined. The cases were selected from different tissues, like stomach, bone, pharynx, soft tissue, liver, bladder, etc. [Eusebi, 1997, p. 14].

Telepathology Services

The system is mainly used for educational purposes and for weekly telepathology conferences. Diagnostic consultations are still executed on a test basis, but are ought to be used in the everyday practice, soon.

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40 The Yale Telemedicine Center is available on the Internet at http://info.med.yale.edu/telmed

Equipment

The workstations at both ends are Macintosh computers. At the Bologna end, a Zeiss Axioskop microscope (Jena, Germany) is used together with a JVC KY-30 FIT camera (Victor Co., Tokyo, Japan). Images are acquired using a Rasterops video capture board (Apple Computer, Cupertino, CA). The referring pathologist selects specimen fields of interest by a mouse click. Typically images are captured at a resolution of 640 x 480 pixels x 24 bits [Eusebi, 1997, p. 14]. Based on the use of the Internet, a video conference communications protocol called 'CUSeeMe' is utilized. The program package 'WorkGroup 95' is used as a communication server.

The used software Pathmaker[41] is an still image acquisition software package, created at Cornell University Medical College in New York City. It was specifically designed to meet the needs of practicing pathologists. It creates an 'electronic case', which contains a brief clinical history, multiple annotated digital images of a patient's specimens, and a short individual legend.

Currently an additional real time system, based on broadband networks (ATM) is in development. This system will be created on the communication protocol 'Apple's Movie Talk' [Kayser, 1999, p. 157].

9.1.1.4 Telepathology in Cambridge, USA

[Almagro, 1996; pp. 470-473; Goldberg, 1994, pp. 1495-1500].

Participants

Expert: Cambridge, MA, USA

Client: United Arab Emirates (Abu Dhabi) and the Kingdom of Saudi Arabia (Riyadh)

Background

Telepathology and teleradiology are practiced between the United Arab Emirates (Abu Dhabi), the Kingdom of Saudi Arabia (Riyadh) and consultants at Cambridge, MA. The objective of this telemedicine approach is to investigate, whether telemedicine can be used anywhere in the world in a affordable and practical way. That is why dial-up telephone lines are used, in combination with multiplexing technology and image compression for the international transmission of both, video and high-resolution digital images.

Pathological Services

The telemedicine equipment is mainly employed for teleradiology consultation purposes. Currently, the telepathology system is only used for pathologists' communication and education. It is planned that telepathology is expanded by obligatory consultation services.

Equipment

For the telepathology system a high-resolution charge-coupled device camera is used, mounted on a conventional microscope. All radiological and pathological images are transmitted successfully by using multiplex technology, connected by four modems to the leased dial-up telephone lines. For the transmission of the telepathology high-resolution

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41 http://telepath.med.cornell.edu/pathmaker.html.

color images (1024 x 1024 x 24 bits) JPEG algorithm at compression ratios from 7:1 to 15:1 are employed. For the image display on the monitor 'Adobe Photoshop' software (Adobe Systems, Danta Clara, CA) is used. Videoconferencing equipment is supplied by Picture Tel (System 4000, Danvers, MA).

9.1.1.5 Telepathology in Georgia

[Source: Weinberg, 1996, pp. 99-101; Prasse, 1995, pp. 259-266].

Participants

Expert: Telemedicine Laboratory at the Georgia Institute of Technology (GIT)

Client: University of Georgia, Dep. of Pathology, Athens, GA, 30602-7317, USA (UGA)

Background

Since 1991 the University Medical College of Georgia (contact person: Jay Sanders) is using a general telemedicine system, which includes the possibility of transmitting microscopic images for telepathology's purposes, too. The project is state funded. By 1995 it included 59 sites state-wide. Each site uses telecommunications equipment that can transmit live images of the patient and other clinical data, like for example heart sounds from an electronic stethoscope. A system for attaching a video camera to any viewing device enables the transmission of images obtained from a variety of sources, including microscopes for the transmission of pathological images.

In pathology desktop interactive audio-visual video conferencing technology was tested for static telepathology between the Georgia Institute of Technology and the University of Georgia. Two-way audio conversation allowed the interpreter to instruct the transmitting pathologist to change microscope objectives, to return to a particular field, or to display additional microscopic fields. The objective of the trial in Georgia was, to investigate if the quality of microscopic images transmitted by such technology is adequate for pathological diagnostic. Cytological, hematological, and histological specimens were tested. Unfortunately, the low cost desktop system was not judged as satisfying for definitive diagnoses, but nevertheless useful for general illustration [Prasse, 1995, p. 264].

Pathological Services

Diagnostic consultations were executed in cytology, and hematology. Also histological specimens were tested [more details about specimen characteristics see Prasse, 1995, pp. 261-262].

Equipment

Low-resolution video cameras and speakers were installed. Further, the system at the UGA is equipped with a single-chip color video camera, Hitachi Model VK-C150 (Technical Industries, Atlanta, GA), mounted on a trinocular Model BH-2 Olympus microscope (Lake Success, NY). The video microscopic output from the camera (NTSC) is directly routed into the auxiliary video input port of the VTEL system [Prasse, 1995, p. 260].

The communication bandwidth varies from 56 kbps to 384 kbps. The system at GIT is equipped with an ASCEND Multiband Plus inverse multiplexer (I-MUX) to multiplex six Switched-56 lines for providing a total available bandwidth of 336 kbps.

The telepathology system uses the VTEL Model 115 desktop video conferencing system from the VTEL Corporation, Austin, TX. It consists of AT-compatible computers, SVGA monitors, and compression/decompression (CODEC) boards using the H.261 algorithm. The interfaces are based on Windows. Image resolution is 640 x 480 x 8 bits (256 colors). Users would have preferred a higher color resolution, but the VTEL software could not handle more than 256 colors properly [Prasse, 1995, p. 261]. Unfortunately, low bandwidth and poor color resolution finally led to problems in diagnostics accuracy at the study in Georgia.

9.1.1.6 Telepathology in Honolulu - AKAMAI

[Source: Weinberg, 1996, p. 834].

Participants

Expert: Tripler Army Medical Hospital in Honolulu**,** HI

Client: Sites in the Pacific and in Korea

The AKAMAI project is funded by the Department of Defense. It links the Telemedicine Clinic at the Tripler Army Medical Hospital in Honolulu, HI, (contact person: Pedro Ramon) with sites in the Pacific and Korea. The used teleconference equipment offers telemedicine services in 20 specialties, including static telepathology.

9.1.1.7 Telepathology in Pittsburgh (RLA/UPMC), USA

[Source: Kayser, 1999, pp. 154-157; http://path.upmc.edu/index.html; http://tpis.upmc.edu/tpis/esential.html].

Participants

Expert: University of Pittsburgh, Department of Pathology

Client: Four hospitals took part at test trials: the Medical Center University, the Allegheny General Hospital, and the Timken-Mercy Hospital, all located in Pittsburgh. The Department of Veterans Affairs Medical Center in Milwaukee, Wisconsin, is the 4th participant.
In the future it is planned to add 35 pathological laboratories of municipal hospitals to the Pittsburgh Reference Laboratory Alliance.

Background

The University of Pittsburgh, Medical Center, is strongly involved in the process of setting up a Reference Laboratory Alliance (RLA). Based on telepathology technology, a transaction system and an image system are utilized. A prototype network capable of integrated data and image exchange is tested with four hospitals [Kayser, 1999, p. 155].

Further Transplant Pathology Internet Services (TPIS) are introduced at the University of Pittsburgh. Registered users get access to discussions about interesting cases via Internet. The system is accessible by Apple as well as by Intel PC computers with installed browsers such as Netscape Navigator or Microsoft Internet Explorer [Kayser, 1999, p. 157].

9.1.1.8 Telepathology in Minnesota

[Kayser, 1999, pp. 156; http://www.mayo.edu/].

Participants

Expert: Mayo Clinic in Rochester, Minnesota

Client: Rochester Methodist Hospital and Saint Mary's Hospital

Background

The Mayo Clinic in Rochester developed its own static telepathology system. Tests are executed with two local hospitals, both located within the boundaries of the same city.

9.1.1.9 Telepathology in San Francisco

[Kayser, 1999, pp. 156; http://pangloss.ucsf.edu/AP/docs/telepathology.html].

Participants

Expert: California University, Medical Faculty, Institute of Anatomic Pathology, San Francisco

Client: National and international partners

Background

The laboratory of surgical pathology at the University of California offers static-image telepathology services. For this the 'Roche System' is used. All cases are stored in a reference case database.

9.1.2 Telepathology in Japan

9.1.2.1 Telepathology in Yonago/Tottori, Japan

[Adachi, 1996, pp. 436-441; Ito, 1994, pp. 801-805].

Participants

Expert: Department of Pathology, Faculty of Medicine, Tottori University, Yonago/Tottori

Client: Matsue City Hospital, Kure, 30 km distance, and the Department of Surgery, Hiroshima University School of Medicine, Hiroshima, Japan

Background

In the Japanese San-In District (Tottori and Shimane Prefectures) the population is rather sparse. There only exist 55 hospitals equipped with more than 200 beds. Of these, 51 hospitals are not capable of performing surgical pathology, since there is no expert pathologist at the place. Therefore, if frozen-section services are necessary, a patient is either referred to the two university hospitals of the region, or to the four local hospitals with an employed pathologist [Adachi, 1996, p. 436].

The Tottori University's objective is to provide intraoperative frozen-section services to improve the standard of medical care for local hospitals without pathologists. First tests

were executed in 1993 with the Matsue City Hospital. At this hospital only twice a week an authorized pathologist is available. That is why the MCH agreed in using still-imaging telepathology. The diagnostic services are utilized during the time when the pathologist is absent. Specimens are embedded in compound and frozen in liquid nitrogen. Tissues then are cut on the cryostat, followed by staining with hematoxylin-eosin. According to the instructions of the pathologist at the Tottori University, microscopic fields are selected and transmitted by the **cyto-technologist**. As soon as the examination is finished by the expert, still-images showing pathogenic changes are transmitted to the monitor in the operating theater and briefly discussed with the surgeon, since experience showed that misdiagnoses are avoidable if cases are discussed with the surgeon [Adachi, 1996, p. 440]. Within two or three days the final diagnosis is verified through direct microscopy.

Pathological Services

At the first tests, biopsy specimens of transplanted kidneys were tele-examined. Later tele-consultations were carried out for remote frozen-section diagnoses and expert consultations in difficult or rare cases of both histopathology and cytology. The system is also used for staff meetings, teaching and education.

Equipment and Communication

The system includes a light microscope with a RGB-three charge coupled device (CCD) video camera (Hitachi, DK-7001). It uses an ISDN-compatible still-image transmission terminal, and a conventional video monitor. The camera has an 0,5 inch interline CCD image sensor with 768 x 480 pixels and 450 lines of horizontal resolution.

Using ISDN, the transfer rate is 64 kbit/s. The image transmission time in 1993 was not very satisfying, since it needed 12 seconds with ISDN, in contrast to 1.4 to 2 minutes by using analogue telephone lines [Ito, 1994, p. 802]. Therefore for high quality picture transmission a higher channel capacity will be employed.

9.1.2.2 Telepathology in Sapporo, Japan

[Fujita, 1995, pp. 105-110; Tsuchihashi, 2000].

Participants

Expert: Hakkaido University School of Medicine, Department of Pathology, Sapporo City, Japan

Client: Shin-Nittetsu Muroran General Hospital, Muroran, Japan, which is a remote hospital, 120 km apart from Sapporo

Background

Approximately 200 specimens are annually brought to the Hokkaido University from outside hospitals for examination. That is why a still imaging system had been employed for executing frozen section examinations on a distance. The system was tested from November 1992 to February 1995. Images were handled by a **cyto-technologist** at the remote site. If no conclusive telepathology diagnosis could be found, the diagnosis was put off till the final diagnosis was executed by paraffin section. Doing so, there were no false diagnostic results reported [Fujita, 1995, pp. 105-106]. Until 1995 approximately 135 routine cases,

mainly lymph nodes, were evaluated [Fujita, 1995, p. 107]. Unfortunately more actual data are not available.

Pathological Services

Telepathology is mainly used to execute primary diagnoses, particularly frozen intraoperative histological diagnoses.

Equipment

A CCD video-camera (Sony) had been attached to a Nicon microscope with objective magnifications of 4x, 10x, 20x and 40x. Still video-images (macroscopic images as well as very low magnification microscopic images) were first stored on a magnetic optical disc and then transmitted in batch mode via ordinary analogue telephone lines. The telepathological communication is executed with the telepathology system 'Pathran 1000'.

9.1.3 Projects in Europe

9.1.3.1 EUROPATH

The project EUROPATH[42] (EUROpean Pathology Assisted by Telematics for Health) started in January 1996. Twenty-five partners of seven European countries are participating in the development and improvement of telepathology applications. The objectives of the Europath's projects can be divided in two major directions.

Firstly the **integration of multimedia telecommunications** between pathologists. This should improve quality assurance, rise diagnostic accuracy, and increase cost efficiency. Another aim is the support of html based software to be compatible with Internet browsers and the development of virtual microscope interfaces to standardize the control of microscopes [Binder, 2000]. For this reason Europath provides interoperable tools and software packages for remote expert consultation, consensus diagnostic through microscope teleconferencing, and remote quantitation of biological markers. For example, Europath offers a software that guides consultation sessions. Another software, the telemicroscopy driving software, supports the remote control of microscopes at a distance. The Internet exchange of any telepathology document generated by these two software tools is supported by an additional specific html communication module. Currently the suppliers Carl ZEISS and LEICA are developing interoperable interfaces to motorized automatic microscopes for the EUROPATH applications.

The second objective setting is the **integration of multimedia European databases**. The main idea is to link databases in such a way that valuable medical research data can be accumulated for evaluation. A lot of biological information available on tissue lesions as it comes from the rapidly increasing number of immunological markers and genetic probes in use could be gathered, analyzed and then used for prognostic and diagnostic purposes. For this the project aims to establish compatibility and inter-operability between the major European manufacturers of microscopes and designers of imaging workstations. Medical protocols and guidelines are developed or adapted. A further achievement of the project is the **design and implementation of transcoding tables** (ADICAP, SNOMED, ICD) for

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42 http://www2.echo.lu/telematics/health/europath.html; see also: Allaert F.; Dusserre L.: "Europath work groups - guidelines for telepathology practice", http://europath.image.fr/EUROPATH/Path_W...th/Path_TelepathPractice/practice1.html

multilingual electronic data and image exchange. Moreover, a common database structure for case reports, reference images and biological markers within the ORACLE database shell is designed and implemented. Many of the European telepathology projects are participating and funded by EUROPATH.

9.1.3.2 Telepathology in Sweden

[Busch, 2000; Busch, 1995, pp. 242-245; Olsson, 1995, pp. 234-41; Cajander, 1996, pp. 482-483; Boeryd, 1995, p. 267].

Participants

Expert: Two Medical Centers: Department of Pathology at the University Hospital of Uppsala and at Sahlgrenska Hospital, Gothenburg. The University Hospital of Linköping served a further permanent node.

Client: 30 pathological laboratories all over Sweden with approximately 200 pathologists. For this 6 systems rotated between these laboratories for a period of at least six weeks.
During the test period international contacts were initiated, too, for example with the AFIP in USA, and with other telepathology users in Scandinavian countries, France, Germany, UK and Greece.

Background

The northern part of Sweden is characterized by long distances, low population density and many small-medium sized hospitals, often without pathological services [Cajander, 1996, p. 482; Boeryd, 1995, p. 267].

Telepathology introduction in Sweden started in 1992. At that time the Swedish Society of Pathology has initiated a project called ‘Telepathology in Sweden’. The project is a joint effort with active participation of the Swedish Telecom, the Swedish Planning and Rationalisation Institute for the Health and Social Services in Stockholm, and the Innovative Vision AB, Linköping. The Innovative Vision AB is a Swedish company, which provides hard- and software for image analysis, image banks and communication. From September 1992 to the end of June 1993 all 30 histopathological and cytological institutions in Sweden were offered six different telepathology stations in rotation to take part at the telepathology trial for at least six weeks [Busch, 1992, p. 429].

200 pathologists got the opportunity to utilize telepathology equipment during the test period for assessing the usefulness of microscopical image teletransmission. Applications were used for demonstration and discussion of microscopic diagnoses, for tele-consultations as well as for quality assurance evaluations. Especially pre and post tests enjoyed big acceptance by the users in Sweden [Olsson,1995, p. 238]. Static DNA-ploidy measurements were also incorporated in the routine practice of telediagnostic [Busch, 1992, p. 430]. Therefore, systems for the quantification of microscopic color images have been added. After the test period parameters like specific user needs, the practical handling of the system, image quality and acceptance, etc. were evaluated. In this way valuable data about the use of telepathology were gained, referring to the specific characteristics and structures of the Swedish health care system [Olsson, 1995, p. 234].

Services should be expanded horizontally and vertically. That is that consultations should be expanded on an international level towards an international network. Vertically, small distant hospitals should get access to frozen section services. Images will be captured and processed in a central database. Data and images are available for scientific and educational purposes [Busch, 1995, p. 244]. On a long term the used static telepathology systems in Sweden should become an integrated features combining picture archiving and communication systems (PACS), as well as emerging administrative systems [Olsson, 1995, p. 235]. A further objective of introducing telepathology on a broad scare in Sweden is the standardization of diagnoses. It is expected that increased standardization will lead to more efficiency of pathological processes.

Pathological Services

Several tele-services are offered within the telepathology network in Sweden. The main services are primary diagnostic for frozen sections and fine-needle aspiration, regular conferences together with invited experts, teaching sessions on selected or requested topics, as well as the consultation of authorities at rare and problematical cases [Cajander, 1996, p. 48]. Boeryd describes the tele-discussion and tele-education activities between Linköping and Motala, a small hospital which is 50 km west of Linköping [Boeryd, 1995, p. 267]. Clinical pathology conferences are held every second week between surgeons, radiologists, oncologists and pathologists.

Equipment

The Swedish telepathology trial was set up to test primarily the consultation and demonstration modes of a static imaging system with a two-headed discussion microscope or alternatively with special mail-box functions [Busch, 1995, pp. 243, 244]. In some cases also distant controlled microscopes were tested [Cajander, 1996, p. 482].

The employed systems include a Hitachi KP-C503 one-chip camera, an one chip CCD color camera Hamamatsu C4200-01 in Gothenburg and Uppsala, and a Sony 3-chip CCD RGB camera in Linköping [Olsson, 1995, p. 236]. Additionally systems include a LabEye 3 x 8 bits RGB color image frame grabber and image compression features (JPEG). The computer performance in 1992 for local pathologists was a 386 SX/20-personal computer with 2 MByte RAM and 80 MByte hard disc, with a VGA-monitor, later a 486 x 25 MHz Intel processor, 12 MB RAM and 40 MB hard disc. At the medical center Digital DEC-System 5000-240, Alpha AXP, UNIX-platform, ICL DRS6000, HP 9000 and IBM RS6000 with minimum 64 MB RAM and 400 MB hard disc were used. Unfortunately more actual data are not available, but it can be assumed that the computers performance are updated to the actual commercially available performance.

The telepathology software is simply to use by a mouse interface and a pop-up menu. Remote laboratories were connected with one of the centrally located medical centers via modem, Ethernet, IDN 64000 or ISDN. Most images of 512 x 512 resolution were transferred with a 2 x 64 Kbit/s ISDN transmission rate. Unfortunately, resolution and transmission was judged as too low by the users. In 1995 first trials for testing the ATM network (34 Mb/s) and a higher resolution for images were utilized [Busch, 1995, p. 244].

Parallel to the telepathology trial the administrative computer system ‘CymPathy’ (Information Logik AB, Malmö, Sweden) was installed at more than a third of all Swedish pathology laboratories for the registration of all pathological events (order sheets, patient data, specimen characteristics, blocks, slides, stainings, special investigation, billing, SNOMED codes etc.). Barcode was introduced to speed up the data input. This adminis-

trative system is directly linked to the telepathology systems to combine and support image grabbing, image storage, report generation (adding typical and representative images to a report), image tele-transmission, image reproduction, etc. in on integrated solution. As PC-platform Ingres Windows 4GL is employed [Busch, 1995, p. 243].

9.1.3.3 Telepathology in Udine, Italy

[Beltrami, 1998, pp. 146-148; Della Mea, 1995, pp. 237-244; Della Mea, 1996, pp. 24-26; Della Mea, 1997/(1), pp. 169-170; Della Mea, 1997/(2), pp. 636-641; Della Mea, 1997/(3), pp. 17-19; Della Mea, 1998/(1), pp. 20-22; Della Mea, 1998/(2), pp. 169-170; Della Mea, 1999; Milosavljevic, 2000; http://www-uniud.it/drmm/anapath/anapatudeng.html; contact: dellamea@dimi.uniud.it; beltrami@uniud.it].

Participants

Expert: Department of Anatomic Pathology at the University of Udine

Client: Institute of Anatomic Pathology at S Chiara Hospital, Trento;
University of Medical Sciences, Department of Pathology, Poznan, Poland;
Military Hospital Nis, Institute of Pathology, Yugoslavia.

Background

In Italy the Internet was recognized as valuable tool for medical purposes. For that reason a static store-and-forward telepathology system was developed. Telepathology techniques are considered as methods to increase cooperation between professionals just by employing off-the shelf components, i.e. e-mail software and commercial acquisition software.

Unfortunately, sending images of difficult or rare cases (histocytological cases, morphometry and cytometry data) for consultation to a specialized pathologist caused limitations and problems. Finally the Italian system was only used for specific diagnostic questions. Legal problems due to the sharing of responsibility on a diagnosis led to further uncertainty. Nevertheless, the system was still described as an useful, easy to use, low cost system, which enables an user to ask for an expert opinion no matter where the specialist is located (e.g. tests between Poland, Yugoslavia, and Udine). Improved solutions for the store-and-forward system are already in investigation. The new version includes the use of very high resolution devices that allow to grab a whole biopsy in a single image, reducing thus the selection bias. This multimedia electronic mail tool will be expanded with medical information management features.

Currently further experiments are executed with a dynamic robotic system from Olympus. This dynamic system is expanded by static features to achieve greater resolution images. Unfortunately, because up to now no standards have been set, only people having the same system can communicate with each other [email from July 99, Della Mea].

Pathological Services

The old store-and-forward system is mainly used for second opinion consultations. The new system from Olympus is used for frozen section examinations with good results.

Equipment

The Multipurpose Internet Mail Extension (MIME, Qualcomm Eudora, v1.5.1) was noticed as an valuable instrument for the transmission of multimedia documents (text, images, sounds) by using the standard e-mail infrastructures of the Internet [Della Mea, 1996, p. 24]. MIME offers additional fields compared to the common e-mail features, which are from advance for static telepathology applications.

The telepathology workstation in Udine is composed of an Apple Macintosh 8500 (Apple, Cupertino, USA), with a NuVista frame-grabber connected to a Sony 3-CCD video camera (Tokyo, Japan), mounted on a Zeiss Axiophot microscope (Zeiss, Oberkochen, Germany). Images are acquired at a resolution of 640 x 480 pixels, 24 bit depth (900 KByte, uncompressed), with the dedicated software of the frame grabber. They are saved in JPEG format at a compression ratio of about 15:1 [Della Mea, 1996, p. 25].

The workstation in Trento comprises a Leitz Quantimet for image acquisition with a 1-CCD camera and a HP700 workstation, which was later replaced by a Lidata P100 (Olidata, Forli, Italy) [Della Mea, 1997, p. 240]. Images are acquired on the Quantimet at 512 x 512 to 768 x 576, at 24 bit color depth (768 KByte, uncompressed). They are transferred to the HP workstation and then mailed.

The Macintosh computer at Udine is directly connected to the Internet through the LAN of the University. The Hospital of Trento is connected via modem to the Internet. Images are acquired by using the standard software Eudora (Qualcomm, USA) and Apple script (PathMail). The workstation in Trento works on Windows 95 and Windows NT.

9.1.3.4 Telepathology Project ADICAP in France

[Hemet, 2000; Diebold, 2000; Allaert, 1995/(1), pp. 200-205; Allaert, 1995/(2), pp. 596-600; Allaert, 1996, pp. 27-30; Weinberg, 1996, p. 835; Vieillefond, 1995, pp. 246-250].

Participants

Expert: Center de Pathologie in Dijon

Client: 32 laboratories in France; two institutes are located at the islands of Martinique and Guadeloupe.

Background

In 1980 ADICAP (Association for the promotion of computer use in Cytology and Anatomic Pathology) was set up in France. The aim of ADICAP was, to develop a software which supports the management of French departments of pathology. Further, to create a thesaurus and codification system (the French ADICAP codification), which is transcoded with ICD and SNOMED codes [Martin, 1995, p. 192].

In 1985, a national digitized image database for diagnosis and teaching purposes was designed. The project was called AIDEAP (Aide Informatique au Diagnostic et à l'Enseignement en Anatomo-Cyto-Pathologie). In 1996, twenty-two working groups of specialized pathologists have selected and stored about 21.000 digitized images [Martin, 1996, p. 461].

For the network in France, the following norms were given to involved information companies:

a) SVGA images transmission (16 M colors - 24 bits);
b) JEPG-TCT/IP/IP-HTML (Hyper Text Markup Language) - HTTP (Hyper Text Transfer Protocol) - Windows 95;
c) various images format: TIFF, Paint, DICOM-3;
d) Netscape or Mosaic browsers and
e) definition of a common clinical file and linkage to an electronic mail server set-up, managed by the Research Information Center of the University of Rouen of Haute Normandie [Martin, 1996, p. 460].

Pathologists get access to this image database or can purchase a CD-ROM, managed by Windows 95. Data can be retrieved for diagnostic and educational purposes by criteria such as the name of an organ, the type of lesion or the ADICAP codes.

9.1.3.5 Telepathology Dijon, France - TRANSPATH

[Flandrin, 2000; Allaert, 1995/(1), pp. 200-205; Allaert, 1995/(2), pp. 596-600; Allaert, 1996, pp. 27-30; contact: gflandrin@compuserve.com].

Participants

1. Expert: Center de Pathologie in Dijon

2. Expert: Brigham and Women's Hospital

Client: First clients: three regional hospitals at Dijon (Dole, Le Creusot Hotel Dieu and Le Creusot Public Hospital)
At the end a national network was created, linking commercial laboratories with academic departments. 32 workstations were connected, including one system at Martinique and at the Guadeloupe Island

In 1987, within the program DARIVS (anatomic pathology diagnosis and visual interactive network for security), the first static-image telepathology network was established in France. It is based on the framework of the European Community Program on Telematics in Healthcare 'PILOT' (Pathology International and Local Telematics). The system is called TRANSPATH [Martin, 1992, p. 420]. The multi-functions of this modular system was set up by a co-operative working group including ADICAP, France Telecom, RESINTEL CY (Réseau International de Télémedecine), and Leica. One of the initiators was Dr. Pierre Dusserre, Dijon. The main reasons for introducing TRANSPATH was that half of the French pathologists (712 out of 1300) work in isolated, small, private laboratories. Therefore many pathologists have to work alone. With the idea of telepathology the wish of second opinion teleconsultations came up and soon the first systems were introduced. Finally difficult or severe diagnoses could have been immediately solved in 85 % of all discussed cases [Martin, 1992, p. 419].

At the beginning six laboratories at the region Dijon were linked over standard telephone lines into a consultation network. This network was expanded into a national network linking commercial laboratories with academic departments. Finally the network connected 32 workstations via ISDN at different sites, including one system at Martinique and at the Guadeloupe Island [Weinstein, 1997/(3), p. 2]. Approximately 200 cases of general surgical pathology and 100 subspecialty cases are shared with this network annually [Weinberg,

1996, p. 835]. Alternatively to TRANSPATH the system VISIOPATH (CERSYM Co.), a system that also exploits the most recent techniques for digital processing of images, or TITN ALCATEL (SAMBA Co.) can be used [Joyez, 1995, p. 304; Martin, 1995, p. 194]. Since 1994, the French network is linked with other telepathology consultants in Europe, and internationally with America, Switzerland, Africa, India and other countries all over the world.

Although the acceptance of TELEPATH increased, Resintel's efforts were discontinued after a time. The reason was that the company was under-capitalized for the scope of the business they were trying to create. When they could not get an additional round of financing, they run out of money [D. Weinberg, e-mail from June 1999].

Another trial in France was described by Flandrin at the Telepathology Congress in Aurich. From January 1997 to April 1999 second opinion consultations were executed between various hematological centers [see Flandrin, 2000].

Pathological Services

The static imaging network is used for remote frozen section services, second opinion consultations, teaching and discussion classes.

Equipment

The 'Transpath' workstation used in France consists of a standard light microscope (Leica, DMRB) equipped with a three-chip CCD/RGB color video camera (Sony DXC M7), linked to Pentium computers with SVGA color TV monitors. The camera is capable of capturing 720 x 600 pixels. It is linked to a digital image capture board (Avis CCIR 601, 702 x 576 pixels, 24 bit color, 4.2.2 standard). Images are digitized and compressed with standard JPEG compression, and transmitted by using ISDN services [Martin, 1995, p. 193; Allaert, 1995/(2), p. 597]. Consultations typically take place with simultaneous discussion of cases by telephone.

Image storage and retrieval is managed by using the image viewing system software TRIBUN (VT Com TRIBUN company, Paris, France) and the computer software 'System 7.1 Quicktime'. The system displays a gallery of all images in reduced size on the monitor. Each image can be selected by using the mouse. Each case contains a data sheet with case number, diagnosis, certainty of diagnosis, and additional comments [Allaert, 1996, p. 29].

Economical Efficiency of Telepathology

The whole systems costs approximately US-$ 62.500. However, since the system is modular, if pathologists use their own microscope, the price drops to US-$ 21.400. If they use a cheaper TV camera, the price decreases to US-$ 17.700, and if they only use a receiver station the price is US-$ 10.700 [Martin, 1995, p. 194].

9.1.3.6 Telepathology at the Canary Islands, Spain

[Source: Ferrer-Roca, 1996, pp. 13-23; Ferrer-Roca, 1995/(1), pp. 1177-1178; Ferrer-Roca, 1995/(2), pp. 151-161; Kayser, 1999, p. 121].

Participants

Expert: University of La Laguna, Institute of Pathology, La Cuesta, Tenerife, Canary Islands, Spain

Client: Different hospitals at the Canary Islands

Cooperation: University of Athens, Department of Cytology, Helenic Anticancer Institute, Athens, Greece for DNA-cytometry analyses.

Background

The telepathology trials at the Canary Islands are heavily driven by Olga Ferrer Roca. She is also a member of the CATAI consortium group (Catedra Anatomia Patologica), which is in the process of investigating the minimum quality image requirements in telepathology.

Pathological Services

The static imaging telepathology system in Tenerife, Canary Islands, is used for primary diagnostic tests, for second opinion consultations, for 'telequantification' of images, and for educational and communication purposes.

Equipment

Images are captured with a three chip CCD camera (Sony). Images of 512 x 512 spatial resolution and of 24 color bits are taken from an Olympus BH microscope at different magnifications. Portable and ergonomic videophones are utilized (VP2000) for data transmission. Images are sent with high resolution and low compression at 9600 bauds.

9.1.3.7 Telepathology in Greece - 'TELE.INFO.MED.LAB'

[Miaoulis, 1995, pp. 275-281; Miaoulis, 1992, pp. 425-428].

Participants

Expert: Metaxas Cancer Institute, Pathology Laboratory, Athens

Client: Technological Center of Laboratory and Diagnostic Medical Informatics in the Technological Education Institute (T.E.I.) of Athens, and the University of Crete

Background

Originally telemedicine in Greece was used as an instrument to support mountainous areas and remote islands with poor health care with telemedical services. The idea of introducing telepathology came up in 1987. The Greek 'TELE.INFO.MED.LAB' project had the objective to accommodate the communication among various laboratory units and to provide

highly specialized telepathology services (consultation, education) within an integrated medical on-line service network [Miaoulis, 1995, pp. 277, 279-280].

The telepathology project in Greece was originally initiated by the Metaxas Pathology Laboratory. As a first step, a comprehensive computer supported information system was designed, which serves the communication with subsystems. To this configuration diagnostic equipment was added. Besides the integration of information systems for the management of patient and laboratory data, the kernel of the pathological diagnostic subsystems are a) the image processing system, b) the diagnostic data management system with its standardized codes (Greek SNOP), c) the morphometric calculation features, and d) the experimental expert system for diagnostic procedures. A unique communication system was set up as the backbone for a standardized smooth data exchange between laboratory and hospital information systems [Miaoulis, 1992, pp. 426-427].

The system is already used between the Metaxas Cancer Institute, the T.E.I., and the University of Crete.

Pathological Services

The medical laboratories applications are capable to provide diagnostic assistance and quality assurance features (DNA analysis, quantitative measurements). It gives access to information databases with information about new laboratory methods, new products, to reference information, and to multiple informative and educational activities in pathology. [Miaoulis, 1995, p. 279].

9.1.3.8 Telepathology in Zagreb, Croatia

[Source: Danilovic, 1995, pp. 282-284; contact: seiwerth@vams.com].

Participants

Expert: University Hospital of Zagreb, Research Department

Client: University Hospital of Osijek, University Hospital of Rijeka, University Hospital of Split

Background

In Croatia there are numerous medium size hospitals with only one pathologist at the place. The elongated geographical shape of Croatia and its many islands make health care support difficult. That is why a static telepathology consultation network is in creation since 1991. This network connects smaller hospitals with a single pathologist to three regional centers (Osijek, Rijeka, Split), and connects these regional centers to the national center in Zagreb. The national center in Zagreb should later be linked with other highly specialized international pathology centers. Due to its price, dynamic telepathology is actually not in discussion. As an extension of consultation services, a tumor bank was established where various tumor tissue samples are collected for research purposes [Danilovic, 1995, p. 283].

Pathological Services

Many different sections are examined, including frozen sections, cytological smears and experimental slides with regular geometrical figures. Images and case data are used to build up a tumor bank for image analysis and educational purposes.

Equipment

The system used in Croatia consists of high resolution color CCD cameras, mounted on standard microscopes from Leitz. Images are grabbed with a spatial resolution of 512 x 512 pixels, with 24 bits color, and compressed using a JPEG compression model. In 1995 the system used 1440 bauds modems and 486 PC computers running under Windows.

9.1.3.9 Telepathology in Sarajevo, Bosnia-Herzegovina

[Source: Nurijy Bilacovic, Institute of Pathology, Medical Faculty, Cekalusa 90, Sarajevo; e-mail: nurijy@mailcity.com].

Participants

Expert:	Institute of Pathology, Medical Faculty, University of Sarajevo, Bosnia-Herzegovina
2nd Expert:	Institute of Pathology, Zagreb (800 km distance); Several specialized medical centers in Europe and world-wide.
Client:	Institute San Raffaele in Milan; Connections to the regional Medical Centers of Tuzla, Mostar, Bihac, Zenica, Travnik and Gorazde are planned.

Background

The first trials in transmitting images took part in September 1996. Within the EC-funded project ‘SHARED’ (proposed by San Raffaele International Biomedical Science Park, Stato Maggiore Della Diffesa, and the European Space Agency), telemedical approaches were executed in radiology, ophthalmology and in pathology. In pathology, store and forward operations, as well as real-time interactions were tested with a hybrid telepathology system.

Pathological Services

The most common field of usage are online discussions and diagnostic examinations between experts who are geographically apart. The system is also used for educational purposes and for the establishment of a national tumor bank. Morphometric and cytometric measurements as well as quality assurance activities will be added.

Equipment

At the beginning, in 1996, ordinary telephone lines were used for image and data transmission. Later images were sent by EUTELSAT. As microscope, the Polywar Reichart Jung microscope with a lateral macro zoom is employed. The 3-CCD Panasonic TV camera takes images with 720 pixels per 600 lines. The monitors in Sarajevo are SVGA color monitors of 17 inch. The video codec is based on the CCITT H.320 standard. The interactive multipoint video conference system ‘DICE’ supports multisite interconnections. It guarantees visual and acoustic contacts, and manages all document and image exchanges

(DICE, developed by Joanneum Research, Graz, Austria[43]). The system is based on Windows NT and uses Pentium Compac computers.

9.1.4 Telepathology in Germany

9.1.4.1 System 'Discus'

[Source: Information folder from: Technisches Büro Hilgers C., Hauptstrasse 82, D-53639 Königswinter, Tel: 0049-2223-22268, e-mail: hilgers@hilgers.com; more information see: www.hilgers.com].

Participants

Several users in Germany:	Dr. Bollmann, Institute for Pathology, Bonn Dr. Mike, University of Mainz Dr. Paulini, Institute of Pathology, Limburg, Dr. Esinger, Institute of Pathology, Darmstadt Dr. Fuezesi, University of Göttingen Dr. Schulz, University of Giessen Dr. Wünsch, University Hospital of Nürnberg Dr. Vazilkadek, Hospital of Hildesheim and others

Background

The telepathology system DISKUS was developed in 1996 by Hilgers GmbH. DISKUS is a static imaging system with reduced live features. The system is very user-friendly, since it was designed in cooperation with practitioners. Images can easily be processed (e.g. focusing), and each session is automatically recorded in a database.

Pathological Services

DISKUS is mainly used for diagnostic consultations between experts.

Equipment

DISKUS uses high resolution CCD cameras like HITACHI VH C 20M. Data are stored either in JPG, BMP, or in TIFF format. Most users have access to ISDN. A typical DISKUS configuration costs about US-$ 10.000.

Since practitioners expressed the wish not just to transmit images, but to discuss cases with several experts at the same time, DISCUS was extended by the program SYNCHRO. This program coordinates communication processes where several users can participate.

[43] Further institutions are participating: The video graphics equipment was designed by the Technical University of Graz/Austria and Dornier, Friedrichshafen/Germany; the Matra Marconi of France, and Newtec of Belgium were responsible for the earth stations, British Telecom of UK, and Vistacomm of Finland developed the video codecs.

9.1.4.2 Telepathology in Aachen - MECOM

[Source: Richter, 1995, pp. 296-300].

Participants

Expert: Technical University of Aachen, Clinical Hospital of the RWTH Aachen, Department of Pathology, Pauvelsstrasse 30, Aachen, Germany

Client: Three hospitals of the region of Aachen

Background

The teaching hospital of Aachen introduced the medical communication system MECOM. MECOM is a modular static imaging system. It is used for radiology as well as for pathology. Its aim is to support image capturing, storage, retrieval and transmission between doctors of the same discipline. It also aims to enhance interdisciplinary communication.

Pathological Services

MECOM is used for second opinion discussion between specialists and for educational purposes.

Equipment

MECOM uses CCD-color cameras or high resolution scanners for image capturing. A lightpen in two colors serves as a marker. MECOM can operate in two modes - as video or as video-consultation tool for conferences [Richter, 1995, p. 298]. Communication is executed with two or more ISDN channels.

9.1.4.3 Telepathology in Berlin

[Source: Wolf, 1998, pp. 127-132; http://www.charite.de/ch/patho/; contact: peter.hufnagl@charite.de].

Participants

Expert: Institute of Pathology, Charité Medical School, Schumannstrasse 20-21, 10117 Berlin[44]

Client: Participants in Hannover, Poznan, and Tampere

Background

The Charité in Berlin, Germany, has developed an Internet telemicroscopy system. Using an Internet browser with Java support, like Netscape or Microsoft Internet Explorer, enables all Internet user to become a telemicroscopy client and thus a possible consultant for telepathology [Wolf, 1998, p. 127].

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[44] Contact address: Iver Petersen, e-mail: petersen@rz.charite.hu-berlin.de
System can be tested at http://amba.rz.charite.hu-berlin.de/telemic.

The reason for developing such a system was the experience that many pathologists want to use their current microscope. Therefore the telepathology system aims to be usable with ordinary microscopes. It should not demand difficult installation processes or special client workstations. Further it should be simple to use and not expensive. The design has to be standardized in a way that colleagues are not struggling by not corresponding systems.

The final solution enables users to control the microscope manually, since changes in the field of view are recognized by the microscope server. New microscope images will be transferred immediately to the connected telemicroscopy client. The system works like a simple microscope, just that images are captured with a CCD camera connected to a TV monitor. Images can be viewed and discussed simultaneously on computer monitors from distant locations [Wolf, 1998, p. 132].

Pathological Services

The system is used as a tool for the discussion of complicated cases between specialists.

Equipment

An automatic microscope, Leica DMRXA (Leica GmbH, Bensheim, Germany) is connected to a 200-MHz PC. All microscope functions (stage movement, objective change, focus and illumination adjustment) are available. The images of the CCD camera are captured with a Matrox Meteor frame grabber (Matrox Ltd., Dorval, Quebec, Canada), which supports all common TV norms (monochrome, YC and RGB in NTSC and PAL).

The utilization of JPEG compression quality parameter < 70 ensures that no essential image information is lost. This compression ratio is based on a research study of Phillips [Phillips, 1996, p. 233]. The user can select small images with a compressed size of approximately 10 KBytes, or full size images of 52 KBytes. The average transmission time of a small image by ISDN is two seconds, by a 28.8-kbps modem approximately 10 seconds. The Internet system is accessible either by modem and ordinary phone line or by ISDN.

The software for the microscope and camera control runs on Microsoft Windows. The telemicroscopy client is based on the programming language Java. Therefore it can run without any system-dependent modifications on a Windows PC, a Macintosh computer, as well as on a UNIX workstation. Using Internet browsers like Netscape and Microsoft Internet Explorer, the telemicroscopy client program based on ‘Java applets’ can easily be executed. Java applets are Java programs, which can be included in WWW pages. The user is able to start the program just by selecting the corresponding WWW address. Since the software is based on layer architecture, microscope and frame grabber can easily be replaced by other products [Wolf, 1998, p. 129].

9.1.4.4 Telepathology Tests in Munich

[Source: Deutsch, 1996, P. 793; Nathrath, 2000; contact: a.klapper@extern.lrz.muenchen.de].

Participants

Expert: Pathological Institute of the TU and LMU Munich, Germany

Client: University of Erlangen- Nürnberg, Germany

Background

In Bavaria, Germany, telepathology is utilized for research purposes between the Institute of Pathology at the University of Munich (TU, LMU), and the University of Erlangen-Nürnberg. The trials at Munich are supported by the IMSE of the Technical University, and the GSF-MEDIS-Institution. During a ongoing surgical operation, frozen section images of tissue samples are taken and transferred to the medical center in Munich. In this way the results are available quickly and the surgical team can continue the operation process [Deutsch, 1996, P. 793]. Another trial in Munich was executed by using the robotic-dynamic HISTKOM system (chapter 9.2.11). At this trial samples were prepared by a surgeon at the client's side.

Pathological Services

Second opinion consultation for frozen section examinations. The system HISTKOM was tested with frozen section examinations of thyroid gland specimens.

9.1.4.5 Telepathology in Aurich

[Source: Ring, 2000; Kreipe, 2000; Woziwodzki, 2000; contact: path-aur@emsnet.de; kreipe.hans@mh-hannover.de].

Participants

Expert: Pathological Institute of Aurich, Germany;
University Hospital of Hannover, Germany;
University Hospital of Dresden, Germany.

Client: Women's Hospital of Aurich, Germany

Background

The Pathological Institute of Aurich is a independent department, closely linked with the general hospital of Aurich. Since several years Professor Stauch is practicing telepathology with a low-cost static imaging system (approx. 7.000-10.000 US-$). Examinations are executed between the Women's Hospital and the Pathological Institution of Aurich. Till now already 440 breast carcinoma were executed. Samples are prepared by the surgeon. In 87% of the frozen section examinations an immediate and definite diagnosis could be rendered [Ring, 2000]. Another telepathological link was created between the University Hospital of Hannover and Aurich. Lymphoproliferative lesions are sent from Aurich to Hannover for second opinion consultations [Kreipe, 2000]. Finally the equipment was also used for DNA image cytometry. 405 cytological specimen images were sent to the EUROQUANT server of the University of Dresden for DNA analyses [Woziwodzki, 2000].

Pathological Services

Primary diagnostic, second opinion consultations, DNA image cytometry.

9.1.4.6 Telepathology Tests in Heidelberg

[Source: Kayser, 1992/(2), pp. 395-398; Slodkowska, 2000; Sternberg, 2000; contact: klkayser@lung.de].

Participants

Expert: All participating institutions are specialized in lung pathology:

- Institute of Pathology, Hospital Baumgartnerhöhe, Vienna, Austria;
- Klinikum Heckeshorn, Berlin, Department of Pathology;
- Department of Pathology, Thoraxklinik, Heidelberg, Germany;
- Institute of Pathology, Robert Bosch Hospital, Stuttgart, Germany;
- Medical Academy of Lodz, Pathology Department, Lodz, Poland

Background

The Thoraxklinik in Heidelberg, Prof. Kayser, is involved in several telepathology trials. Starting in September 1991, the first Quality Control Study on lung cancer was carried out . For more than two years tests for visual data exchange and expert consultation were performed routinely between Heidelberg and Vienna. A still imaging system was utilized for teleconsultations. That is why slides and magnification had to be chosen by the sending client. At consultation sessions, both pathologists are present at the same time to discuss the case. The test between Vienna and Heidelberg showed that in about 14 % of the diagnostic consultations significant support could be given. This proves that the possibility to determine final diagnoses in difficult is of great assistance [Kayser, 1993/(1), p. 333]. The Klinikum Heckeshorn, Berlin, Department of Pathology was involved as a third partner, mainly to test telecommunication in panel discussions and to judge the use of classification criteria (WHO) for telepathology.

Further telecommunication trials by using ISDN were executed between the Institute of Pathology of the Robert Bosch Krankenhaus, Stuttgart, and the Thoraxklinik of Heidelberg. Other tests run between the Pathology Department in Lodz, Poland, and the Thoraxklinik Heidelberg [see Slodkowska, 2000]. And last but not least, a German bone tumor work group' was set up in Heidelberg, based on open Internet tools for quick and effective teleconsultation in uncertain bone-tumor cases among affiliated reference-centers [Sternberg, 2000].

Telepathology Services

The telepathology system was used for intraoperative frozen sections, for second opinion consultation on cases difficult to classify, and for panel discussions.

Equipment

The first test used a color TV camera (JVC TK870) mounted on a conventional photomicroscope (Leitz, Loborlux, Wetzlar). Images were transferred by the commercially available computerized intelligent image transmission system VP 2000. In 1992 images were transferred by a 512 x 512 pixel matrix, with 8 bit color. Since image resolution was not sufficient, the image quality was improved by using laser scan microscopes with 1024 x 1024 pixels [Kayser, 1993/(2), p. 397; Kayser, 1995/(1), p. 55].

Histopathological images for routine expert consultation of intraoperative sections were transferred via a normal telephone line between Vienna and Heidelberg. ISDN was tested between Stuttgart and Heidelberg.

9.1.4.7 Telepathology Tests in Friedrichshafen

[Kayser, 1999, p. 158; http://www.dermatohistologie.com/].

Participants

Expert: Dr. J. Schaller in Duisburg, pathological doctor's office;
Dr. H. Kutzner in Friedrichshafen, pathological doctor's office.

Pathological Services

The system is used for teleconsultations between the two participating laboratories. In the future additional connections with other partners are planned.

Equipment

The static telepathology system works under Windows 95 or Windows NT. It is based on PC computers with Pentium processors (200 MHz and a minimum of 32 MB RAM). Images are transmitted via ISDN with a transfer rate of 128 kbit/s. Image resolution is 325 x 288 pixels or alternatively 288 x 150 pixels. Images are compressed by MPEG (Motion Picture Expert Group).

9.2 Projects Using Dynamic Telepathology Systems

9.2.1 Telepathology in Milwaukee -"Veterans Integrated Service Network"

[Source: Almagro, 1996; Dunn, 1997/(1); Dunn, 1997/(2); Dunn, 1996; http://www.va.gov/telemed/user/remoteDesc.idc; http://path.upmc.edu/index.html; contact: Bruce.Dunn@med.va.gov].

Participants

Expert: The consultant is located at the Clement J. Zablocki VAMC in Milwaukee, Wisconsin, a 888-bed facility with 5 staff pathologists and approximately 80 medical technologists and technicians in the two laboratories. It offers many academic programs and is famous for its strong technology transfer programs.

2nd Expert: The Hines VAMC, a medical center near Chicago, IL, offers second opinion diagnoses.

Client: The client is at the Iron Mountain Veterans Affairs Medical Center located in the Upper Penisula of Michigan, 220 miles north of Milwaukee. There are close cooperation with telepathology users in Pittsburgh and Arizona.

Background

The Iron Mountain Veterans Affairs Medical Center is one of the smaller hospitals (120 beds) in the Veterans Affairs system. It is located at an area which is periodically inaccessible by commercial airlines during the winter months. The hospital offers active surgery

service that generates approximately 1000 surgical pathology cases annually [Dunn, 1996/(2), p. 463; Kayser 1999, p. 155]. The majority of the specimens at Iron Mountain are biopsies (prostate, urinary bladder, gastrointestinal tract, skin) and ordinary specimens (hernia sacs, lipomas, etc.). Only 5 % of specimens require a pathologist's direct tele-supervision for dissection [Dunn, 1997/(1), p. 2]. Using telepathology, these types of specimens require a team approach for gross examination, since the affected tumors need to be thoroughly examined for adequacy of margins and lymph node involvement, to ensure that adequate numbers of tissue blocks are obtained [Almagro, 1996]. The gross examinations for telepathology and the microscopical settings are performed by two full-time employees, a senior medical technologist and a histo-technician. Both are well qualified in terms of educational background and very interested in telepathology [Almagro, 1996, pp. 470, 472].

The project in Milwaukee was introduced in March 1996 between the Clement J. Zablocki VAMC in Milwaukee and the Iron Mountain VAMC. After a period of test examinations, the system now is used for daily surgical pathology cases since August 1996. It is planned that the whole pathology case workload of the Iron Mountain VAMC should be performed by telepathology. Doing so, the amount of frozen section examinations, which is actually rarely performed, should be increased. The surgical pathology workload is approximately 1.000 cases per year.

The overall objective of the telepathology project at Milwaukee is the establishment of a network between the 171 Veterans Affairs hospitals for sharing resources and expertise. The so called 'Veterans Integrated Service Network' is planned to be introduction at three additional VAMC hospitals at Milwaukee [Dunn, 1997/(1), p. 8]. Since VAMC hospitals are located all over the USA, it is to assume that the experience of the Milwaukee's telepathology project will have a major impact on the development of telepathology systems all over the USA!

Pathological Services

Milwaukee is rendering accurate and timely diagnoses in both - surgical pathology and clinical pathology (peripheral blood smears, body fluids, gram stains, etc.). Since July 1996, the dynamic-robotic telepathology application is used for routine, real-time diagnoses in surgical pathology [Dunn, 1996/(2), p. 463]. From April 1996 to November 1996 already 440 surgical pathology cases at the Iron Mountain VAMC have been examined by Milwaukee's pathologists.

Hines VAMC offers second opinion consultations for the Iron Mountain VAMC. Non-robotically controlled microscopes and cameras that are controlled at sending stations, allow to do bi-directional second opinion consultations between the Milwaukee and Hines facilities. In this way a 'virtual' net of 13 pathologists is available, which may improve the efficiency of the pathological workflow [Dunn, 1997/(2), p. 9].

Equipment

The used equipment is a component of the Apollo-Corabi hybrid dynamic-robotic/static-image telepathology system (Apollo Systems, Alexandria, VA, USA) [Dunn, 1997/(1), p. 9]. It integrates a video teleconsultation grossing workstation and a separate video microscopy unit. The grossing teleconsultation module enables bi-directional audio and video conferencing. It uses a readily adjustable camera (Sony VID-P100 camera) to view

gross specimens and employs graphical annotation features to direct dissections precisely. The telemicroscopy unit at Iron Mountain consists of a Sony DKC-5000 video camera (Montvale, NJ) mounted on a fully motorized and robotically controlled Nikon Optiphot-2 microscope (Meville, NY), equipped with five objectives (4x, 10x, 20x, 40x, and 100x; oil-free, coverslip-corrected). These devices are connected by Cybex PC Companion Plus and Extron ADA 380 to the Pentium computer which controls the entire system [Dunn, 1996/(1), p. 467]. Pentium computers are employed at both sides. In Iron Mountain the used monitor is a 19-inch video monitor, consisting of a Sony Trinitron Multiscan 20 [Almagro, 1996, p. 470]. At the client's side the whole system is located in the main Iron Mountain VAMC's telepathology room. For real-time videoconferencing, the staff at Iron Mountain uses a headset, HelloSet Cordless 100 (Hello Direct, San Joes, CA, USA), instead of speakers. This allows to minimize extraneous noise and ensure optimal audio connections with the pathologists at the receiving host's station.

At the Milwaukee site, the workstation incorporates a Sony SE 20-inch video monitor that is used for all modules - for viewing gross specimens and microscopy images, and for face-to-face video conferencing. Codec is used for gross and microscopic specimen imaging. Diagnostic sessions are performed by bi-directional video conferencing. Video conferencing and specimen imaging take place simultaneously in separate windows on the monitor.

Communication

Initially linkage for network access between Milwaukee and Iron Mountain was achieved by using a dedicated T-1 line with a rate of 1.54 Mbps. This connection has been switched to simulate transmission over an inverted multiplex (IMUX) of four ISDN lines, transmitting at 512 kilobits per second. Finally static images are transmitted at 128 kbps, and full-motion video data have proved to be sufficient with ISDN at a rate of 512 kbps.

The Hines VAMC's workstation is identical to the one at the Milwaukee VAMC. The Iron Mountain and Hines VAMC are linked by dial-up telecommunication connections using an inverted multiplex of 4 ISDN-BRI lines. Communication costs are much lower with this multiplexer compared to the T-1 line. For the future a high-speed, high bandwidth wide area network (WAN) is in development. This WAN enables the VAMC to facilitate its telemedicine applications and to reduce telecommunication costs [Dunn, 1996/(2), pp. 464-465].

The system operates with Microsoft Windows (Microsoft Corp. Redmond, WA). The Apollo system includes Micromapper software. The hybrid dynamic-robotic / static-image store-and-forward system runs by a Corabi control module (Corabi International Telemetrics, Inc., Alexandria, VA) [Almagro, 1998, p. 1161].

Process

In Iron Mountain the medical technologist precisely mounts the glass slide on the specimen stage of the robotic microscope. Then the telepathology system in Milwaukee enables the expert to do global mapping of tissue sections on glass slides for microscopy. The host-site computer has functions that control microscope stage movements, focus, and magnification. The expert can position the microscope's objective lens over specific target areas in tissue sections during telemicroscopy sessions. The system can operate in a dynamic mode for real-time viewing or in a static-imaging mode for higher-resolution imaging. The

robotic microscope is used for all cases with no on-site pathologist at the remote station. For the discussion of pathology specimens teleconferencing is used between the two sites.

At a test in 1997, resolution in the dynamic mode was 352 x 288 x 24-bit color, whereas for the static digitized images resolution was first 786 x 486 x 16-bit color, which was later upgraded to 1.520 x 1.144 x 24-bit color [Almagro, 1998, p. 1161]. Dynamic live images were viewed in a 6 x $4^3/_4$ -inch window on the 20-inch monitor (approx. 17 % of screen). The 0.45x lens adapter attaching the video camera to the microscope body displays approximately 40% of the viewing fields in comparison to the observation directly through the microscope eye piece [Dunn, 1997/(2), p. 3]. Most of the diagnoses at Milwaukee are rendered on the basis of dynamic images. However high-resolution static images, viewed in an $11^3/_4$ -inch x $8^1/_2$ -inch window proved to be valuable for examining fine details of specimen structures (e.g. to identify the cell types in an inflammatory infiltrate). Altogether the static feature was only used at 10-20% of the cases, and this mostly with low resolution to reduce transmission time [Dunn, 1997/(1), p. 10; Dunn, 1997/(2), pp. 6, 8].

Currently pathologists rarely use static images for documentation, since glass slides as the ultimate pathology record of Iron Mountain cases are stored in Milwaukee after each case is signed out. For an improved documentation of pathological cases in the future, medical records with digitized images from surgical pathology, clinical pathology and autopsy pathology cases will be stored in a decentralized hospital computer system, which is the hospital information system used in most VA facilities. Case data of Iron Mountain is accessible or can be printed out from both sides. The final objective is that the telepathology system should be fully integrated into the electronically health care systems of VAMC.

Economical Efficiency of Telepathology

In 1996 an Apollo-Corabi telepathology system costed US-$ 110.000 for the remote-site robotic station, and US-$ 30.000 for the hub-site workstation. Connection costs are dependent on the employed network (T1 or ISDN-BRI) and duration of the connection.

9.2.2 Telepathology in Vermont, USA

[Source: Callas 1997, pp. 812-819; Callas 1996, pp. 319-329; Ricci, 1997, pp. 197-205; http://www.vtmednet.org/telemedicine/]

Participants

Expert: Fletcher Allen Health Care (FAHC), a 585-bed tertiary care academic medical center located in Burlington. The FAHC is the principal teaching hospital of the University of Vermont. It is linked to another medical center in Boston for second opinion consultations.

Client: Central Vermont Hospital, with 122 beds, located in Berling (42 miles from Burlington) and the Rutland Regional Medical Center with 188 beds, located in Rutland (69 miles from Burlington). About two-thirds of all telepathology cases are performed for the Central Vermont Hospital and one-third for Rutland. At the Central Vermont Hospital two pathologists and three at Rutland are using the system. Further 78 physicians, who regularly utilize pathological services at the two community hospitals were interviewed about their attitude to telepathology.

In January 1996, Porter Hospital (Middlebury, VT), Copley Hospital (Morrisville, VT), Northwestern Medical Center (St. Albans, VT), Northeastern Vermont Regional Hospital (St. Johnsbury, VT), North Country Hospital (Newport, VT), Alice Hyde Hospital (Malone, NY), and the Canton Potsdam Hospital (Potsdam, NY) became participants [Ricci, 1997, p. 199].

Background

Vermont is one of the most rural areas in the USA. 93 % of its towns have a population of less than 2500 persons. The largest city, Burlington, has a population of about 40.000 inhabitants. Vermont's severe winter weather and mountainous terrain create lengthy periods of reduced accessibility to professional health care.

That is why in January 1995, the Vermont telepathology network was established between three hospitals. The network is not just used for pathology, but for various other specialties and services, but pathologists are the largest group of users [other services see Ricci, 1997, p. 203]. Each system is working independently. All users in Vermont recognized in telemedicine a feature to improve patient care. The use for consultations was judged to be at least as effective as examining the patient in person in most of the cases. Since 1996, in a follow up phase, additional six hospitals use the telepathology services of FAHC. System utilization is climbing continually, firstly due to the additional participants and secondly because the use per site increased, too. Further participation is already planned [Ricci, 1997, p. 197].

Pathological Services

The telemedicine system of the Vermont network is used for consultations at various specialties such as pediatrics, cardiology, nephrology, and for routinely processed tissue microscopic section diagnoses. The most frequent specialty area prompting a consultation is gynaecology for smears or endometrial biopsies, followed by gastrointestinal , as well as skin and soft tissue cases. The system is also used for continuing medical education.

Equipment

The system is a real time dynamic bi-directional video telepathology system with simultaneous audio communication between the referring pathologist at one site and the consulting pathologist at the medical center. It does not offer a robotically controlled microscope. The sending pathologist controls the microscope platform movement, objective settings, and focus. This function was chosen as a compromise between a less expensive static-image system and a more expensive, more technologically complex, completely remote-controlled dynamic imaging system. Image resolution was 352 x 288 after transmission through the codec (coder-decoder). In more detail the following equipment is employed:

- The FAHC uses a Sony 760 three-chip color video camera attached to two Olympus microscopes (one BX40 and on BX50).
- The Central Vermont Hospital uses a Sony single-chip color camera on a Olympus BH2 microscope.
- The Rutland has a Sony CCD3 three-chip color video camera on an Olympus BX50 microscope.
- Some hospitals use a Cannon VC-C1 Mark II pan-tilt-zoom camera.

Transmission is executed via T-1 high bandwidth digital phone lines (1.544 Mbps) and via high bandwidth digital telephone lines - ISDN at 384 kbps.

The network is composed of four VTEL Mediamay videoconferencing units (VTEL Corporation, Austin, TX). The system is portable and runs on PCs with color monitors. It is based on Microsoft Windows and uses a VTEL video-conference card, an ascend multiplexor, and a custom-designed cart for portability. Some hospitals use the video CODEC from Zydacron Corporation (Manchester, NH). The system utilizes the Zydacron Z-250 BRI video-conferencing card and the Zydacron 208 Multiple BRI interface communication board. These software applications include Zydacron OnWan 2.0, the video conferencing software, and Microsoft NetMeeting for collaboration.

9.2.3 Telepathology in Birmingham, USA

[Winokur, 1996, p. 447; Winokur, 1998, pp. 43-49; Kayser, 1999, p. 154; http://etsam2.eng.uab/telepath/telepath.html].

Participants

Expert: University of Alabama at Birmingham, USA, Department of Pathology

Client: Center for Telecommunications Education and Research

Background

A three-step telepathology Applications Research Project (TARP) was set up in Alabama. The prototype system at Birmingham, called ‘TelePath’, is a hybrid system that combines features of static and dynamic telepathology. It was sponsored and developed in cooperation with the BellSouth Corporation (Atlanta, GA). It is called UAB/BellSouth TelePath system.

At the start of each consultation session a low-magnification image of the entire tissue section is captured to provide a complete panoramic view of the specimen. It serves as an

image map. Then the consultant selects with his cursor areas of interest from the panoramic image for viewing them 'live' at any desired optical magnification. The system is comparable to the system in Basel/CH. First live video images are transferred with lower resolution. Then specimen areas of interest are captured with high magnification as static images and transmitted with high-resolution and full color [Winokur, 1998, p. 44].

Pathological Services

The system is used for frozen section examinations and for educational purposes.

Equipment

The TelePath system utilizes an Olympus Vanox microscope with motorized stages (Norwell, Ma, USA). Further a Sony DKC 5000 3-CCD camera (Catseye, Park Ridge, New York, NY, USA) is used. The system is based on TCP/IP network protocols. It is tested by using standard ethernet and a fibreoptic network utilizing asynchronous transfer mode (ATM). No image compression is executed, because excellent image quality is higher rated than transmission time.

The consultant remotely controls the microscope. He manipulates the stage moves with his cursor, changes the objectives, and controls the autofocus and light intensity. Images are transferred to a Pentium computer that acts as the server. The remote client computer is a HP Pentium computer with 90 MHz, running on Windows 95. The monitor is a 21-inch NEC monitor of 1.600 x 1.200 pixels. All images of the TelePath system are of 795 x 598 pixels with a color depth of 24 bits [Winokur, 1998, p. 44; Kayser, 1999, p. 154].

9.2.4 Dynamic Telepathology in Tucson, USA

[Source: McLaughlin, 1998, pp. 11-17].

Participants

Expert: Arizona Health Services Center, Tucson, Arizona; Veterans Affairs Medical Center, Tucson, Arizona

Client: Department of Pathology, Medical College of Wisconsin, and Clement J. Zablocki Veterans Affairs Medical Center, Milwaukee, Wiskonsin

Background

Besides the static telepathology operations of the AITN in Arizona, the Arizona Health Service Center in Tucson started trials with dynamic telepathology. For this a hybrid system was used, incorporating both - dynamic and static imaging. Since the available bandwidth is very high, dynamic images are send with high-resolution over the network. The static tool provides low-resolution images. It was only used to orient and map the specimen and to keep track of the examination process during the dynamic panoramic tissue scanning [Krupinski, 1993, p. 68]. In Norway and Switzerland the dynamic and static features are just used opposite compared to Tucson. These reflects the influence of available bandwidth for the system design.

9.2.5 Telepathology in Kyoto, Japan

[Source: Shimosato, 1992, p. 28; O'Brien, 1998, p. 157; Shimmura, 1998, p. 389; Tsuchihashi, 1996, p. 457; Kayser, 1999, p. 161; http://tsuchi@koto.kpu-m.ac.jp].

Participants

Expert: Department of Pathology at the Kyoto Prefectural University of Medicine, Kyoto, Japan.

Client: Yosanoumi Hospital, 100 km north of Kyoto.

Background

Japan has only 1.535 pathologists. Only the larger institutions employ full-time pathologists [O'Brien, 1998, p. 157]. The history of telepathology in Japan goes back to 1984, when NTSC color images were transmitted using analogue public lines. After 1990 telepathology progressed rapidly in Japan [Tsuchihashi, 1996, p. 457]. One reason for this development was that specialized institutions are required to have at least a 30% referral rate in order to obtain government subsidies. This restriction led to enhanced competition and due to this to a shift in services from general to more specific subspecialties [Shimmura, 1998, p. 389]. Telemedicine was recognized as a medium to transfer the specialty expertise to remote places.

The Hospital of Kyoto, Prefectural University of Medicine, started its first telepathology trials in 1992 with the prototype system OLMICOS. A dynamic robotic telepathology system was used for intraoperative frozen section examinations between the Yosanoumi Hospital and Kyoto [Tsuchihashi, 1996, p. 457]. Main promoter of the system is Dr. Y. Tsuchihashi.

Pathological Services

The system in Kyoto is used for routine telediagnoses of intraoperative frozen sections and for intraoperative imprint cytology diagnostic. Common telecytology diagnoses after prescreening were also executed. Yet, the cytological pre-screening remained in local practice [Kayser, 1999, p. 162].

Equipment

The employed medical microscope of the OLMICOS system is a AX80 (made by Olympus Optical Corporation Ltd., Tokyo, Japan). It has a 10x ocular lens and 2x, 4x, 10x, 40x, and 100x objective lenses. The consultant can remotely control the x-/y-axes of the autostage of the auto-microscope in the regional hospital, change the objectives for the magnifications for observation, control focus and illumination.

First the pathological image input/output system used a digital 3-CCD video-camera (Victor KY-F55). Later it was replaced by a leaf Digital Camera (made by Scitex Corporation Ltd., Herzlia B, Israel), with cooled CCD, 2.048 x 2.048 pixels resolution, RGB sequential input, 14-bit color, and a capturing speed of about 30 seconds/image. Images are compressed to about 1:20. At the camera a focus adjustment ring is available, continuously adjustable within +/- 1 mm (made by NTT, Tokyo Japan) [Okumura, 1997].

As a control computer the Macintosh 8100/80 is utilized (Apple Computer Inc., California USA) with a loading speed of about 60 seconds/image. Later it was replaced by an IBM PC [Kayser, 1999, p. 162]. The SHD frame memory is a super FM-III (made by NTT, Tokyo

Japan), with 2.048 x 2.048 pixels, 8-bit RGB color (16 million colors), 60 frames/sec progressive scanning, and a total of 256 frames. The system uses SHD monitors DDM-2802C2 (made by SONY Corporation, Tokyo, Japan), 28-inch CRT, 2.048 x 2.048 pixels resolution, with a maximum brightness of more than 80 cd/m2 [Okumura, 1997]. Images are transmitted by ISDN with 64 kbit/s. One B channel is used for audio communication and the second B channel for image transmission.

9.2.6 Telepathology in Tokyo, Japan

[Shimosato, 1992, pp. 413-417; Shimmura, 1998, pp. 388-390].

Participants

Expert: National Cancer Center in Tokyo

Client: Clinical Laboratories of the National Sanatorium Matsudo Hospital (which became the second National Cancer Center Hospital in 1992).

Background

Starting in 1990, a robotic live-imaging system was tested between the National Cancer Center in Tokyo and its Diagnostic Pathology Laboratory, 250 meters apart. Optical fiber connections were used to transmit real-time moving HDTV images. One year later this system was used to transmit HDTV images via ISDN connections (64 kbit/s) and public telephone lines from the National Sanatorium Matsudo Hospital to the National Cancer Center, 30 km apart from Tokyo.

In 1992, a further trial with a static imaging system and a conventional monitor of 525 scan lines was executed. The connection was again based on ISDN and telephone lines. Soon the 525 line monitor has proved to be insufficient, since the resolution was not high enough to observe cellular detail, mitotic figures and chromatin patterns compared to direct light microscope examination. That is why frequently disagreement on the degree of atypia in dysplasia had been noted. The advantage of the third trial compared to the second was that with the still imaging system only images of cells of special interest were transmitted for evaluation. In this way the overall tele-consultation process was faster [Shimosato, 1992, p. 416]. Nevertheless again, due to the low transmission rates, the system proved not to be suitable for frozen section examinations.

Several years later, another trial of a real-time video and audio transmission system was described by Shimmura. This time ISDN lines at a transmission speed of 384 kbit/s and networks with a 2 Mbit/s capacity were tested. The test results were judged as more successfully for ocular surface diagnoses than this was the case at the first trials in 1992. Nevertheless finer structures, such as the corneal endothelium, still were not always visible in a satisfying manner [Shimmura, 1998, pp. 388-390].

Pathological Services

Consultation services for frozen sections and cytology smears.

9.2.7 Telepathology in Basel, Switzerland

[Steffen, 1997/(1), pp. 1-53; 1997/(2), pp. 25-29; Oberholzer, 1993, pp. 1078-85; file:///DI/wwwroot/telepathologie/telepath2.html; interviews and case study at Basel in 1998 and 1999].

Participants

Expert: Kantonsspital Basel, University Hospital, Institut für Pathologie, CH

Client: Hospital of Samedan, CH

Background

At the beginning of 1990 in Switzerland the fundamental political decision was made to establish so called 'Communication Model Communities' (Kommunikationsmodell-gemeinden der Schweiz) for testing the practicality of new telecommunications services. For this reason the responsible Swiss authority, together with the Swiss telecommunication network provider 'Swiss PTT / swisscom' (Postbetriebe der Schweiz), collected projects based on new innovative ideas of telecommunications services and put them together to communication centers.

At this time Professor Oberholzer, specialized pathologist at the University Hospital of Basel, Department of Pathology (Kantonsspital Basel), together with the University Computer Center of Basel (Dr. Christen, responsible for the database concept), and the Engineer School of Muttenz (responsible for the construction of robotic microscope control features), had the idea of developing a dynamic telepathology system. In addition, a research and consulting group at Liestal/CH, TMR AG (Dr. Fischer, Dr. Gerber), the Swiss PTT, the hardware supplier Apple AG in Wallisellen/CH, the microscope supplier Olympus in Hamburg/Germany, and Carl Zeiss AG in Zürich/CH were involved in the development process of SAMEBAS [Steffen, 1997/(1), pp. 17 ff.]. The main motivation of these researchers was, to discover the conditions and the extent to which it is possible to transfer medical know-how and expertise from the medical center of Basel to periphery hospitals, often located in the remote Swiss mountains, by using telecommunication technologies. They applied to become a participating project of such a Communication Model Community. The president of the swisscom Engadin (administrative district at the north-west of Switzerland), responsible for the Graubünden's Communication Model Community of St. Moritz, was so impressed by the idea of telepathology that he wanted to win this project for his district. He arranged a cooperation between the Hospital of Samedan, a small hospital close to St. Moritz (110 beds, 250 km apart from Basel), and the University Hospital of Basel. Samedan is a small town surrounded by high mountains and therefore in winter often not accessible. The Hospital of Samedan does not have a pathologist at the face. Therefore it had to send its tissue samples by train, or to transfer the patient to the medical center in Chur (approx. 120 km distance) before they started with telepathology. In 1992 the first intraoperative frozen section examinations were executed. Prof. Oberholzer, the pathological expert at the University Hospital of Basel, tele-examined several surgical and gynaecological tissue samples from Samedan with SAMEBAS.

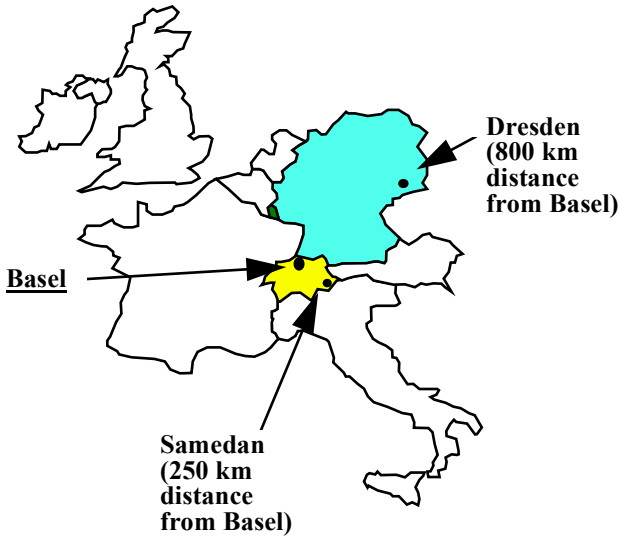
Some years later the Hospital of Burgdorf also installed the telepathology system SAMEBAS. However, even so the surgeons of Burgdorf were very pleased with the system, the administrative top management was against a long term introduction. Since the surgeons could not raise enough money to keep the project going it was stopped after a

short time. In comparison, the Samedan project got money from the European Community's program EUROPATH and from the Swiss Communication Model Community foundation.

Since autumn 1999, a Hospital of Ophthalmology at Basel also started to use the telepathology system. Ophthalmological images are sent to the expert in Bonn (Germany) for a second opinion. Until 1998 e-mail was used to send these images to Bonn. However this held the risk of mixing up images of different cases. Using SAMEBAS as a static image transfer system, images automatically get a number by the system and are directly stored in a database. In this way cases are unmistakable and comfortably put together.

Also in autumn 1999, the University Hospital of Dresden, Department of Pathology, started a telepathology cooperation with the University Hospital of Basel. The University of Dresden is known for its high qualified activities in DNA-cytometry. Objective of the collaboration is the improvement of SAMEBAS. Further the system utilization should be expanded by second opinion diagnoses and by DNA-cytometry examinations for quality control. It is also intended to set up a database for interesting pathological cases, and to develop pathological education programs. The new, more flexible update of SAMEBAS is planned to become active in spring 2000.

Description of the Location and Participants



Milestones

The basic milestone for the introduction of the SAMEBAS system was the political decision to build Communication Model Communities. This was the foundation of the telepathology trial, which proved to be adequate for frozen section examinations over a long distance. Another essential milestone was the successful completion of SAMBAS and its installation in Samedan. As a first step the pathologists of the University Hospital of Basel and the computer experts of the Computer Center of Basel developed the system and database design. As a second step, negotiations with hardware specialists were hold to find the most appropriate equipment for the specific needs of the project. And third, the staff of the Hospital of Samedan was well trained for becoming familiar with the system and the tasks they had to carry out.

The SAMEBAS system is part of the overall hospital strategy at Basel. This strategy is to keep the quality of medicine on a very high level. Another important task is to offer to the smaller hospitals of the region and to the regions of the adjacent neighborhood countries (France and Germany) specialized medical care. With SAMEBAS fast specialized pathological support can be delivered to fulfil this task.

Pathological Services and Performance Data

Up to now SAMEBAS is mainly used for frozen section examinations. The reason is that in Switzerland distances are short so that only for frozen section examinations the robotic telepathology system is from interest. If necessary, SAMEBAS could also be used for emergency support and for urgent 'on call' services between Basel and Samedan. For second opinion examination SAMEBAS is used between the Hospital of Ophthalmology at Basel and Bonn and between the University of Dresden and Basel. Between Basel and Dresden there is also a study which uses SAMEBAS for DNA-cytometry. Cases of SAMEBAS are stored in a reference case database and are used for educational purposes.

Utilization and Synergy

With approximately 25 cases a year the amount of tele-examinations is not very high. The reason for this low utilization is that only the hospital in Samedan is actually using the teleconsultation link to Basel. Other interested users mostly decided not to participate because of political reasons and because of the lack of adequate reimbursement. Perhaps this will change since cases are now reimbursed with approximately 200 US-$. SAMEBAS is only used for pathological purposes. A higher utilization by offering the possibility of teleconsultation to other departments is actually not planned, since the system is located at a separate building in Basel.

Equipment and Communication

In Samedan a cryotom is available (Microm-Kryostat, Microm Company, Heidelberg, Germany) combined with a drying and staining set. In this way the specially trained laboratory assistant in Samedan, supervised by the pathologist in Basel, is able to prepare specimens [Oberholzer, 1993, p. 1081]. The used workstations are Apple Macintosh computers. Since 1999 also PCs with Microsoft Windows can be used. The computer is equipped with a frame grabber (Screen Machine, Proficom, Karlsruhe, Germany), and a image program (provided by W. Rasband, National Institutes of Health, Bethesda, MA).

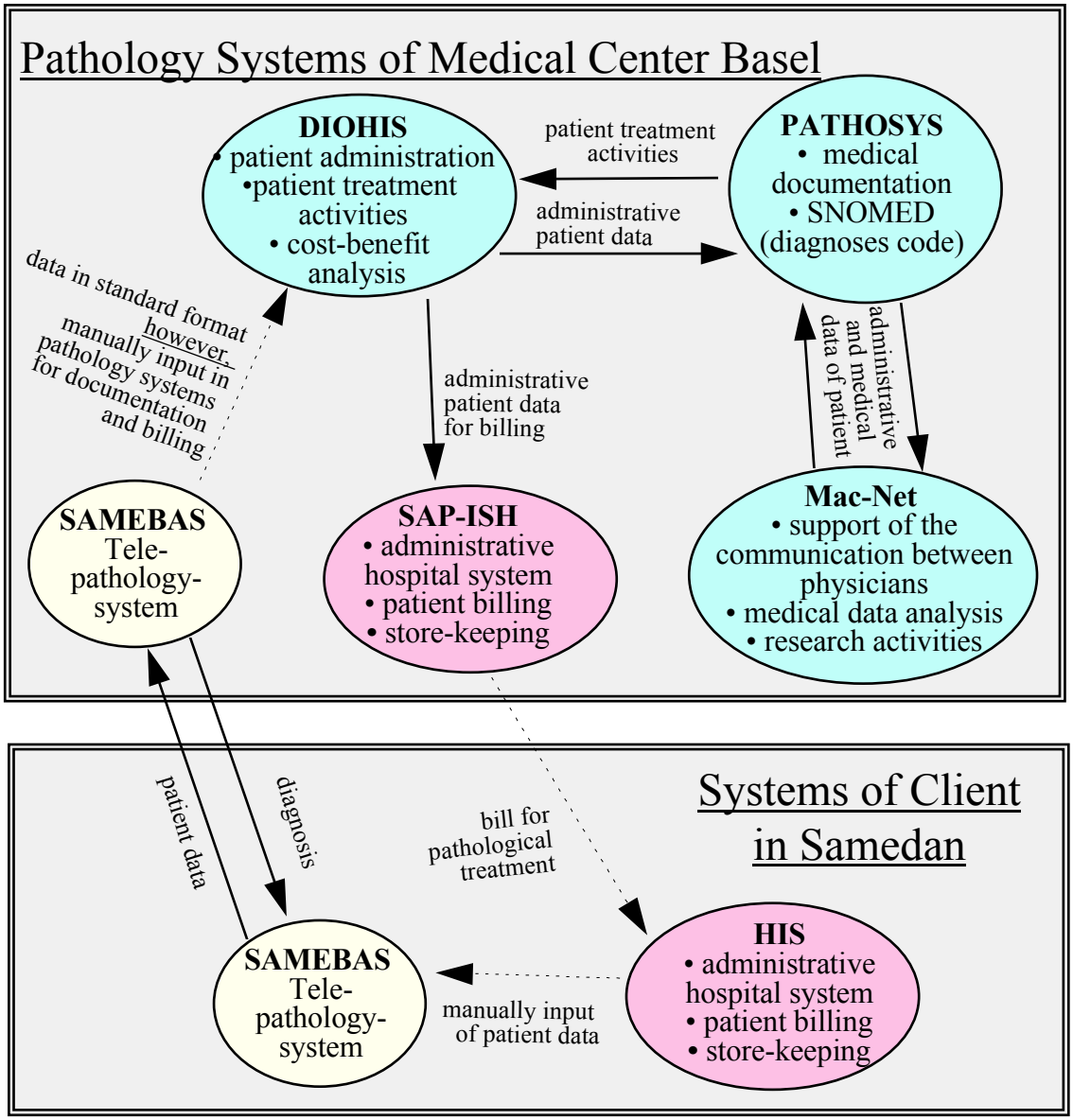
At the first trials in Basel no compression technique was used and images were transferred with 8-bit gray [Eide, 1994, p. 885]. However, it is not practical to do telepathology without color images. Therefore the system in Basel was extended and now images can be grabbed optionally as 8-bit gray-level images or as 8- and 24-bit color images. The system offers low-resolution dynamic imaging and high-resolution static imaging. The resolution of the digitized images depend on the optical objective employed and the size of the grabbed image field projected into the video eye. Low optical magnification images are used for the interpretation of neighborhoods of tumor infiltration into the environment. The temporary reduction of the resolution is found to be acceptable [Oberholzer, 1993, p. 1084]. Images are grabbed in TIFF format. TIFF can be converted into a format that can be processed by the used image analysis program 'VIDAS' (Kontron, Bildanalyse GmbH, Eching, Germany). With a remotely controlled video eye the pathologist in Basel is able to interactively zoom and select desirable specimen fields.

The relational database OMNIS (Blyth Software Inc., San Mateo, CA) was used for all patient-related, case-related, examination-related, diagnosis-related, and doctor-related data, as well as for coding data [Oberholzer, 1993, p. 1080]. The data structure is similar to the pathology information system PATHOSYS used at the pathology department of Basel, which may allow an easy system integration in the future.

Robotic microscopes from Olympus and Zeiss (Olympus Optical GmbH, Hamburg, Germany / C. Zeiss, Oberkochen, Germany) are used for the projection of microscopic images into the system. The remote controlled microscope has six objectives (1x, 2.5x, 10x, 20x, 40x, and 60x). With the help of the picture instrument manager module the x-, y-, or z-axis can be moved and objectives and filters can be changed. This platform is also used by different peripheral instruments for capturing images.

The communication link between Basel and Samedan is based on ISDN (64 kbit/s).

System Integration



Interrupted lines reflect that there is no 'direct' but manual data exchange; continuous arrows are used for integrated data exchanges.

Figure 10: Overview about the systems at the two participating clinics in Switzerland.

As the figure above illustrates, the telepathology system SAMEBAS is an isolated system - in Basel as well as in Samedan. However the data in the SAMEBAS system are in a standard format. Therefore it does not take a lot of effort to create a link to the other pathological and hospital information systems. The reason that SAMEBAS is not integrated with other systems at the moment is that all programming efforts had been invested into the improvement of the SAMEBAS system design. Yet, considering the whole information system architecture in Basel and Samedan, similar to other hospitals in Switzerland even between the running pathological systems and the administrative hospital system the data transfer is not smooth and has to be often specially programmed.

Fortunately, up to now integration proved not to be a problem because the amount of telepathological cases is not high. For the future it is planned that SAMEBAS is integrated with the other hospital information systems (administration, medicine, pathology).

WinMed of swisscom

After the SAMEBAS system proved to be appropriate for telepathology consultations, the supplier TMR AG in Liestal (CH) tried to make a professional software product out of it. However, the health care market in Switzerland did not accept the SAMEBAS system as it was. That is why TMR stopped its effort in commercialization and further development went back to the funded project stage in the research environment at the University of Basel.

Finally the strategy for sales changed. TMR AG, in cooperation with the Swiss telecommunication supplier 'swisscom', developed the new product WinMed[45]. The new product is a complete modular open business system solution for physicians, based on Windows 95 and C++. Knowing that the actual cost pressure in Switzerland forces physicians to enhance controlling activities, WinMed highlighted its administrative support features. These are for example patient administration, registration of treatment activities, billing and reminder, controlling, as well as medical documentation. New customer could be won. Later this internal module can be expanded by the module WinMed 'Consilium', which supports the transmission of medical documents via ISDN and online discussions based on images (screen sharing). It also gives access to research information databases or www-services. However, starting by the dynamic robotic controlled SAMEBAS system, the teleserver of WinMed is just an asynchronous static image transfer system. Altogether in Switzerland the strategy to start with administrative features and then to add telemedicine applications proved to be more successful than reverse.

[45] More information: http://www.winmed.ch; telephone ++41-800-555868

9.2.8 Telepathology in Tromsoe, Norway

[Source: Nordrum, 1991, pp. 514-518; Nordrum, 1994, pp. 881-890; Nordrum, 1995, pp. 253-256; Nordrum, 1997, Nordrum, 2000; Eide, 1992/(1), pp. 405-407; Eide, 1992/(2), pp. 409-412; Eide, 1994, pp. 881-890; Elford, 1997, pp. 1-22; http://www.fm.uit.no/; www.patologi.net; contact: ivar.nordrum@medisin.ntnu.no[46]].

Participants

Expert: University Hospital of Tromsoe, 400 km distance from the remote site in Kirkenes; University of Trondheim; Norwegian Radium Hospital of Oslo

Client: Kirkenes Hospital, Hospital of Hardstad, Hospital of Namson, Hospital of Levanger, Hospital of Arendal;
Additional planned participants: 3 installations in Northern Norway, 8 in Middle Norway, 2 in South Norway.

Background

The use of telecommunications for medical purposes in Norway has a long tradition. Already in the 1920s ships got medical advises and assistance via Bergen Radio. In Norway over 85% of the general Norwegian practitioners use an electronic patient medical record system and most patients laboratory results are processed electronically. The standard of health care facilities is very high. Therefore it is no surprise that the Norwegian Ministry of Health and Social Affairs was one of the first that has acknowledged telemedicine as a legitimate way for health care delivery of medical services, especially since one of the governmental political health care objectives is that Norwegians should have equal access to medical services irrespective of their geographical location. That is why the government recognized telemedicine as a possibility to transfer the medical know-how of the 22 medical centers of Norway to the less populated regions. Together with the Norwegian Telecom the government started to financial support telemedicine activities. In February 1993 the first telemedicine department of Norway was officially opened at the University Hospital of Tromsoe by the Minister of Health. In August 1996, one of the first official telemedicine fee schedules world-wide was implemented in Norway, making all telemedicine services reimbursable by national health insurers [Elford, 1997, pp. 1-2].

The 'Telemed A200' telepathology system in Norway was introduced in 1990 between the University Hospital of Tromsoe and the Kirkenes Hospital. Since the late 1980s these two hospitals already were involved in various telemedicine approaches, for example teleradiology, teledermatology, remote endoscopy, remote gastroscopy, tele-echocardiography, transmission of electrodiagrams, telepsychiatry, electronic delivery of laboratory results or distance learning for health professionals, etc.. In February 1993 the first telemedicine department of Norway was officially opened at the University Hospital of Tromsoe by the Minister of Health. This department helps to maintain, monitor and evaluate telemedicine activities. Today it is staffed by approximately 20 employees and has a guiding position in telemedicine in Norway [Elford, 1997, pp. 1,3].

The introduction of telepathology in Norway was part of the national telematic project [Nordrum, 1991, p. 517]. The pioneer who strongly promoted all activities is Ivar

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[46] Ivar Nordrum, Associate Professor, Department of Laboratory Medicine, University Hospital of Trondheim. Address: Morphology Building, University Hospital of Trondheim, 7006 Trondheim, Norway; Phone: +4773867396; FAX: +4773867130

Nordrum. From 1990 to July 1994 tissues from 100 patients have already been examined [Allaert, 1999]. In June 1992 another telepathology system was installed at the Hospital of Hardstad, 200 km from Tromsoe. Further telepathology applications will be installed between the University Hospital of Trondheim and the Hospital of Namsos and the Hospital of Levanger, and between the Norwegian Radium Hospital of Oslo and the Hospital of Arendal [Nordrum, 1995, p. 254]. At the end of 2000 'PATNET' will be installed, the Version II of the actual system.

Pathological Services

The telepathology system in Norway is used for frozen section examination, for teleconsultations to review microscopic findings, for the discussion of major diagnostic issues, and for educational purposes. Breast and thyroid tissue examination account to 74% of all teleconsultations. With the installation of PATNET, Version II, the use of the system for second opinion diagnoses, group discussions, quality assurance, and the access to various Internet resources will be expanded.

Equipment

The Norwegian telepathology workstation was developed by the company AM ELEKTRONIKK AS (Applied Multimedia Electronic AS, Fetsund) in collaboration with the University Hospital of Tromsoe and the Norwegian Telecom (now called Telenor), Department of Research. Video images of both, macroscopic and microscopic specimens are processed by a single chip video camera (Sony DXC-107P and DXC 3000) mounted on the microscope. They are transferred to a video codec (Philips VCD-2M-G and Philips VCD ZM-G, later changed to Philips Titan Videoreceiver, programmable for different transmission rates on demand from 128 Kbit/s up to 2 Mbit/s) [Eide, 1994, p. 884; Eide 1992/(2), p. 410]. A videoconference unit with a macro-table and a single chip video camera are available for macro-examinations.

The remote hospital in Kirkenes had a Zeiss Axiotron microscope with five objectives (2.5 x 0.075; 10 x 0.30; 20 x 0.5; 40 x 0.75; 100 x 1.3). Later this microscope was replaced by a Leica Medilux microscope (objectives: 1.6 x 0.05; 2.5 x 0,08; 6.3 x 0.20; 16 x 0.48 and 40 x 0.7) and a Mikon A200 remotely controlled motorized microscope, also offered by Applied Multimedia Electronic AS, Fetsund, Norway [Nordrum, 1997, p. 172]. The microscope offers motorization of the stage (Maerckhaeuser, 50 x 75 mm 0.25 μm step) and focusing (Zeiss), an objective revolver and a zoom lens [Nordrum, 1991, p. 514]. The microscope is directed from a workstation at Tromsoe by a computer (IBM PC-AT) programmed for activating the motorized function of the microscope. A computer (PLS, Spider Industries) is connected to the motors to trigger the stage and focus maneuvers from a remote workstation via the tele-network [Nordrum, 1995, p. 255].

Video images can be viewed simultaneously on high resolution 20 inch monitors (Philips 4CM-2789) in Kirkenes and Tromsoe, which enhances the communication between the client and consultant. Frozen sections are prepared by biotechnicians at Kirkenes, who were introduced in doing standard frozen section procedures [Nordrum, 1991, p. 514].

Communication Connection

The system in Norway was designed to use a bandwidth corresponding to approximately 32 telephone channels. The images were transmitted via a two-way video and telephone net-

work of the Norwegian Telecom with a maximum capacity of 2 Mbit/s. With availability of ISDN 6 B-channels (384 Kbit/s) are available.

Image reduction filtering was executed by a Philips VCD 2M-G videocodec, later Philips Titan, which is able to handle rates from 128 Kbit/s to 2 Mbit/s. In 1995 the 2 Mbit/s link was switched to a standard rate of 384 Kbit/s [Elford, 1997, p. 7]. The difference between 384Kbit/s and 2 Mbit/s can be ignored, but 128 Kbit/s had proved to be not sufficient [Nordrum, 1995, pp. 254, 256]. For this the video images are compressed in a video-codec and then transmitted via the telenetwork to the receiver's video-codec for encoding.

Description of the System

The system used in Norway is a hybrid system that incorporates both, dynamic and static imaging. Samples at the client's site are handled by the surgeon and a medical technician. Since the bandwidth at the beginning of the project was poor, the dynamic feature was used for the critical steps of specimen orientation on the slide, for overview interpretation, and for general interpretation of normal and uncomplicated structures of a specimen [Nordrum, 1991, p. 516, Eide, 1992/(2), p. 411]. To improve the transmission speed, the volume of live image information was reduced to a minimum before transmission.

The static imaging tool was used for grabbing video images of fields of interest, storing them without compression, and then separately transmitting them as high-resolution static images for tele-examination [Krupinski, 1993, p. 68]. Since transmission time is long, still image retrieving is mostly used for confirming live image interpretation and is only performed a few times during an examination. To facilitate the capture and transmission of still images, an application called VIDA was added to the workstation's PC [Elford, 1997, p. 7]. Still images are of superb quality and are retrieved on a separate monitor.

Video images have a resolution of 288 x 256 pixels in 24-bit color at 25 frames/s, transmitted over a 2 Mbit/s network. Still images have a resolution of 576 x 720 pixels x 24-bit color [Elford, 1997, p. 6]. The system is based on the PAL video standard [Nordrum, 1995, p. 255]. In 1994 the videoconferencing equipment was upgraded to H.320 standards [Elford, 1997, p. 7].

Video images from macroscopic and microscopic examinations are displayed on monitors at both sides. The pathologist at Tromsoe guides the surgeon in Kirkenes by using an arrow. He controls the remote robotic microscope with a supermouse (Mikon A200, developed by NOVAKOM, Norway), which has special buttons for intensity of illumination, for control of magnification and for the optional remote macro camera zoom. Focusing is carried out by rotating the supermouse about the vertical axis, and the specimen stage is controlled by moving the mouse backwards or forwards and left or right [Nordrum, 1997, p. 172; Eide, 1994, p. 882].

Problems with the System

In August 1993 the telepathology system could not be used because the videoconference network was repaired without notification. In May and June 1994 problems with the software in the new videocodec lead to difficulties with the transmission of video images.

9.2.9 Telepathology in Poland

[Source: Szymas, 2000/(1); Szymas, 2000/(2), http://mic.amu.edu.pl/].

Participants

Expert:	Medical Faculty of the University of Poznan, Poland
2nd Expert:	University of Udine (first trials with the static Internet version); ten universities from the European community
Client:	Pathological Institutions in Lodz, Lublin, Gliwice and Warsaw

Background

The activities in Poznan started in September 1996 under the project name TEMPUS. Starting at the beginning with static system features, which were easily accessible via the Internet by all remote partners, the trials were soon expanded with dynamic components to the so called 'TELEMIC' dynamic telepathology system. The aim of the telepathology introduction in Poland is to construct a network, which will be available for all pathological institutes in Poland and which further matches all international standards.

Pathological Services

First the telepathology equipment was used for student classes (tele-education), forums and discussion circles. Then diagnostic sessions for second opinion consultations and primary diagnostic trials were executed.

Equipment

Some parts of the system are used with simple telephone lines, but there are also trials with the ATM network POL-34. The system is accessible by conventional Internet browsers using the program language Java. Images are captured by a Zeiss microscope (Axioplan2) and a POLAROID DMC digital camera. They are send with a resolution up to 1600 x 1200 pixels, 24 bits, and with a JPEG compression ratio of 6:1. Pentium II PCs are used under Windows NT. Further description, see Szymas 2000/(1) and 2000/(2).

9.2.10 Telepathology in Berlin, Germany

[Hufnagl, 2000/(1); Wehrstedt, 2000; Oberbarnscheidt, 2000].

Participants

Expert:	University Hospital Charité, Department of Pathology, Berlin
Client:	Three campus hospitals, located in different parts of Berlin a) Campus Charité, b) Campus Virchow-Klinikum, c) Campus Buch, Robert-Rössler-Klinik

Pathological Services

Frozen section examinations and second opinion consultations.

Background and Objectives

The TPS (Telepathology System) was developed in cooperation with Leica Microsystems Wetzlar GmbH. TPS was introduced to render second opinion examinations from every frozen section laboratory of the Charité within minutes. A special focus was set on second opinion consultations during a fetal autopsy [Wehrstedt, 2000]. Further telepathology services should be offered to other pathologists and hospitals without pathology.

TPS is a case orientated tool. It allows the handling of static as well as of dynamic images (PAL 762 x 508 x 3 color resolution, ITU standard H.263, H.264). The communication is based on TCP/IP, LAN, ISDN, and Internet supported. Further description, please see Hufnagl, 2000/(1) or contact Peter.Hufnagl@charite.de.

9.2.11 Telepathology in Stuttgart, Germany

[Nathrath, 2000; Wellnitz, 2000; Klose, 2000; Schwarzmann, 2000; Schwarzmann, 1999; Schwarzmann, 1998/(1), pp. 135-138; Schwarzmann, 1998/(2), pp. 176-178; Schwarzmann, 1995, pp. 209-215; Schwarzmann, 1996, pp. 17-20; Schwarzmann, 1992, pp. 383-387; Schmid, 1996/(1), pp. 479-481; Schmid, 1996/(2), pp. 929-933; http://www.uni-stuttgart.de/UNIuser/ipe/res/ip/histkome.html; e-mail: schwarzmann@ipe.uni-stuttgart.de].

Participants

Expert: The University of Stuttgart, Institute of Physical Electronic

Client: Robert Bosch Hospital in Stuttgart, Germany; University of Tuebingen, Department of Pathology, Germany; University of Munich, Department of Pathology, Germany

Background

In autumn 1995, the University of Stuttgart, Institute of Physical Electronic (IPE) developed the dynamic robotic telepathology system HISTKOM. The project was heavily supported by the German Telecom[47]. The objective of this prototype system was to offer an operator friendly, simple to use interface, which meets the needs of routine pathology laboratories. The system was tested with high bandwidth connections (8 B-ISDN channel with ATM) at the University of Tuebingen/Germany, and with a simple ISDN connection at the Robert Bosch Hospital in Stuttgart/Germany [Schmid, 1996/(1), p. 480]. Other tests were executed between the laboratory of Stuttgart and another laboratory at Karlsruhe [Schwarzmann, 1995, p. 210]. Further the Hospital of Bernburg and the University Hospital of Munich made use of HISKOM.

The development of the broadband strategy of HISTKOM was funded by the German Telekom, Carl Zeiss and the Mildred Scheel Foundation. The ISDN-based strategy was funded by the Robert Bosch Foundation and the Krebsgesellschaft Baden-Württemberg [Schwarzmann, 1995, p. 210].

Pathological Services

The system is mainly used for test purposes. Fieldtests have been carried out with material from histology, cytology and hematology. HISTKOM is aimed to be used for daily routine in frozen section diagnostic. Currently the equipment is mainly employed to carry out store and forward as well as interactive second opinion consultations.

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[47] Deutsche Telecom AG, Rabinstr. 8, D-53111 Bonn; www.telecom.de; Tel.: 0049-228-18115332

Equipment

HISTKOM includes dynamic-robotic components for telemicroscopy to perform frozen section services, as well as store and forward features, called 'teleconsult' to support static teleconsultations. A secure public ISDN telephone net access is guaranteed by identification, authorization, and encryption by chip-card technology. Open interfaces aim to enable an integration of HISTKOM into hospital information systems (HIS). A second interface provides a translation of the document to the HTML format of the World Wide Web. Under the restrictions of a reduced data confidentiality, documents can be sent over the Internet to everybody connected to it. No special software is necessary, since the HTML documents can be read with every standard browser [Schwarzmann, 1999].

Since designers of the dynamic component are of the opinion that acceptance of telemicroscopy depends strongly on the network it is linked to, most users of the dynamic features of HISTKOM are using narrow band ISDN connections. The bandwidth of ISDN is smaller than for example the one of broadband ATM links, but also much cheaper. That is why many features are implemented in HISTKOM to overcome the problem of limited channel capacity in telemicroscopy. The IPE Stuttgart introduced intelligent components for image capacity reduction such as autofocus facilities or orientation assistance features within the slide, improved on-line impression, or automated track control of a session [Schmid, 1996/(2), pp. 930 ff.]. The most interesting parts are the automated compression and reduction features, which are adapted to the behavior of an operator. If the user scans the slide roughly, the image resolution is reduced automatically and as soon as he stops at an interesting field of view for a longer time, the image resolution improves. To avoid abrupt changes in resolution, 20 different modes with several compromises between frame rates, spatial resolution and color resolution are implemented [Schmid, 1996/(2), pp. 930 ff., Schwarzmann, 1995, p. 215, Schwarzmann, 1996, p. 19]. The objective of these intelligent features are to provide the user with an on-line impression almost as good as by handling a direct light microscope.

Telepathology in Bernburg – Trials with HISTKOM

Participants

Expert: Medical Center of Bernburg, Germany

Client: Hospital of Köthen, Germany

Background

The Medical Center of Bernburg and the Hospital of Köthen, both located in Germany with 20 km distant from each other, started to use the dynamic-robotic imaging telepathology system HISTKOM. The project was set up in cooperation with the Institute of Physical Electronic at the University of Stuttgart, the Carl Zeiss Jena GmbH, and the Telekom AG. The hospital at Bernburg and the hospital of Köthen are linked by four Euro-ISDN-wires with 8 channels. Using a robotic microscope in Köthen, the expert in Bernburg is able to operate the microscope under remote control. This equipment enables the expert to regulate X-, and Y-position, to focus or magnify an object, to adjust the light, filter and condenser, and to take images at a certain position. Images and patient information are transferred to the screen in Bernburg. There the specialist can render a diagnosis. Results are discussed with the physician in Köthen via e-mail or telephone. The results of the examination and the images are stored in a database [Löbus, 1997; Ulsenheimer, 1999]. Unfortunately due to the high investment costs the system was only introduced for a test period, but not installed permanently.

9.3 Commercial Telepathology Systems

Several commercial companies have developed telepathology systems. The ones, which have a special interest in combining their products with telepathological systems are for example the supplier of microscopes.

ZEISS: The name of the dynamic telepathology system of ZEISS is Axiopath. It was developed in 1996 and is in practice since 1998. Users are for example the Ordensspital in Friesach/Kärnten/Austria, the Institution of Pathology, Dr. Weger, in Salzburg/Austria, the University Spital of Innsbruck/Austria[48], the Kantonsspital, Dr. Joris, in Sion/CH, or the St. Barthdomew Hospital, Dr. Chris Sauter, in London/UK. The price for the system is about 70.000 US-$ (60.000 for the client and approximately 10.000 for the expert).

Detailed information see: www.zeiss.de/micro; e-mail: micro@zeiss.de
Contact address: Carl Zeiss Microscopy, D-07740 Jena; Tel.: 0049-3641-641616 or Carl Zeiss Werk Göttingen, Königsallee 9-21, D-37081 Göttingen;

Olympus The dynamic telepathology system of Olympus 'MIGRA' (Microscope Global Remote Access) is already used at the Kaiser Franz Josef Spital in Wien/Austria.

Detailed information see: http://www.olympus-europa.com;
Contact address: Olympus Optical Co. (Europe) GmbH, Rudi Schmitz, Wendenstr. 14-16, D-20097 Hamburg, Tel: 0049-40-23773-159; e-mail: rudi.schmitz@olympus-europa.com; or microscopy@olympus-europy.com

Leica: Leica is cooperating with the Charité of Berlin to test and improve their dynamic telepathology system version.

Detailed information see: www.leica-microsystems.com
Contact address: Leica Microsystems Wetzlar GmbH, B. Stock, Ernst-Leitz-Str., D-35578 Wetzlar, Tel: 0049-641-292838 or Leica Mikrosysteme, Lilienthalstr. 39-45, D-64625 Bensheim; e-mail: Bernd.Stock@lmw.leica.com

Nikon The dynamic robotic telemicroscopy system Nikon-ZEM-DYNAMIC is used for frozen section examinations, tele-education, quality assurance, and for research purposes. It uses the robotic microscope Nikon ECLIPSE E1000M. The system is already in practice in Münster and Steinfurt/Germany, in Wien/Austria, and in Oxford/UK.

Detailed information see: www.nikon.de
Contact address: Nikon GmbH, Abt. Mikroskope / Optische Meßtechnik, Tiefenbroicher Weg 25, D-40427 Düsseldorf, Tel.: 0049-211-94140; e-mail: mikroskope.messtechnik@nikon.de

Further system descriptions can be found in Kaiser, 1999, pp. 138-150.

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48 Project description see: [Mairinger, 1998, pp. 41-46].

9.4 International Projects

9.4.1 AFIP - Armed Forces Institute of Pathology

[Source: Mullick, 1996, pp. 187-193; Mun, 1995, p. 160; Yatsenko, 2000; http://www.afip.org/telepathology/].

Participants

Expert: Armed Forces Institute of Pathology, 6825 Sixteenth Street, N.W., Washington, D.C. 20306-6000

Client: All over the world

Background

The Armed Forces Institute of Pathology (AFIP[49]) had been created by the U.S. military health care support services of the Department of Defense. Already starting in 1862 with the objective to improve medicine of the U.S. Army, three national medical resources arose:
a) the National Library of Medicine, b) the Walter Reed Army Institute of Research, and c) the Army Institute of Pathology, later renamed to Armed Forces Institute of Pathology - a joint agency of the Army, Navy, and Air Force. The AFIP had put a lot of effort in the evaluation and distributed deployment of emerging telecommunications technologies within the Institute's environment. It sees its mission in medical consultation, education and research[50].

The AFIP's experience with telepathology began with a pilot project that extended from 1991 to 1993. Telepathology services in the form of diagnostic consultations were provided to remotely located Army, Navy and Air Force pathological laboratories. Since diagnostic results were satisfying, the practice of sending both, digital images and glass slides was discontinued soon. Soon the transmission of glass slides was no longer necessary, due to the improvement of image acquisition technologies which provide high resolution images.

Since 1993, the AFIP's telepathology services are also offered to civilian laboratories and pathologists globally [Mullick, 1996, p. 187]. First the AFIP furnished three pathology laboratories in the states of South Carolina, Tennessee and Ohio with telepathology units. These units provided brief on-site technical training and established access to structured formal anatomic pathology diagnostic consultations. A further telepathology service unit was built in the Commonwealth of Puerto Rico (V A Medical Department, Puerto Rico Health Sciences Center, University del Caribe). It serves the U.S. Navy, as well as local private laboratories with tele-consultation and tele-education services. Interestingly, the minimal communication requirement between the AFIP and case referring laboratories was as modest as a conventional telephone line and an Internet access.

Telephone lines are judged as sufficient because the AFIP employs static imaging systems where transmission speed is less important. The AFIP's activities in consultation are

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49 http://www.afip.org; contact address: T. J. O'Leary, Department of Cellular Pathology, Armed Forces Institute of Pathology, Washington, DC 20306-600 [Becker, 1993, p. 909].

50 http://www.radpath.org/history/body.html

mostly focused and organized on single organ systems, such as dermatopathology, genitourinary pathology, or GYN/breast pathology. Several other disciplines are organized on larger, more encompassing areas like infectious and parasitic diseases, veterinary pathology, or medical and molecular genetics. Since 1996 the AFIP has also started to employ real-time system options for specific pathological needs. In 1995, already 200 cases had been successfully referred for diagnostic consultation.

Parallel to the tele-consultation services, the AFIP started to conduct the first electronic slide seminars through telepathology. Soon the AFIP began to offer courses and teaching programs world-wide on the WWW[51] . International pathologists got access to Internet-based conferences where criteria of difficult and rare diagnoses were discussed. Further the AFIP's Wednesday Department Slide conference, which previously reached 135 institutions every week by mail, started to enjoy a world-wide audience on the department's WWW site [Mullick, 1996, p. 191].

In 1996 the AFIP already grew to a total staff number of 825 employees. Over 540 civilian and military staff were employed in 22 specialized pathology departments in consultation, education, and research. Remaining 285 employees are working in ancillary or support services. Each year, the AFIP responds to more than 48.000 surgical pathology and autopsy consultation requests from all over the world, including investigations of military and civilian aircraft accidents and other national disasters. The AFIP claims to get relevant patient information and clinical history in advance of a consultation session, to be able to do a proper interpretation of images,. The fee is approximately US-$ 50 (overview about fees, please see appendix IV). The AFIP is known for rapid turnaround times. In general final diagnoses are faxed to the contributor within 2 to 4 hours after receiving the images (average of 3 hours) [Mullick, 1996, pp. 187 ff.].

Pathological Services

The AFIP offers consultation services, education classes, and runs various research activities all over the world.

Equipment

Case consultations can be sent either by file transfer protocol on the Internet, by modem, using the Roche Image Manager system (Roche Image Analysis Systems, Elon College, NC), or through the Internet, using Silicon Graphics (Silicon Graphics, Inc., Mountain View, CA.).

The cameras used by the AFIP are able to magnify in the ranges of 2x, 4x, 10x, 20x, 40x. The following cameras are employed[52]: Kontron Electronic (resolution: 1024 x 768 pixels), Pixera (resolution: 1024 x 768 pixels), Polaroid DMC (resolution: 1600 x 1200 pixels), Sony DKC 5000 (resolution: 1500 x 1144 pixels), Sony DXC-760 MD (resolution: 768 x 500 pixels).

The AFIP telepathology service can handle multiple-image formats. The most common ones are JPEG compressed files. Images are viewed by using Adobe Photoshop 3.0

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51 http://www/afip.mil
Extensive information: http://www.afip.org; contact: Director Bruce H. Williams, telepath@afip.osd.mil or consultation@tele8.afip.org

52 Source: http://www.afip.org/telepathology/cameras/webpages/40x.htr

(Mountain View, CA) or Mediaconvert, a graphics tool in Irix 5.3 System 5 (Silicon Graphics).

9.4.2 Telepathology Network in Arizona - the AITN

[Source: Bhyttacharyya, 1995, pp. 9-17; Weinstein, 1995, pp. 219-226; Halliday, 1997, pp. 17-21; Nelson, 1997, p. 176A; Kayser, 1999, p. 153; http://www.ahsc.arizona.edu/telemed; contact: ranaldw@u.arizona.edu].

Participants of the Arizona-International Telemedicine Network

Expert: University of Arizona, College of Medicine, located in Tucson, Arizona.

Client: Four hospitals in USA, (Phoenix / Mesa, Cottonwood, Kingman, Yuma), one in Mexico (Hermosillo), and one in the People's Republic of China (Hangzhou). Two of these hospitals have a single pathologist in solo practice employed, at each of the other sites three to eight pathologists work together as a team of colleagues.

Background

A similar service as the one of the AFIP had been created in Arizona - the Arizona-International Telemedicine Network (AITN) within the Arizona Telemedicine Program (ATP). The ATP is a rural telemedicine network that serves rural communities in Arizona with multi-specialty telemedicine services. Cases are tracked through this network to sub-specialists, who will give diagnostic advises to the referring pathologists.

The AITN became operational in June 1993, with 'pathologist-to-pathologist consultations' as its first service. It linked referral sites in three countries to the 'Central Telepathology Laboratory' at the University of Arizona, College of Medicine, located in Tucson, Arizona. The AITN does not set any limitations on the types of cases that would be accepted for consultation. Eleven pathologists are employed by the Central Telepathology Laboratory of the AITN.

The AITN mainly works with static image telepathology systems. It tries to create a model, where general pathologists operate as triage telepathologists, and where telepathology workforce could be organized with sub-specialty pathologists utilized on an ad hoc basis. The triage model may be suited to pathology practices that incorporate general pathologists into their customary work flow. Cases are distributed and tracked by a central office of the network. The network's objective is to increase collegiality to improve the quality of diagnoses, and to reduce the need for subspecialists at remote sites. Subspecialists are readily available 24 hours a day as consultants for general pathologists. Approximately 30 cases per month are transmitted within this network. So far, second opinion consultations have been executed for over 300 cases and many telemedicine training programs have been offered. Since the services were found to be valuable they already gained high acceptance.

Pathological Services

The AITN's network has been established for primary diagnostic services, second opinion consultations, and quality assurance programs. That is that the AITN provides 'telepresence' services for cases for which a referring pathologist requests assistance in rendering a primary diagnosis, and it offers 'telediagnostic' services for cases for which a referring pathologist had already rendered a diagnosis and now asks for verification.

Equipment

The camera (Kontron ProgRes 3012) operates at 1024 x 774 pixels and at 24 bits of color. Images are compressed by JPEG to a ration of 6.5:1. The frame grabber has resolution options of various pixel combinations. The finally used resolution is 768 x 580 pixels or lower for specimen orientation images, and 1024 x 774 x 8 pixels images for diagnoses. A Zeiss microscope (Oberkochen, Germany) with a 10x eyepieces and 2x, 4x, 10x, 20x, and 40x objectives is used. Data are stored in a reference case database (Paradox, Boreland International, Inc. Scotts Valley, CA).

The aim of the AITN is to offer consultation services, accessible by using ordinary telephone lines. All sites are connected by standard telephone lines using error-correcting 14.400 bps modems. Average images are compressed via a lossless algorithm (JPEG) to approximately 300 KB.

The AITN uses the Roche Image Analysis System (RIAS-ImageManger, Roche Image Analysis Systems, Inc., Elon College, NC). It works with a Microsoft Windows platform (Microsoft corporation, Redmond, WA) and uses PC computers.

9.4.3 ICIT - International Consortium for Internet Telepathology

The idea to build up an International Consortium for Internet Telepathology[53] (ICIT) was formed in 1995. The original participants were the Oxford University (Oxford, England, Dr. McGee), the Armed Forces Institute of Pathology (Washington, DC, USA, Dr. Fontelo), the Wright Patterson Medical Center (Dayton, OH, USA, Dr. Elsayed, who also initiated the static image telepathology at the AFIP), the Japan National Cancer Center in Tokyo and Chiba, Japan (Dr. Mukai and Dr. Matsuno), and the Georgetown University Medical Center together with the Imaging Science and Information Systems Center, both located in Washington, DC, USA (Dr. Azumi, Mr. Yagi and Dr. Mun). The ICIT is designed to be an open forum for international telepathologists - a so called ‘telepathology system for the masses’. The Internet is used as communication medium for a rapid and frequent exchange of opinions, ideas, cases and consultation services among international pathologists.

The ICIT is based on static telepathology systems, because such systems are cheaper, not as complex as robotic systems, and hard- and software can almost be bought off-the-shelf. Compatibility between systems is easy to achieve by using almost existing hardware, software, image, and communication standards [Azumi, 1996, pp. 447, 448, 451]. The idea is to create an easy to access and easy to use telepathology network at an affordable price. This network should be used for the everyday pathological practice. It should help to improve the communication, consultation and education of pathologists. Interesting cases can be posted to the ICIT’s web site and used for educational purposes. ICIT may lead to a quick evolution and adaptation of new entities and classifications among international pathologists.

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[53] Web site: http://gomyan.basic-sci.georgetown.edu and FTP server: ftp://gomyan.basic-sci.georgetown.edu; contact person: Mr. Norio Azumi, Department of Pathology, Georgetown University Medical Center, 3900 Reservoir Road, N.W., Washington, DC 20007, USA.

9.4.4 UICC Telepathology Consultation Center - TPCC

[Source: Conceptual paper, UICC meeting on telepathology. Charité University Hospital of Berlin, Institute of Pathology, 16.-19. July 1999, M. Bodó, S. Hufnagl, not published; Hufnagl, 2000/(2); Dietel, 2000].

The TPCC[54] is an actual approach to offer international consultation services. It is comparable with the activities of the AFIP in Washington, USA, with which a cooperation is intended. The consultation center will be located at the Charité University Hospital, Institute of Pathology (Rudolf-Virchow-Haus) in Berlin, Germany, since this institution offers with about 40 pathologists a sufficient background. It has the necessary capacity and communication infrastructures, as well as the pathological and computer know-how at hand. The objective of the TPCC is the improvement of the histological and cytological diagnostic quality in tumor pathology, and an enhancement of pathological communication. The TPCC provides a time-saving and easy access to high-quality pathological consultations independent of the client's location. Particularly attention will be given to TPCC's access by developing countries and smaller institutes of pathology in Eastern Europe, Asia, and Africa.

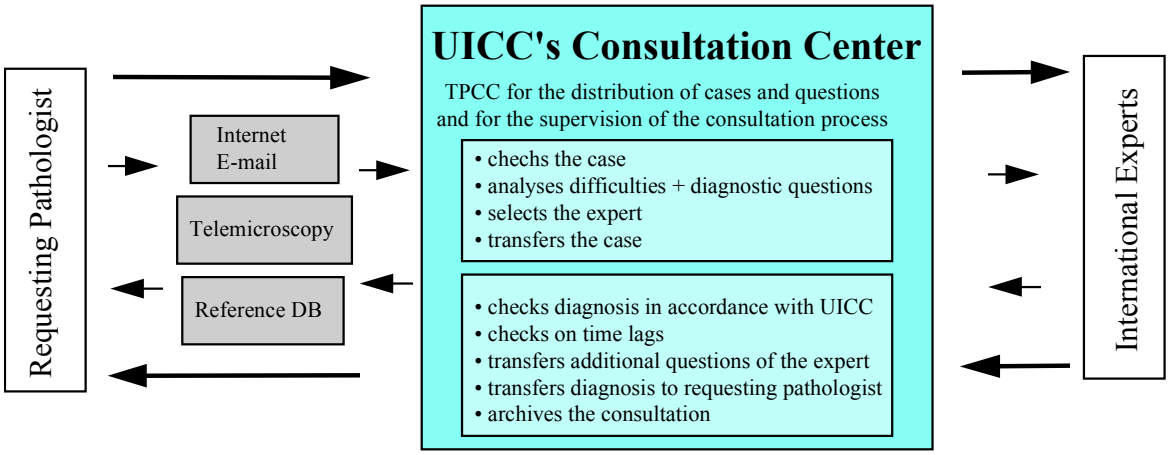

Figure 11: Tasks of the UICC's consultation center in Berlin.

Consultation Process of the TPCC

The request for consultation services must come from a pathologist, who is visiting the TPCC homepage to register as a new user. Then this client will download and fill in a form, where diagnostic and clinical information is requested and image fields for microscopic and macroscopic images are provided. Alternatively, the client can contact TPCC by e-mail, which automatically sends back a reply with the desired form. A TPCC server confirms each arriving filled in form by sending a tracking number. As soon as a case arrives at TPCC, a pathologist checks it for completeness, analyses the difficulties and the diagnostic questions, and forwards the case to an experienced pathologist. For this the TPCC has 'voluntary contracts' with internationally recognized pathological tumor experts. If additional questions or further inquiries will arise, the TPCC meditates between the requesting pathologist and the participating expert.

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[54] Conceptual paper, UICC meeting on telepathology. Charité University Hospital of Berlin, Institute of Pathology, 16.-19. July 1999, M. Bodó, S. Hufnagl, not published

Before a diagnosis is transferred to the client, it is checked at the TPCC for possible time delays. Currently a reply should be given within three working days. Further each reply is checked for inappropriate interactions and for differences according to the UICC guidelines of tumor diagnostic, e.g. UICC-TNM, WHO-terminology. The TPCC is the central organization to facilitate and standardize procedures of telepathology in the field of tumor diagnostics with regard to the WHO terminology (e.g. SNOMED, ICD-O code). In addition it will contribute to the integration of quality standards and ethical rules. Each diagnostic result is sent to the client, either passively by fax and e-mail, or actively by visiting the TPCC homepage. Doing so, the TPCC is adding a form to each result. This additional form will help to follow cases. Each case is stored in a reference case database, which will be used for documentation, scientific research purposes and telepathological educational lessons. Altogether, the standardized request forms and answer sheets for diagnoses will increase the automation at the TPCC. At present, cases are based on XML or HTML. In the future DICOM standards will be employed. Requested cases, which are generated with other telepathology systems, can be directly imported into the TPCC's database.

The TPCC will start his tasks in the year 2000. Two pathologists and a computer specialist are employed by the UICC for the TPCC tasks. Consultations are for free for the first two years. After then reimbursement will be charged by the first-world-countries, while the developing countries will still have free access to all services. It is predicted that at least between 100 to 200 cases per week will be sent to the TPCC during the first two years. Carrying out consultations, the final legal responsibility always remains at the requesting pathologist and is not taken by the UICC or the UICC's experts.

10 Politics and Management Factors of Success

10.1 Political Factors

The political and cultural situation of health care delivery systems is dependent on the religious, sociological, philosophical and natural science's view of a population, as well as on the type of state and economy. It has to be taken into account that behind the terms patient, medicine and 'health care delivery system' there are people, who follow their tasks and interests. Between all of them there is an interaction corresponding with the respective system [Köhler, 1997, p. 11]. To understand the political and cultural situation, which may have an influence on telepathology introduction, it makes sense to have a look at the key players of telepathology system introduction and their main interests.

10.1.1 System Suppliers

From the point of view of the private sector there are only two ways to increase sales in a commodity market. Either one increases the size of the total market by expanding the demand for bandwidth, or market shares have to be increased by marketing and product differentiation. Telemedicine applications promise to serve both. No surprise that much of the current enthusiasm for telemedicine applications is being generated not just by pioneer physicians, but mainly by suppliers of information highway services and by other commercial developers. They are interested to offer and to extensively market their products and services for telemedicine to ensure that an investment pays for itself or even gains profit [Perednia, 1995/(3)].

Considering telephone and cable television companies, many of them have invested vastly in optical fibre cable networks, which they now want to be used. They realize that telemedicine applications are based on the network transfer of a huge amount of data. Therefore they are increasingly funding pilot telemedicine projects to assess their commercial viability (horizontal integration in the value added chain) [Puskin, 1995/(1), p. 64; Swett, 1995, p. 594]. As an example, in the German telepathology project HISTKOM, as well as in the Swiss SAMEBAS project, the telecommunications providers were the driving force. Searching for new markets, also manufacturers of video conferencing, imaging, computers, medical, and multimedia equipment have likewise been attracted to the telemedicine market. The same takes place with microscope suppliers, for example, Olympus, Zeiss, Leica, and Nicon, which are all offering solutions for telepathology (see chapter 9.3).

However, designing a system is not simple. Users' needs have to be assessed, system specifications have to be written, prototypes have to be tested and still there is no assurance that the system will be used in clinical practice [Weinstein, 1997/(3), p. 1]. Those, interested in developing telemedicine systems struggle a lot. They often have to note that policy-makers and regulators have still not shaped tariffs, payment policies, and laws that respond to technological change and its applications for health care. Therefore not rarely the pioneer suppliers of telemedicine systems went bankrupt, because the lack of these factors did not allow to find customers and to create a market (e.g. Resintel at the project in Dijon/F – see chapter 9.1.3.5). Another reason that developed systems failed, is that the actual available systems do often not meet the needs of physicians and are not capable of being integrated into the 'everyday' practice. That is why critics recommend that all the people concerned should participate in the design and development processes of telemedicine applications, including potential users, the federal government, congress, states, telephone companies, health care providers, and other public and private institutions [Puskin, 1995/(2), p. 64; William, 1995].

10.1.2 Health Care Providers

During the last years the situation of health care providers was embossed by increasing competition for a shrinking economic pie [Braly, 1995/(1)]. This situation is driven by the policy of health care reforms and insurance behaviors, which resulted in falling insurance capital investment rates, discounted provider payments, and deeply slashed government health expenditures. Consequently the economic pressure of health care providers increased.

The health care providers responded. First of all they started to think more 'economically'. Many controlling activities were introduced. For example providers shortened treatment processes and thereby lengths of hospital stay. They avoided unnecessary diagnostic and surgical procedures, or reduced inpatient utilization by shifting patients as soon as possible to ambulatory units [Fack-Asmuth, 1996, p. 385 ff.]. Second, facing a situation of strong competition, many providers started to think like entrepreneurs and **interacted strategically**. They either followed a price-based strategy with faster cash flow, reduced cost, pro??cess optimization, and improved resource utilization, or they followed the nice or differentiation strategy and invested in very high specialized quality medicine [Austin 1995; Whipple, 1993; Hufnagl, 1999, p. 93]. Such providers not rarely seek telemedicine links to prestigious academic institutions as part of their quality assurance program [Swett, 1995, p. 594]. In addition '**patient satisfaction'** was declared as overall aim [Thill, 1996, p. 232; Murphy, 1993], combined with extensive 'quality assurance' activities and marketing campaigns [Rode, 1997, p. 20]. Third, they created **business alliances**, multi-unit hospital chains and corporate medicine by either co-operating with competitors, or by just mergers and acquisitions [Taylor, 1994; Weinstein, 1987, p. 647]. Health care networks were created, sometimes even '**virtual delivery systems'** [Coile, 1995].

One of the most important pier of these developments and key to success are information systems. Providers realized that information system plans therefore have to be tied closely to the overall strategic plans of their organization [Solomon, 1995; Landis, 1991, pp. 23-26; Newman, 1990; Lumsdon, 1992]. A kind of 'marriage of information technology' and care delivery arose [Braly, 1995/(1)]. Within this structural changes, telemedicine applications were recognized as powerful tools of the future, which therefore were integrated to the overall information architecture [Slipy, 1995].

Due to the situation of increased competition, mandated access to care, and increased provider risk with regard to patient outcomes, the interest of providers in telemedicine technologies increased continuously. On a long term, with telemedicine support providers hope to become more competitive in winning health care contracts, to reduce the economic and medical risks associated with caring for patients in rural areas, and to provide relatively low-cost specialty services to areas where full-time staffing is impractical or uneconomical. However, as long as equipment is expensive and rates of capacity utilization are low, existing telemedicine systems rarely showed efficiency. This is especially obvious at dynamic-robotic telepathology systems. That is why most provider who are following the strategy of cost reduction, went in a position of 'wait and see'. An exception is the 'Veterans Integrated Service Network'. The decision makers of the Veterans Hospitals in USA see in telemedicine a possibility to share resources. Therefore they have invested in telemedicine applications, even though the actual trials are mostly not cost efficient. Considering the behavior of physicians, especially specialized physicians recognized telemedicine as a figure to efficiently deliver their highly specialized services. With this they hope to

increase there position in the state's 'shared care' policy [Blobel, 1998, p. 72, Wyman, 1995]. Such kind of physicians often were found to be the pioneers of telepathology.

Altogether most providers recognize in telemedicine applications tools which could improve both - access to certain types of specialty care and the overall quality of the care provided [Perednia, 1995/(3)]. From the position 'to wait and see' they slowly change to a curious behavior.

10.1.3 Insurance Companies and HMOs

Insurance companies can be seen as the representatives of patients. In the USA 100 million Americans are enrolled in HMOs (Health Maintenance Organization) or preferred provider organizations. 33 million people are enrolled by Medicare and Medicaid, the governmental health programs for older and poor US citizens [Coile, 1995]. No surprise that insurances with such high member rates and health market penetration have a huge influence on health care politics and thereby on the development of new technologies like telepathology applications.

There are two main interests of insurance companies. Firstly to keep health care cost low in order to avoid an increase of membership premiums, and second to guarantee high quality of medical treatment. However, due to the higher life expectancy of members, and the growth of new expensive technologies and treatment procedures (e.g. operation on the heart, expensive implants and medicine), together with new medical equipment (e.g. CT, lithotripter) the cost recovery of the health care systems became a problem all over the world.

In the USA the problems of under-served rural areas pushed the development of telemedicine applications a lot. That is why the reaction of the US-insurers is from high interest, since it may be adaptable to other countries' situation. At first insurers **shaved an attitude of reserve**. But after some telemedicine applications proved to be cost-efficient and appropriate, for example 'teleradiology' services, billing-codes were introduced hesitantly. Some HMOs and managed care organizations started to experiment with their own systems to improve access to specialists. For example, they started trials where radiologists are no longer summon to hospitals at night, but where CT scans and MRIs were transmitted to their homes instead. Others, like Kaiser-Permanent system or the HMO in Albuquerque, are piloting dozens of telemedicine projects by themselves. The objective is, to expand services to other rural parts of America, where primary care physicians can teleconsult the participating specialists [Ziegler, 1994].

Considering the behavior of insurers all over the world, by contrast to the US-insurers, most of them prefer to remain in some kind of waiting position. They fear increased health cost if these new tele-technologies are introduced. As an exception, some insurers support research activities with grants. Up to now most insurers did not set up regulations for continuous billing of telepathology services and do not give clear statements, if and when they will do so. This cautious reaction may create a barrier for telepathology introduction and is therefore investigated at this study (see chapters 18.3.1, 19.1.2.9) To overcome this resistance, Turcan recommends the strategy of heavily involving insurers in network discussion to persuade convince from telemedicine applications.

> *"I have yet to hear any commercial insurer refusing to reimburse a medical consult when they've been involved in the network and process design." [Turcan, president of Telemedical Systems Integration, an Atlanta based health care consulting firm specializing in telemedicine, in Wyman, 1994].*

10.1.4 Governments

While insurers and suppliers are more or less starting to realize the value of telemedicine, much of the money used to develop systems still comes from the federal governments [Ziegler, 1994]. Many governments regard it as their task to guarantee health care support for their people. That is why for example in Switzerland or Germany hospitals are often owned by the state or communities.

Congresses act to reform health care delivery and create various reform packages. These packages try to consider and answer the health market needs, to improve the disease management, and to coordinate the health care delivery process as a whole [Braly, 1995/(1); Rienhoff, 1998, p. 9]. In addition, organizations like the WHO (World Health Organization) generate frames to support the development of an integrated international health care delivery system. Since the WHO recognized that telemedicine application may be a good tool, it asked their member states to develop national programs which may improve the introduction of telematic solutions in health care [Rienhoff, 1998, p. 7]. With the introduction of such systems the WHO hopes to improve the overall quality of international health care, especially the one of third would countries.

To discover the potential of telemedicine, several governments set up market analyses. For example in Germany, in 1996 the Government passed the study 'Info 2000' - Germany's development towards an information society (Deutschlands Weg in die Informationsgesellschaft[55]). Further in 1997 the Roland Berger & Partner GmbH[56] in Munich was instructed to examine the situation of telemedicine in Germany [Matthies, 1998, p. 98]. Both reports search for solution to overcome the exploding information flood. It was hoped that the demand for high quality care and cost reduction in medicine can be answered by telematics. As a result of these studies, several plans of actions were developed and the work group 'telematics in health care' was built at the ministry of health care [Dietzel, 1997/(1), p. 2; Dietzel, 1997(2), p. 171]. In parallel, several state governments in Germany introduced model programs. The Bavarian Government for example introduced 'Bayern Online', the Government of Sachsen introduced the program 'Telemedicine Sachsen', and the Government in Berlin supports the 'high-speed network of Berlin', which connects the University Clinic Charité of the Humboldt-University of Berlin with other medical institutions. The Charité is also considerably involved in telepathology trials [Wedekind, 1998, pp. 59-63; Brummer, 1996, p. 15; Thiel, 1996, p. 17].

In the past, state policy makers in the USA often failed to consider needs and solutions across the range of state activities. This resulted not only in missed opportunities for capacity and cost sharing, but also led to cost redundancies and incompatibilities. However, governments started to concern a lot to provide accessible, low-cost health care to all Americans [Perednia, 1995/(3)]. That is why they became highly interested in the provision of political, technical and economical frames for a managed care approach to health service delivery and telemedicine introduction. Since analyses showed that one problem of telemedicine introduction is inadequate information infrastructure and uncoordinated infrastructure planning, state decision makers put a lot of effort in the standardization and coor-

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55 http://www.kp.dlr.de/BMWi/gip/programme/info2000.

56 Roland Berger Study: "Telematik im Gesundheitswesen - Perspektiven der Telemedizin in Deutschland". Study for the German Government, Department of Education and Science, and for the Department of Health Care Policies. http://www.hcp-protokoll.de/arbeit.html

dination of technical environments. Frames were developed, which especially consider the integration of information technology planning and development processes across state agencies and within communities. Within these approaches the US-governments recognize the national effort to develop the electronic information highway, which is needed as a back-bone for telemedical services. Moreover, since former states' telecommunications legislation often failed to consider the integration of health care concerns, too, legal aspects were adapted to the new situation [Flaherty, 1995/(2)]. In parallel, several national 'Shared-Care' and 'Managed-Care' concepts were developed. Doing so, a special focus of federal governments became the deployment of advanced medical telematics in rural communities to increase the viability of their education and health care systems [Smith, 1997]. Examples for US interstate telemedicine demonstrations are the WAMI network in Alaska, Idaho, Montana and Washington, or the High Plains Rural Health Network in Colorado, Kansas and Nebraska. Since recent years several other state funded telemedicine networks arose. Finally governors, their cabinet officials and budget directors regarded the integrated planning process of telemedicine not just as a part of periodic high-level initiatives but also in the course of the regular budget process [Flaherty, 1995/(2)]. A similar situation can also be recognized, for example, in Norway, Sweden or Japan, where the governments started to push telepathology developments.

In summary, governments showed even more interest than insurers to support and examine telemedicine approaches, since they are aware that the 'health of their people' is an important value, and they feel responsible to protect this value. That is why they maintain health care delivery systems and are keen on a high level health care for all their citizens. Telemedicine seems to be a tool for them to serve this objective.

10.1.5 Professional Organization of Pathologists

At most countries similar groups of people or organizations are united in an association of interest, often referred as lobby. Depending on the size of the group, such unions often have a huge impact on the policy and developments in their environment.

Pathologists are mostly united to such associations, which care about their interests. In Germany for example it is the 'Deutsche Gesellschaft für Pathologie' (association which cares about pathological scientific issues), the 'Berufsverband Deutscher Pathologen e.V.' (professional organization of pathologists, which concerns about political, economical or structural issues), and the 'Bundesärztekammer' (professional organization of doctors). These associations make the policy from the point of view of pathologists, take care of the quality of pathology procedures, set up documentation standards, initiate directions for the future, or give statements about critical points in pathology, e.g. legal statements, organizational recommendations, or statements about the estimation of new technologies such as telepathology.

To give an example about the reaction and influence of such unions, on April 12th of 1996 the directors of the German professional organization of pathologists published a statement about intraoperative frozen section examinations (see appendix I, letter 2). Their judgement was very negative and rejected frozen section examinations executed by telepathology. Firstly they denied macroscopically examinations being executed by a less experienced client. They argued that macroscopy demands many years of experience and huge competence and therefore can't be delegated to the client. Secondly they warned their colleagues about the legal consequences related to the increased risk if tasks are no more directly under control of the examining pathologist. Such statements are almost like a written law

and therefore are followed by most pathologists. Nevertheless, some pioneer pathologists in Germany started to use telepathology systems, mostly static systems for second opinion consultations. Since their experience was positive, in 1999 they made a statement[57] to their professional organization of pathologists with the request to revise the negative statement of 1996. As a reaction in June 2000, the professional organizations in Germany set up a work-group to investigate telepathology applications. Pathologists now await the statement of the professional organization full of suspense, since it will strongly influence the telepathology distribution in Germany. It is to assume that, similar to Germany, also in other countries the influence of professional organizations will have a huge impact on the national telepathology developments. Therefore the participants of this study were requested to judge this impact for the success of telepathology.

Other important interest groups in pathology are the International Academy of Pathology (IAP), and the International Academy of Cytology (IAC), together with the Scientific Association of Pathology. These organizations set up the directions in pathology education and training, and decide which new procedures, treatment practices and therapy forms will be used by pathologists in the future. They are also responsible for the training of young physicians to become specialized pathologists. That is why it is to assume that their judgement about the different telepathology services will also have an impact on pathologists' telepathology acceptance.

10.1.6 Support of Decision Makers and of the Top-Management

At a research study of Williams, who requested telemedicine project leaders about their experience, one director of a successful telemedicine project attributed the secret for success to the commitment from management and from the top of the sponsoring organization to adapt telemedicine. Another project leader reported that the managers of his healthcare organization almost killed his project before it even started. A third director described how organizational support for telemedicine was not a forgone conclusion, even after equipment had been purchased [Williams, 1995; Moore, 1995, p. 3]. Also Puskin discovered effective leadership as a cornerstone of any telemedicine system. He found out that if there are champions, there is a much greater likelihood of a project being successful. The promotion of leaders with an influence on decisions, who are within a community's power structure and who can dictate action and commit resources, both human and financial, is needed. Further Puskin also carried out that the support of clinical leadership is necessary, otherwise systems are doomed to failure, since it are practitioners who drive telemedicine utilization. For example, a telemedicine project at Fort Stockton, Texas, was supported by a very skilled administrator but not supported by the hospital's community, which already had referral relationships with specialty physicians whose practices were within reasonable travel-time for patients. This project never got off the ground. In contrast to a project in Alpine, Texas, where right from the beginning of the project there has always been at least one physician champion for the project. This project survived, despite the absence of federal funding [Puskin, 1995/(1), p. 63]. Also at this study several users of telepathology systems reported that the support of decision makers is vital for the success of telepathology implementation.

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57 Konsensus-Report Telepathologie- Entscheidungsvorlage für den Berufsverband Deutscher Pathologen e.V., meeting at the 20.11.1999, at the Charité University of Berlin, Institute of Pathology, M. Dietel, S. Hufnagl, not published. For information about the state of the Art, please contact Mr. Hufnagl:, Charité, Dep. of Pathology, Berlin.

10.2 Historical and Geographical Factors

10.2.1 Cultural and Structural Factors

Cultural, structural, and geographical factors are also stated as critical factors of telepathology's success in the literature. A lot of experience due to political and cultural situations was made in disaster medicine, where global international telemedicine networks across boundaries had to be established very fast. Soon problems arose concerning the countries' specifics. Political and bureaucratic barriers occur. Also the problem of differences in language and literacy, differences in medical practice standards, cultural differences in acceptability of telemedicine, differences in resources available for medical care, or differences in basic supporting infrastructures are not simple to solve [Williams, 1995; Merrell, 1995, p. 17; Ferguson 1995/(1), p. 36]. In most cases approaches were unlikely to be successful until matched by intensive local area efforts [Llewellyn, 1995, pp. 29-34]. Therefore it is very important that organizational, cultural, and technical factors, as well as the political reality are taken into account when establishing telemedicine networks, since all these factors seem to have an impact on the adaptation and utilization of telemedicine applications.

10.2.2 Problem of Communication

Not rarely, when cultural boundaries are crossed, there is a difficulty in communication as well. People are used to do things differently, yet even to think differently due to their cultural background. The process of telepathology system introduction therefore has to be done with a sensitive feeling for all these resistances. Doing so, again it makes sense to learn from the experience of disaster medicine, which mostly crosses boundaries and cultural regions (see chapter 4.1.5).

10.2.3 Problem of Language

Another problem of international telemedicine exchange is language. Thinking about all the emergency links between USA and Russia for earthquake emergency help, or the telemedicine support of third world countries (e.g. by the AFIP), this problem becomes obvious. Williams recommends that for serving telemedicine across boundaries it is useful to employ the increasing software applications available that can assist in 'machine-translation'. He is already testing a software for automated translation of medical reports from Spanish into English [Williams, 1995]. In addition the introduction of international standard vocabularies in pathology should be speeded up (meaning of standardized vocabulary, please see chapter 14.2.1.2).

10.2.4 Geographical Factors

Most visual information exchange and telemedicine approaches settled down at geographical environments with less population. For example in Canada even the mail service was difficult to organize, due to the huge areas with less population. As a consequence of such geographical situations, e-mail was early introduced and telemedicine, too. A similar situation is reported from China and Russia [Zheng, 2000; Gribunov 2000]. In Greece, there are so many islands with small health care facilities that telemedicine enjoys high acceptance. On the island Mali, only a dozen physicians are available that is why again telemedicine services were the answer for poor health care facilities [Williams, 1995]. The Scandinavian

countries or Switzerland have specific geographic conditions with a low population density and with road connections, which are often hindered by high mountains. Thus, it is nearly impossible and expensive to offer the rural population a health care system of the standard available for the citizens of the main cities. Telemedicine systems seem to be an adequate technique to increase the health care standard in these regions. To give an example that the geographical situation has an impact on telepathology introduction - the Institute of Pathology of the University of Tromsoe in the less populated Northern Norway is one of the leading institutions in telepathology. Another example is Samedan in the mountainous Switzerland, where one of the first dynamic telepathology systems is provided by the University of Basel/CH [Kayser, 1995/(2), p. 198].

Regarding the situation in health care world-wide, there are areas with an oversupply of physicians and with a strong representation by all subspecialties, and there are vast areas with little or no access to modern state-of-the-art health care (e.g. Africa). Such geographically under-served areas would benefit a lot from telemedicine access [Swett, 1995, p. 601]. South Africa or the Ukraine are already using the services of the AFIP and also Thailand shows a huge interest in telepathology support [Banach, 2000; Yatsenko, 2000; Sampatanukul, 2000].

10.3 Management Factors of Telepathology

10.3.1 Integration of Telepathology in Strategy Settings

> *"Information systems are going to play an increasingly important role in the success of health care organization of the future." ... That is why ... "...someone in the organization must be linking* ***information systems' capabilities with the strategic direction of the organization.****" [Larry Grandia, Vice President of Information Systems at Intermountain Health Care, Salt Lake City, Utah/US., in Hard, 1993]*

Health care provider are facing a situation of strong competition and cost pressure. To answer this situation, they introduced business strategies and aligned goals for their information systems with those of their strategic plans to meet the future challenges towards a '**Health Strategy Centers**', as Andersen Consulting is calling it [Hard, 1993; Hard 1992; DeBow 1994]. There are several widely accepted strategic frameworks described in the literature and adapted to the situation of health care providers, such as Ansoff's strategic management model, the four strategic orientations of Miles and Snow, or Porter's competitive analysis model [Austin, 1995]. No matter, which strategy is followed, e.g. in Porter's model **cost leadership** strategy based on aggressive approaches to cost reduction and efficiency, **differentiation**, where health services are offered that are different from those of competitors, or **niche strategy**, where providers attempt to focus on a particular market segment or on a specific geographic location, information systems can and should play a broad role in the support of strategic planning and strategy development. Sometimes they even will create strategic advantages and new services by themselves. That is why telepathology systems should be an integrated component in health care providers' overall strategy, and be embedded into a well structured information management [Judge, 1993; Puskin, 1995/(1), p. 64; Weinstein, 1989, p. 41].

Scenarios How Telepathology Can Support Strategy

In the context of telepathology, strategic advantages may be gained in continuous quality improvement, in improvements of productivity and efficiency, or in supporting physician

relationships and the creation of health care delivery networks. Lets give some scenarios for illustration.

Cost leadership: The owner of three hospitals, one medical center (A) and two smaller clinics (B/C), want to reduce cost. He employs three pathologists at the medical center, one at clinic B, and clinic C is served by center A, either by specimen transport or a pathologist from A is travelling to C. With telepathology, pathological examinations at clinic B and C are now served by A. Consequently staff and transportation cost are reduced at C and B. In addition, to ensure that investment pays for itself, productivity at A is increased by serving two other clinics in the region with telepathology services. Further, the pathologists cooperate with another telepathology consultant, so that holiday and weekend services can be shared.

Differentiation: Hospital A only employs one general pathologist as it is usual for its size. Therefore, if this pathologist cannot give his diagnosis without any doubt, he is sending the specimen to the medical center, which is more than 100 miles away. Thus the patient has to wait for his result and perhaps a second operation is necessary. Now this hospital uses telepathology, so that expert pathologists can be consulted and knowledge databases can be accessed via Internet. This may make this hospital more attractive to patients than the competitor's one, although they are eventually more expensive.

> *"We're trying to do something that nobody else has done so we can get a big strategic advantage and everybody else will spend their time catching up." [Dewey, Manager of Clinical Information Services at Kaiser-Mid-Atlantic, in Taylor, 1994]*

Niche Strategy: A pathologist at A decides to create a specialized telepathology service center. He employs highly specialized pathologists, invests in the newest equipment, and links his institution with other pathology experts and to knowledge databases. In parallel, he starts with aggressive marketing activities, offers bulletin boards and online education lessons. Following this strategy, the Armed Forces Institute of Pathology is now famous all over the world for its pathological consultation quality.

Business Plans

After the strategy direction is set up, the strategy is transferred into business plans. These are high level, corporate-wide plans for all areas of the institution, describing the future production and capacity planning processes and the interrelationship between different functions. Also market shares and profitability are estimated in such a plan [Titone, 1994; Grace, 1995; Williams, 1995, p. 16].

Unfortunately, although decision maker know about the importance of strategy development opinion polls showed that at many hospitals there is a lack of a strategic information system or business plans. As consequence, systems are often not integrated across separate facilities and their introduction often does not follow an overall strategy direction [Grace, 1995]. Perhaps this is one reason for the often isolated situation of telepathology systems (see judgement at chapters 19.1.2.9 and 19.1.2.11).

10.3.2 Project Planning

10.3.2.1 Planning and Management

> *"You have to have a plan and you have to know what your goal is. Is it to improve access to health care, to reduce costs, to reduce professional isolation? It is so tempting to get confused, because you know, you can do all of that. But first you must know which one of these things is most important to you. Then, and only then, you can plan." [Moore, 1995]*

> *"There were two physicians who didn't want to be on call every night, so they hooked their two small hospitals together. That is a simple solution to a simple problem. But with a more carefully developed plan they could have been linked to an entire network of specialty care." [Moore, 1995]*

Based on the business plans of the institution experience showed that the success of telepathology introduction depends on a thorough **planning and management** process (guidelines for introduction, see ITC, chapter 5.1.3, please). Managerial issues seem to play an important role in both, the effectiveness and utilization of all types of telemedicine services [Perednia, 1995/(3)]. **Goals** and priorities must be defined early and coordinated at all levels of the project. The planning process should **involve all users.** Doing so, users' needs can be easily identified and systems will be perceived as useful as possible and of high value to potential users. Lessons learned from project evaluations showed that it is essential to well understand the users' needs and perceptions, before equipment is purchased and programs are developed [Ricci, 1997, p. 205]. The planning of continued education, periodic meetings and seminars are further effective means of promoting telepathology among health-care professionals and to increase acceptance [Sheng, 1997, p. 71; Puskin, 1995/(2), p. 126]. (Judgement of management factors see chapters 18.3.1 and 19.1.2.9).

Ongoing Evaluation Process

After all needs and goals are fully defined, data are collected and evaluated. Introduction plans are developed to avoid duplication efforts and misallocation of resources. The types of equipment and electronic services required is brought into the planning process.

Now ongoing evaluation is needed to determine whether investments made or approaches taken have been worth the effort, especially as telepathology technology continues to grow and change. Goals, technologies, and practice patterns that make sense today may not make sense tomorrow. Re-evaluation is necessary to ensure that the needs of users are being met in the future, too [Perednia, 1995/(3)]. Therefore it is recommended to use **guidelines or frameworks for assessing the performance** of the system with the given system goals. Evaluation goals for telemedicine have been suggested by Puskin [Puskin, 1995/(3), pp. 393 ff.] and by the Institute of Medicine [Institute of Medicine, 1996]. Puskin distinguished three general evaluation types: a) proof of concept, b) feasibility and value-orientated studies, and c) clinical trials. Several areas are regarded, in which the impact of telemedicine on health care has to be measured, including technical acceptability, integration into the health care system, or acceptance factors.

10.3.2.2 Strategy of Project Introduction

> *"You need to make sure that the initial few sites work well before bringing additional sites on-line. This minimizes the number of variables you need to troubleshoot." [Reid, Project Director of the Eastern Montana Telemedicine Project, in Anonymous, 1994]*

System introducers mentioned the temptation to try to do too much at first, since the technology makes so many things possible. That is why Puskin recommends, to build new telemedicine applications on the current telecommunications and to 'start where you are at the moment'. In his experience even the simplest telemedicine systems provides a catalyst for communities to collaborate across a wide spectrum of users and services. This behavior automatically will create the market demand necessary for supporting more advanced telemedicine services, he argues [Puskin, 1995/(1), p. 66]. Also Dzubur recommends for the beginning just to use an existing ordinary telephone network or ISDN connection, specialized low cost equipment, and specialized custom designed software [Dzubur, 1995, p. 269].

> *"My best advice is to have a plan that focuses on priorities. Start out small, and get functioning before your expand." [Comment of a project leader in Moore, 1995]*

10.3.3 Organization of Diagnostic Procedures

10.3.3.1 General Organization of Pathological Processes

Pathology procedures are either done for a specific **single case** (e.g. frozen sections or secondary diagnoses, where a specific case is discussed with the correspondent expert), or for a set of multiple '**en-bloc**' cases from different patients in a sequence without any break (e.g. for cytological smears). Telepathology is usually performed on single case diagnoses, since the appropriate equipment, line connections and organizational structures are not available for en-bloc cases, yet [Kayser, 1996, p. 476]. Considering telepathological procedures, the diagnostic behaviors of the involved pathologists have an impact to a smooth process. In addition, diagnostic performance and scheduling questions have to be solved to avoid long lasting breaks in diagnostic procedures.

Considering single cases, there are two different forms of telepathology organization - **synchronous** and **asynchronous**. Synchronous means that participating health care staff is discussing a patient's case at the same time (real-time interaction); asynchronous in terms of telecommunications means that transmission is not dependent on the synchronization of timing or frequency between the two nodes. Synchronous meeting up to now is rather a rarity in health care practice, since it would take far to much coordination effort. Most group and treatment coordination are carried out in an asynchronous manner, via the medical record, where most information is passed via textual, graphic or photographic materials [Allely, 1995, p. 208; Moynihan, 1995]. In telepathology, still imaging systems are managed asynchronous, dynamic live systems are synchronous.

10.3.3.2 Experience with Organization of Telepathology Sessions

Many telemedicine clients already reported about difficulties in answering the question how and at what time is it possible to contact a colleague or specialized expert. Who is the expert who can give a rapid and accurate solution of some difficult or emergency problems

in pathology? They also stated that scheduling is a problem, because interactive dynamic systems require the coordination of at least three schedules - at minimum two clinicians and a patient [Wyman, 1994; Martin, 1992, p. 420]. The problem of coordinated time schedule can go so far that rural site even prefer one medical center to another, as one project leader reported [Williams, 1995]. Also at a study in Sweden a limitation of the employed system was the difficulty to reach the right person to consult at the desired time (in 20 % the desired person was occupied) [Olsson, 1995, p. 240]. At another telepathology trial in Vermont, individual units could not rely on the connection every time. This led to the necessity of making test calls prior to schedule clinical interactions or meetings. This caused additional waiting time, adding to personnel costs and usage charges [Ricci, 1997, p. 202]. And not to forget, if a telepathology session last longer than it was set up, the following sessions will start with a delay, which again leads to an inefficient workflow. Therefore synchronous telepathology sessions have to be carefully planned and the task of each person has to be carefully defined, since it is to assume that a smooth workflow could have an impact on the overall acceptance of telepathology.

One possibility to overcome the problem of coordination is, to introduce a **coordination and control center** for telepathology services. Instead of the diagnosis expert has to be selected by the user, a medical data center handles criteria to automatically propose and select a diagnosis center for the requesting client. Selecting criteria are for example specialization, workload, up-time service, urgency, etc. [Allaert, 1999; Kayser, 1995/(1), p. 55]. Examples of such a center are the network of the French National Medical Association or the UICC Telepathology Consultation Center in Berlin.

10.3.4 Conclusion

The decision to establish telepathology services should support the strategic direction settings of an organization. The introduction of telepathology systems has to be carefully planned and managed. Within this planning process, the evaluation of the users' needs and user involvement, as well as the support of decision makers is important to make telepathology introduction successful. Many experienced telepathology decision makers recommend, first to start small and then to enhance equipment and services. As soon as a system is introduced, its performance should be permanently measured by guidelines and frameworks, based on the strategy and goal settings. One has to remember that telepathology technology is permanently changing and that systems have to be adapted to actual and future situations. The usage of telepathology services will demand structural and organizational changes. Especially at synchronous real-time sessions, the coordination of human and equipment resources has to be carefully planned. Since in telepathology, several persons are participating in a session, their tasks and responsibilities have to be clearly defined in advance.

11 Telepathology - System Design and Equipment

Technical Developments

In the 1960s and 1970s video equipment was very expensive and its quality was poor compared to today's standards. The long-distance telecommunications networks available at that time could not support the rapid, wide bandwidth transmission necessary for real-time videoconferencing. Computing resources were expensive and limited in speed, power, and flexibility. Compared to these previous developments, the recent resurgence of telemedicine is a function of the convergence of several economic and technological factors. These include continuously improvements of high resolution video cameras and monitors, digitization and compression of data, the development of powerful, inexpensive, and easy to use computing resources, as well as the improvements in the quality and distribution of telecommunications networks and applications [Grigsby, 1995/(1), pp. 19-20]. These development let to a widespread attention for telemedicine applications for sharing resources and know-how, for controlling health care expenditures and in serving people with high quality care. Soon decision makers and pioneers in pathology became interested in investing in telepathology systems and searched for equipment.

Components of a Telepathology System

To give a survey of the major components of telepathology's equipment, there is first of all a telepathology **workstation** necessary. A 'telepathology workstation' is a place where the pathologist receives images and audio information from remote areas. It incorporates a color monitor on which to view the transmitted images. Second, a **telecommunications network** to link the transmitting and receiving sites is needed. Third, a high-resolution **video camera** mounted on a **light microscope** to capture images of pathological specimens at the transmitting site is required. At some workstations (bi-directional workstation system) **video devices** are attached to the microscope for the transmission of images to other pathologists. Dynamic telepathology workstations integrate functions for the **remote control of a robotic microscope** at the local site. Another potentially useful component is a macroscopic television camera with a remote-controlled zoom lens for examination of the **gross specimen.**

The list of the given components is quite rough. In the following, a more detailed description is given. As technique is improving permanently, the given parameters have to be seen as minimum configuration quality.

11.1 Hardware and Networks

11.1.1 Multimedia Workstation

The multimedia workstation of telepathology systems mostly consists either of an Intel-based (Pentium) or Macintosh-based standard personal computer. The internal memory (CPU) should be at least 32 MB or more, and the mass storage device (hard disc) should be at least 1 GB or larger. The combination of display card and monitor should be able to handle at least 1024-pixel horizontal resolution and 14-bit color depth or better and 17 inch or larger in size. It has a video display accelerator with a PCI bus (e.g. Matrox Millenium bus PCI Card). A sound card (standard sound input/output) with speakers and microphone

is also necessary for video-teleconferencing. At most systems a color laser printer is available. For telecommunications TCP-IP interfaces or 10/100 Base T network interfaces with routers are often used [Allaert, 1999; Stieglitz, 1998, p. 17; Azumi, 1996, pp. 447-452].

The actually available personal microcomputer and video color screens provide adequate price-performance ratio for telepathology systems, by means of standard off-the-shelf multimedia platforms.

11.1.2 Image Capturing Devices

Macroscopy Image Acquisition

For the examination of gross specimens telepathology applications use **simple video cameras** or macroscopic television cameras with a remote-controlled zoom lens, integrated with telecommunications processes. A robotic laser pointer allows the pathologist at the diagnostic hub to point to the areas of interest in the gross specimen. In this way the requesting client is able to show samples or other physical elements in real time to the tele-expert and to discuss them with him. In North America **NTSC cameras** and capture cards are employed for macroscopy. Although resolution and color separation are marginal of these most common types of TV cameras, they seem to be suitable for macroscopy image capturing. At some macroscopy stations also a small-part ultrasound system is added to enable the pathologist at the diagnostic hub to map the specimen for areas of firmness or calcification [Krupinski, 1993, p. 67; Weinstein, 1986, p. 433; Weinstein, 1987, p. 648].

Microscopy Image Acquisition

The most used components of a digital microscopic image-capturing station are a **RGB camera** kit (e.g. Sony), a computer with a **frame-grabber board** (capture card) and specialized software to digitize and store the image (communication cards). A three-chip charge-couple device (**CCD**) TV camera captures red, green and blue separately. These cameras are more expensive than single-chip cameras or those that provide a composite video signal output, but offer higher resolution and better color separation. In composite video, color information is encoded in a single output signal, which results in inferior color and spatial resolution [Weinberg, 1996/(1), pp. 832, 833]. Image-capture boards are required to convert continuous analogue images to digital form. Most available image-capture boards are now able to sufficiently handle most imaging tasks. Each discrete region of the image (pixel) is stored as a digital value representing the intensity of each color signal at the point.

An alternative to CCD Cameras is a **digital camera or scanner** that incorporates these components and provides digital output directly to the computer. The role of the computer is again to store, process, analyze and transmit the image with the assistance of the appropriate software. Although a scanning camera is not suited for dynamic-image systems, it is perfect for static-image telepathology. A scanning camera can capture more high-resolution static images than a TV camera. The image information is output in digital format, which can be brought into a PC through SCSI interface or other interfaces, which are cheaper than a high-resolution image capture card. Since scanning cameras do not use real-time images, it is difficult to focus or choose fields on screen. Many scanning cameras, however, have a low-resolution almost real-time (very fast) scan mode producing 10 frames or more per second. Other use a combination of TV camera and scanning camera that allow selecting and focusing images on the monitor screen, e.g. Sony DKC-5000 (combination of RGB and scanning camera), or Leaf MicroLumina [Azumi, 1996, p. 449]. Images with extremely

high resolution can be captured and monitored with resolutions of 1.024 x 768 pixels by the digital cameras Kontron ProgRes 3012 (Kontron Electronic, Eching, Germany), used in the Roche Image Manager (AutoCyte Inc., Elon College, North Carolina, USA), or the Kodak DCS-420 scan (Eastman Kodak, Rochester, New York, USA). A less expensive digital camera is offered by Pixera (Los Gatos, CA, USA) .The very-low-power image, the most obstinate challenge to digital capture, is currently best addressed with digital scanning technology, such as represented by glass slide or Kodachrome scanners (Path Enabler Ploroid corp., Cambridge, Massachusetts, USA) [O'Brian, 1998, pp. 149, 150]. At the electronic dealer show (41. Funkausstellung) at Berlin, Germany, cameras with a resolution of over 2 million pixels were introduced. Such cameras are already available for US-$ 1000-2000 [Britz, 1999].

Another image capturing device are **file scanners** for still imaging. It produces high-resolution low-power images unmatched by any other method of capture. Examples are Polaroid SprintScan (Cambridge, MA, USA), and 'Pathscan Enabler' (Meyer Instruments, Houston, TX, USA), which offers 3500 x 2300 pixel resolution [Azumi, 1996, p. 449].

Never mind which camera will be chosen, both, the quality of the camera, as well as for the video screen should be kept on a high level. In general the color image quality is 24 bits (palette of 16.7 million colors). However a research study showed that 8 bits color definition (palette of 236 colors) may also be sufficient (see chapter 16.2.2.4) [Doolittle, 1997].

11.1.3 Remote Controlled Microscope

The microscope is the main tool of a pathologist. For doing telepathology, a high-resolution video camera has to be attached to the microscope to capture microscopic images for transmission. If an automatic microscope is employed, robotic mechanical features and a control software have to be added to remotely manipulate x and y position of the scanning stage, for zooming and focusing of lenses, magnification control (selection of objectives), and illumination. Keyboard, mouse (super-mouse), and special joysticks are used as remote manipulation panel of the microscope. At many systems the telepathologist will find in front of him a kind of phantom of a microscope with all the well known knobs at the well known position, but without any optical components. Yet, instead of looking in a eyepiece of a microscope he watches the specimen image at the screen [Schwarzmann, 1992, p. 385; Weinstein, 1987, p. 649].

These instruments preferentially have been developed by the microscope suppliers (Leica, Zeiss, Olympus, Nicon). Unfortunately, the coordinates of the different robotic microscopes (x-/y-mechanism) vary between the different vendors, so that robotic features of dynamic-robotic systems are mostly not compatible.

11.1.4 Communication Links - Telecommunications Services

For the transfer of data, images and audio in telepathology different types of network are available. Some use separate networks, others parts of the public specialized or general tele-network. Some operate with narrow band networks if only this kind of network is available or if cost should be kept low, in contrast to broad band networks, which are more expensive but much faster. The best known types of transmission media are twisted copper wires, satellite, coaxial cable, microwave, fibreoptics, and integrated services digital networks (ISDN) [Kayser, 2000]. The most important ones are explained in the following.

11.1.4.1 Public Switched Telephone Network

The largest and most accessible network is the public switched telephone network (PSTN), which operates mainly by telephone companies. These public network is a common carrier of information or messages, and is available to anyone or any organization that can afford to use it. Because the original public network was designed with only intelligible voice transmission as requirement, its **capacity is limited** in signal speed and complexity. In general the common analogue telephone connection only allows a transmission rate up to 28.8 kbps. A consequence of this low capacity rate is for example when voice sounds flat at the phone due to the complexity limitation where the higher and lower frequency ranges of voice are not transmitted. However, even so the restriction of slow data transmission rates, these networks have the advantage of being **almost available everywhere** world-wide and that the price for the basic services is low. Conventional telephone lines are quite satisfactory for the transmission of low-volume still images, however for the transmission of live video images they are inadequate [Swett, 1995, p. 594]. To overcome this problem, it is possible to enhance telecommunications capacity by connecting multi voice channels (e.g. ISDN or T1 is equivalent to 24 voice channels), but then the price is higher. Besides the public network, since some years commercial network suppliers are also allowed to offer network capacity. This led to price reduction and to an expansion of the overall network availability [Williams, 1995].

11.1.4.2 Integrated Systems Digital Network - ISDN

Within the discussion of public switched network upgrades, the digitally coded ISDN network became introduced. It is available world-wide, can be operated on-line like a telephone, and is flexible in sending data, images or audio. ISDN enhances the capacity of traditional telephone lines by substantial compression of signals and data reduction so that several services can be operated simultaneously with a single call. With ISDN physicians can confer by voice on the outcome of a study while sharing linked computer screens showing images. The advantage of ISDN is that besides its **wide distributed** in many countries and its **flexibility** when using data, images and audio communication that **operating costs are mostly low** [Eide, 1994, p. 884; Oberholzer, 1993, p. 1078; Schwarzmann, 1996, p. 19].

Because ISDN is a fully digital service, it is **distance-independent.** It can be expected to be reliable and to have very low error rates. Computers can be plugged in and dialed as easily as a voice call to connect a range of voice, data, and video alternatives, or even some combinations of all [Stewart, 1994, pp. 37 ff.]. ISDN does not replace existing telephone lines, but simply packs more information into them. With the standardization of national ISDN-protocol to the so called Euro-ISDN in 1994, in Europe the telemedical information exchange based on ISDN increased a lot [Klutke, 1997, p. 67]. Similarly in the USA, where the government is strongly pushing the ISDN initiative to provide national information infrastructures - one is talking about the creation of an US-information superhighway [O Brian, 1994].

The conventional public ISDN service has a data capacity of 64 kbps [Giacomuzzi, 1998, p. 41]. Where one channel carries 64 kbps, the basic rate when talking about ISDN is two channels each carrying 64 kbps, so that 128 kbps are available. With a 128 kbps ISDN connection low quality video can be transmitted, which is sufficient for most telemedicine purposes. Using three lines to give six ISDN channels (6 x 64 = 384 kbps, which allows for

a time resolution of 30 frames per second) is better but more expensive. At six channels, one channel is reserved for audio signals, while the remaining five channels are used to transmit video signals [Shimmura, 1998, p. 389]. The maximum transmission rate offered by ISDN as now is 32 channels each carrying 64 kbps, so that 2 Mbit/s are available for the user, which of course is better resulting in a transmission performance, but again is more expensive [Wootton, 1997/(1), p. 399; Adeyinka, 1996, p. 21].

11.1.4.3 T1 and T3 Lines

In the USA most projects use T1 lines (e.g. 384 kbps up to 1.544 Mbps). There are also T3 lines (45 Mbps) available in some locations with asynchronous transfer mode switching (ATM). Unfortunately they are expensive and therefore the usage is rare[Grigsby, 1995/(1), p. 24].

11.1.4.4 ATM

Although ISDN is available, still the data transfer rate of networks is often named as a problem by telemedicine users. That is why the increasing number of users and growing data traffic on the information highway already caused dissatisfaction. The ATM-technology was introduced to enable a better utilization rate. Developers hope to increase the **data rate up to 155 Mbit/s** and more [Boese, 1997, p. 12]. Since some years in Berlin/Germany such a ATM connection (speed 155 Mbit/s) is already tested for several telemedical services [Thiel, 1996, p. 17]. In opposite to the synchronous transfer technology, ATM enables that several users can use the same connection, which is especially valuable for tele-discussions of cases with several experts. An disadvantage of ATM is that because network capacity has to be high, in general it requires fibre optic cables [Wootton, 1997/(1), p. 399]. As a consequence, ATM is expensive. Therefore, although the technology is available (physically), most physicians cannot afford it so far.

11.1.4.5 Broadband Switched Network

Broadband networks are fully capable of switching **high quality video images** along with multiple voice channels and high speed data transfer. They can simultaneously provide mixes of voice, text, graphics, and **multimedia** moving image displays. Programs and data of highly compressed digital form in video file servers allow a direct high speed interaction between remote locations. Broadband networks are therefore suitable for interactive multimedia services such as real-time telemedicine applications.

However, unlike ISDN, switched broadband technology is different and public network would have to be rebuilt for them. This demands high investments. Federal governments' funding is limited, so that it is unlikely that they build such networks. Telecommunications providers such as Bell companies or AT&T react cautious, as long as they are not exempt from state regulations, and as long as a market of potential customers is not in sight [Weinberg, 1996, p. 832].

11.1.4.6 Digital Radio Links and Microwave Transmission

The very first trials in telemedicine were already based on radio and **microwave transmission** (see chapter 4.2.1). In 1996 another project based on microwave communication was described by Anderson. Microwave technology was employed for pediatric and perinatal

pathology between the State University of New York, the Health Science Center in Brooklyn and Maimonides Medical Center. The system was successfully used for teaching and medical education, as well as for consultation purposes [Anderson, 1996, pp. 455 ff.]. For telepathology, no utilization of microwave transmission is reported up to now.

Digital radio technology could lead to increased portability of terminals, services, and integration of broadcast and wired networks. It allows an **increased flexibility** and decentralization. One possibility to achieve portability is to have digital radios linked to voice-telephones and to computer terminals. A digital terminal could provide immediate connection to the voice network, so that physicians in the field are able to quickly access and exchange the data they need. Telecommunications vendors are talking about a 'Personal Communication Network'. Users are located by their personal electronic address anywhere within the range of the digital radio transmission-reception facilities to get access to the network. Another application of digital radio is the development of 'Wireless Information Network' facilities. With switching digital communication signals among all stationary and mobile units, mobile 'dial-up' voice, data, text, or simple image connections between two individuals or stations can be established for accessing and using all available services [Williams, 1995].

11.1.4.7 Internet

The Internet, a network by which originally the U.S. military and various universities began to link their computers, is an interesting parallel telecommunications development. The Internet is not owned by anyone, but can be seen as a cooperative arrangement of researchers, governmental and a growing number of commercial users. One objective of the Internet was that computers with different operating systems are able to share information by using this open digital telecommunications network. The answer was the communications standard known as Transmission Control Protocol/Internet Protocol (**TCP/IP**). Nowadays a large number of networks are inter-linked by using this standard. Operating protocols were created, on which many innovations for seeking out information, data exchange, and methods for sharing documents were introduced. Soon the Internet had proved to be an **inexpensive** and **easily available** test-bed for technology commercialization [Williams, 1995; Feuer, 1996, p. 23]. Also international medical consortiums and telepathology developers made use of these advantages. For example, the capability to receive image files through the Internet provides an open system for case consultation. The AFIP for example offers rapid second opinion consultation on difficult and perplexing cases with a turnaround time from just 2- to 4-hours [Mullick, 1996, p. 191; Parsons, 1992, p. 432]. The Internet is also considerably used in disaster health care. However it is the least desirable solution for real time or on-line consultation because of issues of bandwidth availability, network speed and impaired performance due to traffic overload [O'Brien, 1998, p. 153].

11.1.4.8 Overview of Network Capacities

Bandwidth[58] [Weinberg, 1996/(1), p. 832]		
Network	**Speed**	**Data Types**
POTS (old telephone service)	9,6 to 28,8 kbps	voice low resolution images
Switch 56	56/64 kbps	voice, data; graphic files low resolution video
ISDN (2 B channels)	128 kbps	
T-1/ISDN-6	384 kbps	voice, data; graphic files high resolution video
T1	1,5 Mbps	voice, data; graphic files high resolution video high quality audio
VBN	2 Mbps	
T3	10,8 Mbps / 45 Mbps	full motion video
ATM - Asynchronous transfer mode	25-622 Mbps (most common 34 Mbps and 155 Mbps)	voice, data; graphic files high resolution video high quality audio
Fast Ethernet	10 to 100 Mbps	"
Fibre distributed data interface (FDDI)	100 Mbps	"

Schedule 1: Digital telemedicine communications - common communication rates.

11.1.4.9 Criteria for Network Selection

The telecommunications medium chosen for telepathology programs is dependent by several criteria, like cost, bandwidth, availability or reliability. In most forms of telemedicine, the choice of the telecommunications medium is essential for the data transfer performance. The final decision often results in a compromise, since considering the advantages and disadvantages, there is a conflict of aims. The most obvious is cost and bandwidth, since both are related with each other. From this point of view the PSTN is lowest and ATM is highest.

Availability, Standardization and Network Costs

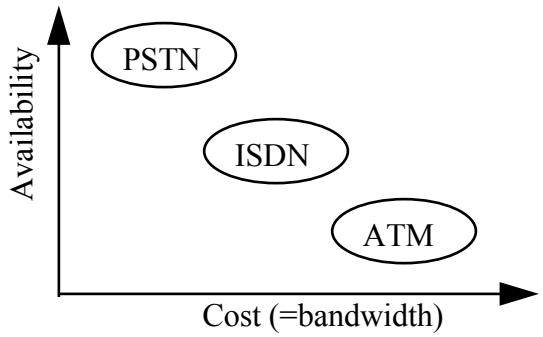

Figure 12: Choice of telecommunications network for telemedicine applications [Wootton, 1997/(1), p. 399].

[58] Further network descriptions see: Ausseresses, 1995, p. 150; Wootton, 1997/(1), p. 394; Schwarzmann, 1995, p. 210; Hufnagl, 1999, p. 95. Another schedule of telecommunication link's capacity can be found at Swett, 1995, p. 594.

Network Availability

Public switched telecommunications services are almost available at every place all over the world. Yet channel capacity is often small [Schwarzmann, 1992, p. 385]. The same it is with ISDN connections, which are also available at many places and at very moderate cost. They can be used easily nearly world-wide. In contrast, high bandwidth / ATM are expensive and not universally available.

Considering the situation of developing countries, there are often only public switched telephone networks available. That is why at a trial between the United Arab Emirates (Abu Dhabi), the Kingdom of Saudi Arabia (Riyadh) and a consultants at Cambridge, MA, public dial-up telephone lines were tested, in combination with **multiplexing technology** and **image compression** for international transmission of both - video and high-resolution digital images. The idea of testing conventional telephone lines was that telepathology services, which would require access to fibre optics or satellite communications, remain unrealistic from both - a practical and a cost-benefit standpoint at many third world countries. It is to assume that most third world countries anyway will not employ dynamic-robotic systems due to the high prices and the high technical complexity (problem of maintenance). Yet, if static telepathology systems are utilized, questions like speed or size of files are not so important, but robust and reliable connections are desirable to provide affordable access to telemedicine services by using existing telecommunications infrastructures [Goldberg, 1994, pp. 1495-1500].

Problem of Standardization

Unfortunately in some countries telecommunications network are not fully standardized yet. They show differences between sophisticated digital communication and standard analogic transport at remote places. In some countries one has to overcome different and often idiosyncratic regulations. In addition sometimes different telephone carriers enhance the problem of coordination and integration, too [Puskin, 1995/(2), p. 126]. That makes telepathology introduction and data exchange complicated. Industrialized countries mostly offer access rooters, which give access to digital public (or private) network, and S.O. standard interfaces, with a warranted flow of 128 kb/s.

Problem of Cost

> *"Expense is an important factor in the choice of systems" [Eide, 1994].*

Efficiency and cost are important factors of influence for the selection of communication links [Weinberg, 1995, p. 833; Schwarzmann, 1992, p. 385]. Due to the expense of braodband satellite transmission, and the low performance of copper phone lines, ISDN and fibre-optic networks are mostly the favored modes [Houtchens, 1995, p. 113].

Kind of System and Kind of Service

Further criteria for network selection are the kind of services (primary diagnosis, second opinion consultations, education) and the kind of systems (static / dynamic) which should be used. For example, if primary diagnostic should be executed by dynamic telepathology, high communication bandwidth should be available in order to handle remote controlled features with a satisfying speed. Live images need at least ISDN or T1 lines, with a high speed and a better line quality than standard dial-up phone lines would offer. In opposite, low resolution still images can be transmitted via common telephone lines [Kayser, 1995/(2), p. 197; Schwarzmann, 1992, p. 385].

Transfer Time and Image Size

Preliminary analyses showed that the average time of 25 seconds for the transmission of one full color image is the upper limit [Dzubur, 1996, p. 269; Oberholzer, 1993, p. 1078; Barker, 1998, PP: 1411-1416]. The time needed for image transfer is dependent on **network performance** and **image size**. The relevant parameters for performance measurement or communication capacity of networks are bandwidth, bit rate, and digital or analogue signaling mode. Bandwidth is expressed as the data transport rate, measured in bits per second (bps), kilobits per second (kbps or kbit/s) or megabits per second (Mbps), depending on the medium.

The size of an image depends on its quality. In general the size of an image compared to an textual file is much higher. That is why the time (seconds) required to transmit a still image, or the bandwidth (bit/second) required to transmit a moving image is quite high[59]. In practice, to keep cost and time associated with saving, moving, and viewing of pathological full-motion, moderately high-resolution, color audio-video images as small as possible, and to overcome the bottleneck of transmission speed, the information of an image is often reduced by **data compression** [Perednia, 1995/(3)]. For most still picture transmission the standard JPEG is used, for moving scenes the standard MPEG. Image compression algorithms are divided into two categories: lossy and loss-less. Lossy algorithms are capable of up to 20:1 or 30:1 ratios. Most loss-less algorithms only allow compressed images up to 3.1 ratios or less [Mun, 1995]. At this point there occurs a conflict of aims - transmission speed and image quality at live imaging systems.

To overcome this conflict, one possibility is to examine slides by **panoramic scanning**, since only a small fraction of the rate required to transmit all of the data in a given field has to be transferred [Weinstein, 1987, p. 651]. If there is not enough bandwidth available for robotic telepathology systems, Richter recommends to **prepare data files in advance**. Different image modalities and details could be scanned and recorded before the video conference, so that these can be played in during the conference. In this way the search and focusing for the appropriate image detail could become less time consuming [Richter, 1995, p. 299].

Another possibility is to **use low resolution images for the low magnification** rough scanning process, but high **resolution true color images for the detailed examination** of specimen fields of high magnification. A map of the tissue slide with a position marker will indicates from which area of a sample the high magnification field has been selected. This helps to avoid unnecessary scanning procedures. Hybrid systems used for example in Tromsoe and Basel are already employing this variant. If **necessary several ISDN channels could be bundled for a short time interval** to provide increased channel capacity [Schwarzmann, 1992, p. 387]. Because focusing of images in microscopy is often time-consuming till the best focus is found, the use of **autofocus facilities** could also save plenty of time [Schmid, 1996/(2), p. 931; Schwarzmann, 1996]. A comparable alternative is to use **intelligent JPEG-compression**. JPEG parameters could be implemented as a self adapting procedure, which adjusts the image resolution according to the operators inten-

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[59] A single medium-resolution image 640 x 480 pixels in 24-bit color has a file size in uncompressed format of approximately 1 MB. The large size of image files stresses processing capacity, and 16 MB of RAM or more is the current minimum specification for an imaging workstation's personal computer that uses Windows based software (Microsoft corporation, Redmond, Washington, USA) [O'Brian, 1998, p. 149].

tion. If the operator scans the slide roughly the image resolution is reduced automatically, and if he examines an interesting field of view for a longer time the image resolution improves again up to the maximum value of the camera resolution [Schmid, 1996/(2), p. 931; Schmid, 1996/(1), p. 480].

However, although JPEG compression was used at a trial with static image in Sweden, average image transmission for low, medium and high resolution images was approximately 5, 20 and 45 seconds with ISDN networks (1 x 64 kbit/s). This was judged as not sufficient by many users [Olsson, 1995, p. 240]. At the system in Vermont, bandwidth of 384 kbps with ISDN appeared to be adequate for the great majority of medical applications. Nevertheless, users claimed to get the ability to change bandwidth, for choosing the most appropriate bandwidth for their specific need [Rici, 1997, p. 204]. (Further chapters discussing network speed see 16.2.2.8, 18.6.3.2, 18.6.6.7, and 19.1.2.2).

Reliability

Another problem of networks is the risk of **lost data**. Not rarely physicians waited in vain for the demanded images due to technical network problems. For example, at the BERMED project in Berlin (Germany), loss of data was the reason that five of ten participants stopped the usage of their telemedicine system [Boese, 1997, p. 12]. Never mind which network is used, telepathology systems have to guarantee a **secure** and professional access and data exchange over the network, with warranted telecommunications **reliability** [Allaert, 1999].

One criteria of reliability is the connection architecture. The question is, whether the link will be established permanent within a restricted area or between restricted participants, or whether the stations will be embedded in a net of users with changing partners, in the extreme case ‘world-wide’? The most secure connection architecture are the so called point to point connections, with dedicated wide band communication lines. This approach is the most expensive. The alternative is to use existing global networks, such as the switched-digital networks. The Internet may be the least secure network due to its easy accessibility. In contrast, commercial switched-digital networks provide dependable performance but at much greater cost [O’Brien, 1998, p. 153].

11.2 Interface

11.2.1 Telepathology Software and User Interface Design

Researchers and developers agree that one of the weakest link in modern network services remains the interface between the human and the technology [Wyman, 1994]. Therefore the interface design has to be done carefully.

Dynamic software can be briefly described as a specialized video conference system[60], with a video data communication interface, video/audio sources, loudspeakers, monitors, and a

[60] For example, one standard videoconference system which is employed for telepathology is ‘Intel ProShare 200’, which allows a communication by a European standardized ISDN connection, or the ‘Intel Business Video Conferencing System’. The main components are the conference manager, which coordinates data-input and data-output, the video window that displays the images, the data and image transfer features, the memo pad and the ‘application sharing’ tool, which enables all partners to work on the same pad and to use the same applications [Klutke, 1997, p. 68]. Further video conference systems used for telepathology are ‘In Person’ (Silicon Graphics, Mountain View, CA, USA), ‘CUSeeMe’ (Cornell University and White Pine, Nashua, NH, USA) together with the Macintosh based telepathology system ‘Path Maker’ or ‘NetMeeting’ (Microsoft, Redmond, WA, USA).

video switch [Hartviksen, 1994]. Two-way audio and video is part of all dynamic telepathology communications. The dynamic robotic telepathology software further has to establish a data connection for controlling the remote video switch, for coordinating all microscope control tools, the light for the macro camera and for displaying the remote cursors at both locations. Thus one can say that the basic requirement of dynamic telepathology software is, to handle the system integration between the robotic microscope, the multimedia workstation, and the telecommunications procedures.

Static imaging systems are often realized by simply employing e-mail systems and Internet data exchange, expanded by image capturing and image management features [Kuakpaetoon, 2000; Rosenthal, 2000; Beltrami, 2000; Della Mea, 2000/(1); Della Mea, 2000/(2); Mihailovic, 2000].

User-Friendliness

Systems should be **user friendly** from the practitioner's perspective, and as **simple to handle** as the telephone. Procedures for conducting telepathology services have to be as plausible and as effortless as possible [Puskin, 1995/(2), pp. 126-127; Klutke, 1997, p. 77; Coen, 1997, p. 207]. That is also that physicians like to be able to operate a system without a huge training effort. Most pathologists have limited knowledge of computers. Therefore systems have to be so user friendly that no technological problems preclude its daily use.

> *"Operating a telepathology system is analogous to walking; knowing exactly the origins, insertions, and actions of the leg muscles is not necessary for the ability to walk. Hence, one does not need to be a computer expert to operate remotely a computer controlled robotic microscope." [Almagro, 1998, p. 1162].*

It is obvious that there is a need for adequate user interfaces to create pathological working environments where even non-computer minded people, as physicians often are, can feel at home. Whereas complex program **commands**, and complicated screen layouts may result in refusal of usage. It is important

> *"... maintaining compatibility **with people** not using the software by means of the Internet standard protocols" [Della Mea, 1995, p. 242].*

That is why designing telepathology interfaces has to take the general research findings of interface developments in consideration. Mouse, pull down menus, buttons, or touch screen interfaces are more accepted than keyboard commands. Moore even claims that physicians need an extremely simple system.

> *"You just push one button. Anything harder than that, and the docs won't use it." [Moore, 1995, p. 3].*

Unfortunately system designers often fail this demand and create frustrating tools for the physician. For example, if there is a window-like **icon screen** on the system's front-end, which does fail to lead to the expected screen, or if physicians have to know exactly how the system recognizes commands, or even have to type commands correctly, physicians will not accept the system as practical [Mariner, 1995]. Regarding telepathology, such systems have to be multi-medial to manage all textual, visual and acoustic data. The retrieval of case data or image capturing has to be simple and fast. For example, at the system used in Sweden, the telepathologist is able to return the microscope to a specific image position with the original magnification just by clicking on that image in the gallery [Cajander, 1996, p. 483].

A new requested feature by physicians is the data input by **spoken commands** as well as the capability to recognize speech for computer commands or for generating text from speech. With such tools physicians would be able to directly dictate comments to a case, which are automatically converted to text for insertion into medical records. As an example, the supplier 'GSF-Medis[61]' is using the voice processing system 'IBM-Voicetype' for developing tools especially for pathologists. This system directly picks up voice dictation by a microphone fixed at the microscope and sends them to a PC for macroscopical and microscopical documentation. The system is a combination of dictation and command input, where a controlled, well structured vocabulary is guiding the user through a workflow structure. When practicing across boundaries, such features could even be combined with translation services [Williams, 1995; Kolb, 1998, p. 114].

Support of the Telepathology Processes - Workflow Management

An important demand of users is that systems should support their workflow instead of the physician has to follow technological restrictions.

> *"Designs of current systems are driven more by technology than by the **needs of practitioners.**" [Puskin, 1995/(2), pp. 126-127]*

> *"First keep the focus on program objectives and secondly on technology." [Wyman, 1995]*

When considering for example the workflow process of a pathological consultation, case selection or the creation of a new file has to be simple and clear. Two users of this study argued that 'multistep working' does not satisfy users. That is if the user has to control several tasks within a telepathology session (image transfer, storage, remote microscope control) instead of all these functions are logically integrated. System functions have to be reliable, adequate, and flexible enough for the specific needs of the users and to support all tasks efficiently. In this way telepathology systems could become an important part of everyday pathology practice.

First of all telepathology applications must have a **patient data management module**. This module should present patient data input features for the identification of data and clinical comments. It should offer automatic internal index files for the linkage to external patient ID, patient file retrieving functions, as well as patient file archiving and deleting features. Already available patient data should be easily retrievable and linked with the actual data [Bria, 1994]. It would also be from value, if the user is offered a list of actual communication partners to select from. After a partner is selected, a command should be sent through a serial port of the PC to the data terminal equipment to set up the connection [Hartviksen, 1994].

Other very important features of the telepathology software are **image capturing and manipulation tools**. First of all macroscopic video images have to be captured and documented automatically. Then microscopic image acquisition and digitalization tools have to be available. Image visualization and presentation should be kept flexible and clear (size, icons). The ergonomy should be intuitive and user-friendly. Interfaces have to offer simple to use image treatment tools such as zoom functions, or image cutting and positioning features. Field width and luminosity, image contrast rendering are further criteria for satisfying interfaces. The pathologist has to be able to select the camera connected on the micro-

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[61] GSF-Medis, Institut für Medizinische Informatik und Systemforschung, Neuherberg, Germany

scope to capture images which will be included in the patient's file. In addition, the telepathologist has to get the possibility to easily add comments of a case to the file and to safe the file with his signature [Allaert, 1999]. The telepathologist further has to have the option to create diagnostic reports for the client or other involved physicians without a lot of additional effort.

Compatibility With Other Telepathology Systems

Dynamic telepathology systems are mostly based on video conference systems. Since the ITU set up the standards H.320 and T.120, most of the standard videoconference systems are able to communicate with each other. The point of weakness is the coordination of the remote control features, which are not standardized and therefore make dynamic system integration difficult and the selection of telepathology partners restricted. Static telepathology systems are mostly compatible with each other that is that a telepathologist in New York can exchange images with a colleague in Paris without difficulties. Many static systems use open interfaces and documents are translated into the HTML format of the World Wide Web, since such documents can easily be read with every standard browser and no special software is necessary [Schwarzmann, 1999]. In summary, system compatibility has to be taken seriously, since clients may wish to contact different experts, dependent on the kind of service and examination they wish to execute. If a system is only compatible with one partner, which is the case at the moment with many dynamic systems, but also with several static ones, users may be disappointed (the problem of standardization is discussed in chapter 14).

11.2.2 Integrated Systems at the Physician's Desk

> *"Technology trends suggest that, within the next few years, health care providers will be able to see patients at remote sites by using a desktop workstation or laptop computer in a mobile, wireless configuration. Clinicians will be able to select interactive video and store-and-forward modes as needed. Simple, intuitive software shells will allow seamless access to pertinent patient records, radiographs, pathology slides, pharmacy information, and billing records. Instant access to on-line libraries of medical information, diagnosis and treatment algorithms, and patient instructional materials will be available. Referral to specialists and allied health personnel will be done by computer-based scheduling. Patient information will be stored in archives that can be accessed by authorized medical personnel anywhere in the world. Privacy and security will be provided by encrypting data and restricting user access by means of passwords." [Perednia, 1995/(3)]*

An elementary requirement of telepathology system design is **openness and interoperability**. This was also named by five telepathology users as an important criterion for a successful system design in this study. Physicians need applications that cross disciplines and cross application boundaries. In this way useful and convenient electronically supported working environments for physicians will be provided [Williams, 1995; Eide, 1994, p. 888; Busch, 1995, p. 242; Aller, 1997, p. 201].

> *"Fight the temptation to create a stand alone technology." [Wyman, 1995]*

Therefore interfaces have to be capable of being integrated into the existing medical practice of pathologists. One has to consider that a patient has to see several physicians within a treatment process. Rarely these are located at the same institution. That is why it would be valuable if standardized interfaces support the documentation of the patient's treatment procedures in such a way that each involved physician will get the complete patient data he needs in one place, yet that they are even able to access patient case data and systems form their home office [Boese, 1997, p. 8; Marquardt, 1997, pp. 78 ff.; Mariner, 1995]. Using

UMTS (Universal Mobile Telecommunication System), the new generation of handy communication, access may become even totally independent from the location of the physician.

Again, this is calling for **integrated standardized electronic medical records** as backbone, interfaced with the main clinical systems. Such integrated telemedicine systems have to be able to transmit video when indicated, text when appropriate, still images such as X-rays and pathology slides when necessary, audio when needed (such as electronic stethoscope) and fax when appropriate [Wyman, 1994]. They should be able to transfer data to office systems (e.g. Microsoft Office / Word). The written communication between physicians could be simplified and speeded up, since text elements and data could be automatically retrieved from the pathological database into the pathologist's report. Further the compatibility of systems could help to overcome the problem of busy time schedules, if coordination of resources (equipment and staff) could be supported by automated features. How this could look like in the case of frozen section examinations and dynamic telepathology systems (organizational and from the technical point of view), where the client and the consultant have to be available at the same time, has to be thought about.

Integrated Workflow Environment at the Physicians Desk

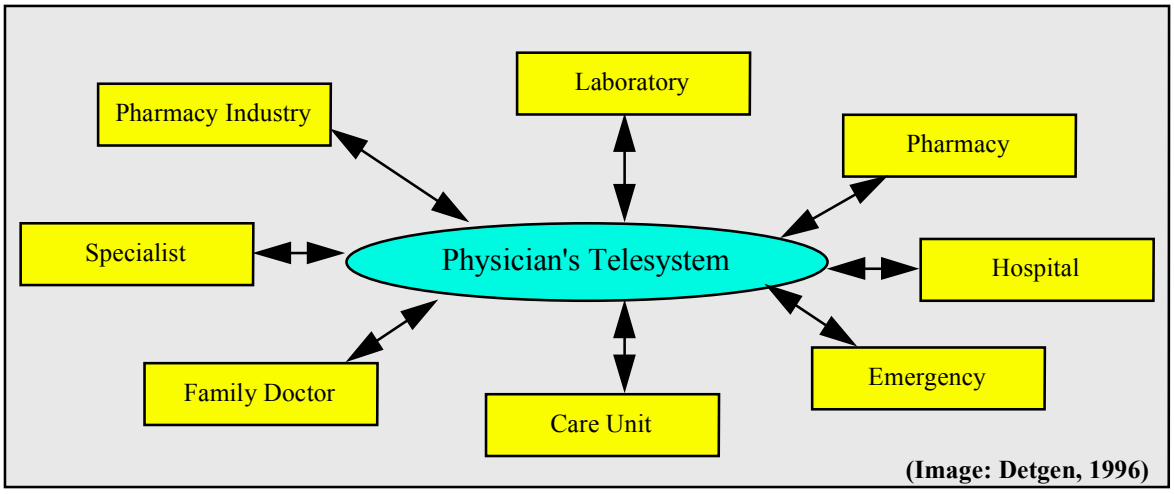

Figure 13: Physician's telesystem - integrated electronically supported workflow.

"Technology alone is not the answer." [DeBow, 1994]

Until recently the purpose of the computer on the cytologist's or pathologist's desk was to provide a connection to the laboratory information system. Today it is providing a link to an increasing number of new functions. For example access to proprietary digital image atlases, to cytometry and quality assurance features, to expert systems and other advanced knowledge databases for diagnostic and treatment to maintain an up-to-date database in making a diagnosis [O'Brien, 1998, p. 149; Sanders, Medical College of Georgia, in Wyman, 1994; Busch, 1995, p. 242]. Further physicians want to integrate telecommunications links to the Internet and use services like e-mail, bulletin boards, discussion groups, news groups, WWW home pages, or access medical information databases (Medline, Cancerlit) just to name the most frequented services [Runkel, 1997, pp. 123 ff.; Clements, 1995; Churbuck, 1994; O'Brien, 1994; Balis, 1997, p. 245]. Since it is to assume that most of the pathologists do not use all these available tools and services at the full scale, it should be possible that users are able to mix and match the elements of telemedicine and

other electronic resources that are most valuable and efficient to them. That is why interface software should allow such a diversity that tools can be employed on the task at hand [Allely, 1995, p. 211].

The integration and coordination of all these different applications into the productive life of pathologists is a difficult, but interesting challenge. However, physicians already seem to be keen of introducing information systems for the support of their workload as a study, executed by Hatcher, showed. Almost all requested physicians of his study (90 %) said that their available information systems helped to improve efficiency, improve delivery and quality of care, satisfy information needs, improve productivity, and improve the overall management of care at their office. They do not want to work without them any more [Hatcher, 1998/(2), pp. 379-380].

To establish such an integrated workflow environment, not just the interface design and equipment development have to be standardized and compatible, but **organizational** structures and processes have to be **adapted to the new procedures**. Vöge even talks about a development starting from physical cooperation to a level of manipulation in virtual structures, up to business workflow processes in semantic networks [Vöge, 1996, pp. 9 ff.].

11.2.3 Computer Operating System in Telepathology

Many telepathology systems use a multitask system like Windows 98 or Windows NT, since they are appropriate for safety reasons in professional usage. Yet, there are also several telepathology systems which are based on Macintosh, UNIX or an other operating system.

11.3 Database

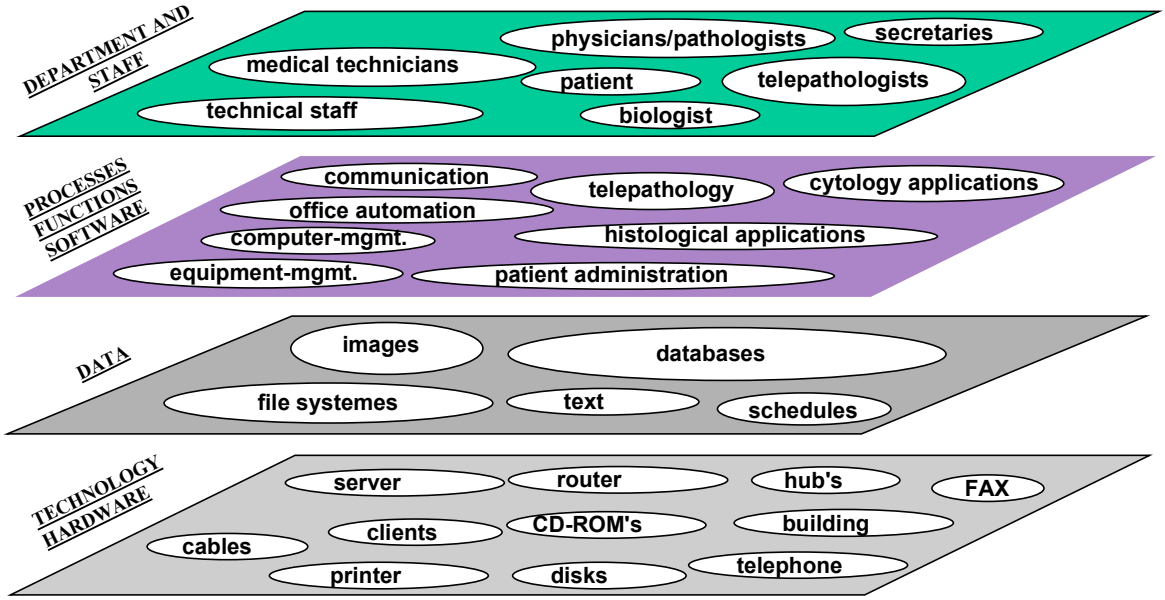

Figure 14: Different views on data, which have to be integrated.

A well designed database is an important backbone for the management of all telepathological data and images. However, the data in telepathology are complex and therefore the

data views have to be designed carefully. The image above may demonstrate the multi-layer data types and systems, which have to be integrated in pathology.

11.3.1 Relational Databases

On the technical side, most of the telepathology systems use a **relational database** for the data and image management, because it enables a well structured and fast handling of data. A relational database allows that images are clearly identified and related to the case they belong to. In addition, such well structured databases are the basis for fast display and presentation of images, and the foundation for smart imaging and decision support features.

Medical Record Design and Image Management Systems

To design a conceptual model of a standardized medical record is not easy, since the data fields in such a record are quite heterogeneous. A lot of questions about the content, structure, format, vocabulary, code system[62], standards, costs, etc., have to be taken into consideration. In pathology it is mainly patient data (name, age, sex, address and phone number, social security number, medical registration number), medical data, images, text documents like diagnosis, sometimes even hand written documents and audio should be added [Löbus, 1997/(1), p. 557]. The design of such a database has to follow international standards of data formats, vocabularies and codes that a later data exchange with other medical systems is possible without additional effort. Instead that data have to be manually typed, they are just downloaded from the client's or pathology laboratory's information system. A challenge - especially if international facts have to be taken into account in the design of such a record [Amatayakul, 1995]. And not to forget, the functional requirements of simple operation, questions of data accessibility, accuracy, legibility and protection of patient confidentiality have to be met [Detmer, 1994]. Proper records are needed for medical, financial or legal requests [Allaert, 1999]. To avoid an information overload, redundant data or slow systems, the content of such a record has to be carefully determined. The decision, whether such a record is lifetime or event-driven has been made [Sicotte, 1998, pp. 431 ff.; Detken, 1997, p. 101; Appleby, 1995; Houtchens, 1995, pp. 98 ff.]. If the design of medical records in a database is taken seriously, a lot of money could be saved. It is estimated that US-$ 30 billion could be saved in the USA, if applications for sharing patient information in a sort of complete 'super-patient record' would be used [Shoor, 1994].

Tele-Imaging and Image Management Systems

Digital images are the kernel of pathological databases [Dzubur, 1998, p. 158]. In the future, pioneers hope that pathological institutions will go almost slide-less. Large slide libraries could be replaced by optical jukeboxes and tele-imaging [analogue Mun, 1995, p. 153]. The basic components of tele-imaging include image acquisition, image management, image display and presentation, smart imaging, decision support and communication [Mun, 1995, p. 154]. Image management consists of image handling, storage, archiving and retrieval.

One image management system incorporated into telepathology's applications, specially designed for pathology and cytology laboratories is **AutoCyte's Image Manager System**

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[62] To build up efficient standardized databases, medical diagnosis codification such as SNOMED, ICD, ADICAP, or RESINTEL thesaurus, ideally in multi-language format, should be used [Klossa, 1998, pp. 207, 209; Allaert, 1999].

(appendix III). It is based on a relational database and allows to store and retrieve multiple file formats, including JPEG. AutoCyte uses the operating system Windows NT. The software supports multiple networking environments and can be linked directly to a pathology or cytology department's laboratory information system [O'Brien, 1998, p. 153, p. 154]. Another example is Roche Image Manager, a PC computer-based system [Wray, 1995, pp. 271-274].

The **Roche Image Manager**[63] is a PC computer-based system, running under Windows. It allows an user-friendly storage, viewing, printing, and transmission of large sets of images from various sources. To reduce storage capacity, images are compressed into JPEG format. Images are stored with associated information, text notes, annotations, and a 'thumbnail' image. The user is able to search for images on a number of information fields. He can retrieve cases for expert discussions, conferencing, training and educational purposes [Wray, 1995, pp. 271 ff.]. In France, the ICG[64] is the main supplier for telepathology's data management.

Unfortunately up to now, total tele-imaging approaches have not shown a satisfying performance due to the size of image files [O'Brien, 1998, p. 155]. This reflects that tele-imaging systems and databases have to be carefully designed, to guarantee an efficient electronic work-desk for pathologists in the future.

11.3.2 Special Restrictions of Database Designs

11.3.2.1 Size of Images

Image files mostly have a huge size. Therefore the storage, archival and retrieval of images always bring up the subject of data volume, levels of storage and data compression. The amount of storage required varies widely depending on what type of imaging modalities are used. Factors like **image size** (which depends on color, spatial resolution, contrast resolution, number of pixels per image array, the number of bits per pixel) as well as the **number and kind of images** per study stored, have an impact on the performance of a database. In other words, an image with a huge array size and with great bit depth will demand more storage space than smaller size matrix images, and a case with many images will do this, too. An optimum relation of image size and image quality has to be found, and the most meaningful images should be displayed first.

11.3.2.2 Availability of Files

Medical data are only available at certain periods and at certain locations. They are bound to a space-time relationship. Basically, data of patients have to be available for retrieval as long as the patient is under treatment[65]. Later cases are stored in the archives, so that all data are available if the patient will attend again. This process reflects the problem of availability and case-design. Should a record follow a **life time or an event-driven** design

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[63] Contact addresses: Roche Image Analysis Systems, 112 Orange Drive, Elon College, NC, 27244 USA; Roche Biomedical Laboratories, Center for Molecular Biology and Pathology, 1912 Alexander Drive, Research Triangle Park, NC, 27709, USA

[64] ICG Systèmes - Mémoire Directe, 12, rue Blaise Pascal, F-92200 Neuilly-sur-Seine, Tel.: (1) 41 92 00 52; e-mail: icgsys@csi.com

[65] A patient's case can conclude several visits at different physicians and several clinic admissions at different times. One just have to think about a cancer being diagnosed. After extensive diagnostic procedures, a surgery operation may follow. Afterwards the patient has to attend as a ambulatory patient for several cancer treatments and for security checks for several years. During the whole process, patient's data have to be easily accessible by all involved physicians.

[Appleby, 1995]? How long should data be stored? Kayser names an average period of ten years, where case information should be available for physicians [Kayser, 1999], whereas Löbus plead for thirty years, after which liability demands of patients come under the statute of limitation [Löbus, 1997/(1), p. 557].

11.3.3 Database for Quality Improvement in Research

The computer is also a powerful tool to facilitate standardizing and monitoring of care [Clemmer, 1995, p. 47-50]. The role of medical informatics in telemedicine is dependent on using the power of the computerized database for not only feeding patient specific information to the health care providers, but to use the epidemiological and statistical information in the data base to improve decision making and ultimately care. By this, patient identification has to be avoided for security and confidentiality reasons. Doing scientific and statistical evaluations, specific data of medical cases, especially if they are of a rare event, could be extended by information like 'neighboring events' and stored in a research database. Such databases are from huge value for research analyses to improve medical therapy. Data in a standardized database can easily be used for quality control, for teaching and education lessons or for staff discussions. One example is the telemedicine project REGKOM, where data of tumors and analyses for quality improvement in oncology are recorded [project description see Kunath, 1996, pp. 31-32].

Designing relational medical databases for pathology, it is important that pathological images are accurately linked to their associated textual and coded alphanumeric data. This allows to create a **library of pathological images** and a library of printed pathological text data to serve as a single unified resource for pathological information, so that words may be used to find pictures and pictures may be used as an index to locate relevant text. The National Library of Medicine is one of the main organizations in the USA, discovering knowledge structures for the integration of images and other medical information.

Another organization, the Clinical Telemedicine Cooperative Group (CTCG) was created by the Telemedicine Research Center, a non profit organization located at the Oregon Health Sciences University in Portland. The function of CTCG is patterned after the Southwest Oncology Group (SWOG) in which members pool specific case data to create a data base from which statistically valid conclusion can be derived. To create such a database the CTCG has to rely on the willingness of participants to devise, share, and abide data by high quality protocols for multisite evaluation. Standardized systems would allow an authorized download of these data. This fact should be taken into consideration when designing a telepathology database.

11.3.4 Image Storage Media

There is a correlation between cost and both capacity and speed of storage. Various digital storage devices, such as magnetic hard drives, optical and magneto-optical discs and magnetic tape storage systems are available at increasingly competitive prices. Drives with removable magnetic or magneto-optical disks with a storage capacity of 20 megabytes to several gigabytes may offer good solutions for stand-alone workstations. New rewritable optical drives, such as the Panasonic PD/CDTM (Panasonic-Matsushita Electric corp. of America, Secaucus, New Jersey, USA), are a medium to conveniently transport data between workstations. They are available at approximately US-$ 50 and hold a storage capacity of 650 mega-bytes. Since such image storage have proved to be very useful, many departments of pathology are already starting to replace glass slides and photography with

digital imaging. CD-ROMs are playing another increasing role due to their large data storage capacity, although they provide slower access to files than do magnetic media. WORMs (write once read many) are an ideal storage medium to ensure preservation of the authenticity of images. Optical disk libraries provide the most cost-effective storage media for large volumes of multimedia. They can provide timely access to terabytes of archived image files. A further cost-efficient, high speed digital storage system is RAID (random array of inexpensive disks). It consists of an array of multiple drives and offers a very large storage capacity [O'Brian, 1998, p. 150]. For the future, IBM is already talking about a new storage capacity of 37 gigabyte, which is comparable with the capacity of 280 CD-ROMs [Anonymous, 1999]. Which storage media will be finally chosen for telepathology is dependent on the situation of the institution. Yet it should be appropriate for a secure and fast data processing, which also accounts to future demands.

11.4 Equipment and Users' Needs

At most practicality studies of telepathology systems, technology has rarely been reported as a problem. Yet, one problem which is often reported is the selection of the appropriate equipment. The most important factor in determining the equipment, system, and communications requirements for telepathology are **clinical and operational needs**. Each local installation has to be configured for **precise users' needs**. For example, expert pathologists may demand exclusively dedicated configurations for diagnosis processes, whereas a general pathologist may need a completely different configuration.

For physicians it is often difficult to select the most adequate equipment fitting in their working environment and appropriate for their specific needs. While some recommended 'the best equipment you can buy' others were equally emphatic in recommending 'the simplest and least expensive technology that will meet the needs'. Unfortunately there are a lot of vendors selling equipment in rural communities that does not help, work, or is too sophisticated [Moore, 1995, S. 3.]. How valuable telepathology applications are, is heavily dependent on clinical expectations, and how carefully technology is matched to medical needs, to economic and organizational factors, and other specifics of the health care provider [Perednia, 1995/(3)].

For matching the **users' needs**, pathologists should be **directly involved in the system selection process** [Edens, 1995]. Within the selection process it is to recommend, to build a team which sets up important criteria and expectations. If available, **vendor independent support** in the selection of the tools that are most appropriate for the users is from high value (selection support see chapters 5.1.1 TRC, 5.1.3 ITC, or 53.3. HEALTHPLANS and the results of the study in chapters 18.3.9 and 19.1.2.7). If no standard software is available on the market and systems have to be developed, users should early be **involved in the system design.** This way systems are not just applicable to their specialty, but users also feel a sense of ownership [Hatcher, 1998/(3), p. 390; Scott, 1995; Puskin, 1995/(2), pp. 127, 129; Marsh, 1990, p. 35]. In addition, during the system development process, **data should be continuously collected**. For example, at a telemedicine project in Regensburg/Germany, test users had to fill in forms after system usage, where they were asked to

judge several important parameters[66]. These parameters were used for the improvement of the system [Stieglitz, 1998, p. 18].

> *"**Human performance studies** in telepathology, fully feasible today, must provide the foundation on which to build the **standard** telepathology networks of tomorrow. Such studies are essential for establishing telepathology system **specifications** and for defining the **limitations** of the technology." [Weinstein, 1986, p. 434]*

As soon as a system is selected and introduced, physicians further need sufficient information about their available facilities and information about how they can use their equipment most efficiently for their purpose [Grigsby, 1995/(1), p. 25].

> *"It is more than a matter of which tools he uses, but how and when he chooses to use them that is important." [Allely, 1995, pp. 210-211]*

11.5 Conclusion Equipment

If an institution wants to introduce telepathology, several criteria should be noted to select the most appropriate solution for its specific needs. First, the decision has to be made, whether the system should be a static or a dynamic one. Best if a system is modular that it can be expanded if desirable in the future. Considering the different components of a telepathology system (microscope, camera, monitor, workstation), most available equipment of the shelf does already offer a satisfying performance for telepathology. Yet, one component, which often causes frustration is the interface. Therefore vendors have to be forced to develope systems which are user-friendly, flexible, and reliable. They have to support the working processes of pathologists, instead of following technical instructions. They should be compatible to other applications at the physician's desk to guarantee an overall, smooth, integrated working environment. Further, the integration with other internal and external information systems is an important issue. The employed databases have to ensure a smooth data storage, long-term archiving, and record tracking. Security, reliability and flexibility are important issues, too. Considering the data transfer and the network which may be chosen, factors like the size of files, speed, as well as security and reliability have to be regarded.

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66 The form asks for data about the time needed from the request till the execution of the consultation, the time needed for the preparation, the conference and the documentation, distinguished by client and consultant. Further data about the participating persons and their profession, about the amount and quality of images and textual data, as well as the kind of image digitalization techniques (scanner, camera) are collected.

12 Security and Safety

12.1 Security of System and Data Access

The experience showed that the main offending of data security are not produced from externals, but often from intern. The transmission of sensitive data by internals to externals is technical not avoidable [Runkel, 1997, pp. 127 ff.]. Nevertheless technical as well as organizational activities have to be taken to protect sensitive patient data as good as possible. In general these security measures have to be managed and controlled locally.

Security of Location

First of all, security is dependent on the location and accessibility of computers and telepathology systems. The question is, whether only the staff of the organization is able to access the computer's room, or are rooms also frequented by patients or other people? The problem of physical computer access is not just a problem of telepathology, but of the whole health care delivery system, since computers with sensitive patient data are almost available on each physician's desk. Unfortunately measures like special access precautions of doors, identification of staff, continually control by security personnel or room surveillance techniques are often not practicable in the health care environment [Ulsenheimer, 1999, p. 201]. Hence, telepathology mostly has the advantage that the contact with patients is low and surgeon's, as well as pathologist's offices are on separated locations. Therefore the problem of accessibility can be solved more easily.

Computer equipment has not just to be protected from unauthorized access and vandalism, but also from natural catastrophes like fire or water. In any case, data back-ups have to be executed frequently and stored safely.

Data and System Access Security

Different physicians may have different access rights on patient and image data. Therefore, at institutions where online databases of pathological cases are maintained, the control of data views has to be taken seriously [O'Brien, 1998, p. 152]. The access to systems and data can be solved by authority concepts (exact definition of responsibilities, task-protocol), user **identification** and password control [Ulsenheimer, 1999, p. 200; Marquart, 1997, pp. 78 ff.; Thiel, 1997, p. 135; Wyman, 1994]. The access on the telepathology network is actually often controlled by a secure **chip card** - the Health Professional Identification Card [Allaert, 1999].

12.2 Stability of Telepathology Systems

When relying on telepathology, the pathologist has to be certain that the system is usable and that system errors won't occur (technical errors as well as errors due to improper human operations). User studies already showed that the **availability of the system**, for both consultant and the remote client, is judged as essential for increasing future usage [Ricci, 1997, p. 203]. Nevertheless, it never can be guaranteed that there are no system errors or even system break-downs. How to keep system interruption low is the question?

First of all, telepathology systems should only be allowed to be sold on the market, if analogue to **MOT**, an independent technical control organization (e.g. BSI[67] - Office of Information Technology Security) gives a quality certification. In addition, systems should be checked in a regular period of time, to guarantee system functionality [Berger, 1997]. Pathologist, clinical technicians and other health care support staff may often be befuddled by the technical or logistical complexities of using scanners, networks and telecommunications links. Again, there is the need that systems are kept **simple and robust in usage**, so that errors due to operation mistakes are low. **Help-menus** and good written system descriptions may give advises to the physician as a first aid at system errors. Besides **adequate training** of telepathology participants, qualified services should be available, e.g. a **24-hour staffed help desk** is needed with certified telepathology technicians who not only understand how to operate scanners, run computers, but also know about pathological pro??cesses. Since such technicians are quite expensive, the realization of such a service has to be content of future thoughts.

In Vermont such a help desk is already available. The focus of the technicians is to fix the problem as soon as possible so the conference or consult can proceed. Inevitably, they would troubleshoot by repeating a number of steps that worked in the past, such as rebooting the computer. In such situations, they concluded that the problem was software related. A unusual high number of errors also occurred due to hardware failures. Problems with the ISDN lines were a further source of system interruption. On occasion, ISDN-related problems were the result of user errors, but also due to network problems [Ricci, 1997, p. 202]. Difficulties with ISDN were also reported from Basel/CH and Heidelberg/Germany. In Heidelberg unexpected breakdowns of ISDN connection occurred in 4/25 of the transmissions[68] [Kayser, 1995/(1), pp. 58, 59]. At a trial of static systems and the use of ISDN in Sweden in 45 % of the cases no connection was established due to malfunctions in the network or terminal [Olsson, 1995, p. 240]. To solve problems as fast as possible, assessment tools for the investigation of errors were employed in Vermont. It is also from great value that errors of the past are analyzed and documented for being avoided in the future. If it is not possible to get the system to run or to create a communication link, an emergency concept has to be available. In general if there occurs a total system breakdown, processes will be executed in the conventional manner.

12.3 Date Transmission Security

> *"Cracking the code protecting medical data transmissions might be a game to a student or electronic media aficionado, but not to those whose private parts end up on some strange person's computer screen ... more-secure methods of data transmission and encryption need to be established." [Karinch in Blanton, 1995].*

Firewalls and Private Networks

Using telemedicine systems, data are transmitted by using local and public networks, which mostly can easily be listen in on. Careless data transfer is opening the door for damaging programs and viruses. By using standard software packages with macro features, e-mail, or

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[67] Bundesamt für Sicherheit in der Informationstechnik in Germany

[68] ISDN test between Heidelberg and Stuttgart. ISDN-line breakdowns could only be detected by separate conventional telephone calls. Failures of the modems could be excluded due to the fact that no acoustic information transfer by use of ISDN telephones was possible for hours. The technical reasons for acute breakdowns were not known. Fortunately complete breakdowns of the connection by using telephone lines to 2400 baud were observed very rarely, in less than 1 %.

download of WWW-information, even the careful user is not safe and so called '**firewalls**' are easily bypassed. Firewalls are security shield around an organization to control a safe data input from externals. In general with a firewall, it is not possible to build up a direct connection to the internal computers behind this wall form extern, but initialized data exchange from internals to externals is possible [Thiel, 1997, pp. 132 ff.; Allaert, 1999]. '**Screening Routers**' are for example firewalls on the protocol level (ISO/OSI level 3), which safe the communication between computers. Another possibility are '**application gateways**', which first simulate applications on the firewall. In this way no direct connection with external computers is established and the application gateway will check input data. However, although firewalls are employed, by using the Internet and the TCP/IP protocol there is still a risk that IP-packages or sender addresses are manipulated for getting access to sensitive information or even to add for example 'electronic bombs' to transmitted data. That is why some organizations started to place sensitive data on a highly secure internal network, which only gives restrictive access to the Internet [Runkel, 1997, p. 127]. To minimize the infection by a computer virus, it is important to use actual **antiviral packages** to double-check the secure access to workstations and medical databases.

Security of Public Networks

In general the question arises, whether medical information systems should be linked at all to public networks for exchanging their sensitive data via open networks like the Internet, especially since the security concerns of Internet technology and applications are not viewed as accomplished [Hatcher, 1998/(1), p. 376; Pommerening, 1996, p. 7;]. Systematical analyses of the threat and risks of security are necessary to develop adequate specifications, concepts and mechanism to ensure safe communication between partners. These concepts have to take all layers of the ISO-OSI-model for open system data interchange into consideration. An conceptual overview about these layers and their requirements for communication security is designed by Blobel, who distinguishes between communication and application security and regards both in the context of data, algorithm, mechanism, service and concept relations. Within this distinction, several sets of security services have to be ensured. For example the authentication, integrity, and confidentiality of the transferred information, which is mostly realized by standard formats at the application layer like HL7, EDIFACT, XML, MINE. Further the liability that the original of the message and received message are identically has to be guaranteed, which happens by SSL (Security Socket Layer) [Blobel, 1998, pp. 72 ff.].

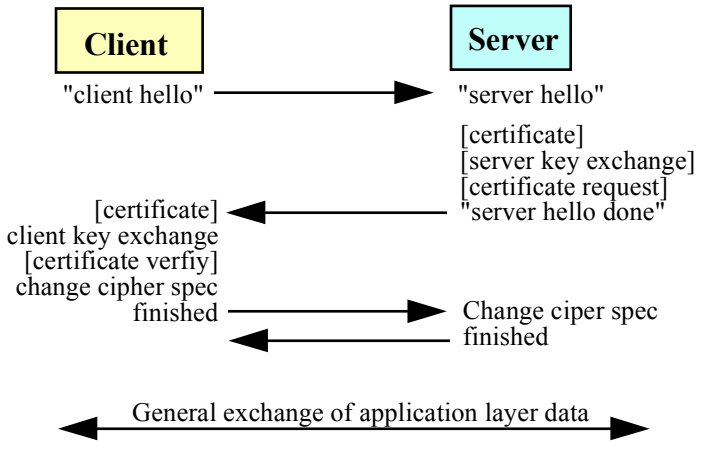

Figure 15: SSL-connection between client and server [Matthies, 1998, p. 100].

Other approaches for a secure medical data exchange are investigated in Berlin, Germany, within the MedSeC project. The University of Berlin, Benjamin Franklin Medical Center and the Technical University of Berlin, are testing a combination of TCP/IP and online coding features, and FTP transport protocols in combination with DICOM-standards [Bernarding, 1998, pp. 91 ff.]. Investigations showed that the coding of data on the TCP-IP-level by SSL, which are implementable on each computer, reduce the rate of data transfer. To code all data between rooters depends on hardware components and therefore this possibility is quite inflexible. High transmission speed is needed for the transfer of images. This makes an online-coding almost unacceptable. That is why it is tested only to code parts of the data, e.g. the patient relevant sensitive ASCII-data. Later special dynamic features will unify the sensitive coded data with the uncoded data at the receiving end [Thiel, 1997, pp. 132 ff.].

Other research projects, which are actually investigating security requirements and are systematically developing protocol for security mechanisms and services are ISHTAR (Implementing Secure Health Telematics Applications in Europe), TrustHealth-1 and TrustHealth-2, MEDSEC, EUROMED-ETS, HANSA or DIABCARD. An organization which is further busy in the development of security standards is the ITU (International Telecommunication Union) in Genf, Switzerland.

Electronic Signature - Health Care Professional Card

With increasing penetration of computers at the physician's work environment, simple but secure authenticity solutions for users, applications, systems, and machines have to be introduced. The idea of a 'health professional card' was born. This chip card basically includes public key algorithms, added by a secret key, as well as qualification and authority statements of the legitimated user. With the combination of possessing such a card and knowing the secret PIN-code for it, a high security level can be reached. As soon as the user has activated his card with his PIN-code, the cryptographic processes are used automatically by the system [Debold, 1998, pp. 84 ff.; Kayser, 2000]. Further approaches for identification are for example biometric methods like finger prints in combination with card terminals.

Cryptographic Coding

Cryptography is the science of data coding. It can be distinguished between symmetrical and asymmetrical procedures. By the **symmetrical coding**, sender and receiver use the same coding key, whereas by the **asymmetrical coding** two matching keys are used - the coding is done with a general known '**public key**' of the addressee, taken from a central key-server, and admitted and controlled by a certification authority, whereas the decoding is done by a '**private key**', only known by the receiver [Hufnagl, 1999, p. 95; Thiel, 1997, p. 134]. This coding is done on the application level. In general cryptage algorithm software has to be installed either within the workstation or at the telecommunications router level [Allaert, 1999]. For encrypting and digitally signing, programs are available at the Internet[69] [Agbamu, 1997, p. 1440].

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69 PGP (Pretty Good Privacy) program, available free of charge at the Internet: http://web.mit.edu/network/pgp-form.html (for citizens of North America); http://www.ifi.uio.no/~staalesc/PGP/ (for the rest of the world)

Cryptography not just guarantees that data can't be read by unauthorized persons, but also provides features to clearly recognize communication partners. In advance, cryptography further forgery-proof data handling and there guarantees the liability of documents and communication's contents. The means for that is the **electronic signature**. One example for the handling of the coding keys is the usage of chip cards as described before. In any case, if data of a patient is exchanged between telepathology partners, its safety has to be guaranteed with the employed security features.

12.4 Conclusion

Utilizing telepathology applications, sensitive data of patients are processed. That is why first of all data and systems have to be located at rooms where access security is guaranteed. Since telepathology demands data exchange in open networks, the security of the external data transfer is often named as a problem. Data security and protection in open information and communication systems need mature security methods like cryptography or splitting of patient data and case data. Only if safety of data communication is ensured, the exchange of sensitive data is acceptable. If telepathology systems are used for telediagnostic and teleconsultation, system stability and system reliability are further important issues which have to be carefully regarded, since uncertain systems may lead to reduced acceptance by the users (judgements of this study about security factors see chapters 18.3.8, 19.1.2.2, and 19.1.2.5).

13 Financial and Efficiency Aspects of Telepathology

13.1 Cost Development

Telemedicine systems in the 1960s and 1970s were largely supported by grants. Video equipment was very expensive and its quality was poor compared to today's standards. The long-distance telecommunications networks available at that time could not support the rapid, wide bandwidth transmission, necessary for real-time videoconferencing telemedicine systems and transmission costs were also high. Computing resources were costly and limited in speed, power, and flexibility. Therefore projects were expensive to set up, to operate and to maintain, and many questions remained unanswered regarding their quality. As a consequence of these factors, none of the programs being launched before 1986 became financially self-supporting as funding for telemedicine projects ran out. They either were discontinued or are still operating on a funded tryout basis [Grigsby, 1995/(1), p. 19; Moore, 1995; Perednia, 1995/(3); Shoor, 1994]. That indicates that a main reason of their failure was the inability to justify the activities of telemedicine on a cost-benefit basis.

13.2 Efficiency of the Whole Health Care System

When considering efficiency, one can either have a look at the single business management of a health care provider (hospital, physician's office), or consider the health care economy as a whole.

The overall health care system is searching for solutions to reduce or at least to control health care expenditures by simultaneously keeping or improving the quality standard of care. Nevertheless there was almost a 'cost explosion' in the last years. One reason is named with the growth of high technology in medicine, which for sure improved the quality of health care, but also increased the cost of medical services. Telemedicine is such a (telecommunication) technology. Since it improves the access to qualified care and to preventive care, which otherwise would be unaffordable, it is likely that it increases health care cost for the society [Flaherty, 1995/(2); Hanwehr, 1995, pp. 219-222]. That is why the judgement of Jay Sanders, director of the Medical Center of Georgia may be realistic when he asserts that

> *"We are all naive if we think that total health care cost will go down in the first few years. While telemedicine can definitely result in decreasing costs on a per-patient basis, the increased access provided to people who are currently disenfranchised from the nation's health care system will probably lead to an initial increase in total costs." [Sanders in Shoor, 1994]*

Nevertheless, it is not true just to say that each new technology in medicine will increase costs. There are several other aspects, which have to be considered when talking about costs and not to forget, there are several telemedicine applications which have decreased service costs. Shoor even pretends that telemedicine provides a way to save billions of dollars. That this statement is true was already documented in a 1992 study by the international consulting firm Arthur D. Little in Cambridge, Mass. The study showed that the ability of hospitals, clinics, physicians, laboratories and insurers, to use the nation's widespread telecommunication infrastructure for high-speed, high-resolution video, image, and data exchange could cut the nation's health care bill by as much as US-$ 36 billion [Shoor, 1994]. Already the tele-possibility to better manage the disease to reduce emergency room visits and hospitalization may result in a 25% saving [Braly, 1995/(1)].

Another matter of efficiency is that telemedicine applications support to better utilize expensive equipment and staff expertise and help to enhance the delivery of high quality health care across separate, regional and remote facilities [Wyman, 1995; Wyman, 1994, Ulsenheimer, 1999/(2), p. 898]. That is why health care delivery organizations of the future can use telecommunication-based management to move more resources from the central organization out to the patient and closer to the people who need them. Remote pathologists may get access to highly complex computer image analysis systems that screen specimens independently or offer automated quality control re-screening [Grohs, 1998, p. 166]. Highly specialized care, based on the newest technologies can be shared, regardless of the resources available at the patient's location [Mariner, 1995]. Skills will be shared, and access to information resources can be given within the 'virtual health care organization' [Williams, 1995]. This will overcome the basic problem, which Sanders described:

> *"Our skill (expert) at diagnosing and treating disease continues to improve, our ability to distribute and deliver that care has not" [Sanders in Wyman, 1995]*

Consequently, telemedicine applications may help to improve the usage of available high quality medical resources and by this improve the overall health care.

However, payers are critically considering cost factors. They claim a financial balance between health care costs and benefits. Either quality of care has to be clearly increased for the patient, or investments have to lead to cost reduction in the long run. If cost-effectiveness cannot be proved, a technology is likely to be denied by insurers. Therefore the projects most likely to be funded are those, able to demonstrate the likelihood of continued viability after the grant money has ended [Puskin, 1995/(1), p. 64; Poremba, 1998, p. 318].

13.3 Telepathology and Providers' Budgets

Providers of telepathology services cannot ignore efficiency aspects. With cost-reduction regulations like the introduction of fixed prices for treatment and therapy activities or fixed department budgets, health care providers are forced to introduce cost efficient methods - or with other words, they have to avoid cost intensive procedures [Heinrich, 1996, p. 17]. To answer this situation, financial managers, for example at the New England Medical Center followed the strategy that there is no hospital-wide 'telemedicine budget', but that each department decides if telemedicine would work for them, and if so, how it can be worked into their budget [Slipy, 1995]. A situation was created, which made physicians to think economically. Therefore telepathology systems will only be introduced, if the overall efficiency is guaranteed.

13.4 Efficiency Calculations in Telepathology

13.4.1 Problem of Efficiency Evaluation

The statements above reflect that economical aspects seem to play an important role in telemedicine project introduction. Unfortunately, with few exceptions, there has been no systematic attempt to evaluate telemedicine's costs, effectiveness, or impact on the health care system. Considering the few empirical studies that have been conducted, these mostly

have been focused on very narrow issues such as monetary effectiveness[70] [Grigsby, 1995/(1), pp. 19, 24-26]. One reason for this is that many projects are still in a 'research' status instead of a routine basis, and therefore there are too little case examinations executed for doing satisfying cost-benefit-analyses. Another reason is the lack of reimbursement. Due to missing reimbursement regulations, there are often no direct revenues which could make a calculation meaningful.

13.4.2 Methods of Efficiency Evaluation

If one wants to calculate the efficiency of telepathology approaches, the question for the most appropriate measurement and method comes up. Doing efficiency studies of telepathology, cost issues should not be addressed or resolved in isolation, but considered in a larger framework encompassing for example accessibility and quality of care, too [Bashshur, 1995; Williams, 1995]. The reason for this is that most hospitals and other health care providers are facing a turbulent and competitive environment, which is not only driven by costs, but also by quality and strategic aspects. That is why simple cost calculations are often not sufficient as efficiency measurement.

> *"Income-based financial figures are better at measuring the consequences of yesterday's decisions than they are at indicating tomorrow's performance ... what matters is how a company (health care provider) is doing compared with its current competitors, not with its own past." [Eccles, 1991, pp. 132, 134]*

Therefore it makes sense to shift from financial figures as the foundation for performance and efficiency measurement (acquisition costs, operating costs, compared with cost-saving and revenues) to a broader set of measures. Several measurement systems added variables like patient's satisfaction, quality improvement (e.g. due to shorter anesthesia time, less amount of later operations, less false diagnoses due to fast second opinion consultations, improved know-how standard by improved education, fast access to quality assurance features e.g. DNA-analyses; increased access to health care and preventive care by use of telecommunications), enlarged market shares (changes due to improved reputation of provider), convenience, or human resources.

Methods which consider non-financial criteria are for example 'target costing', which is orientated at the customer/patient's needs, or the 'benchmarking' method [Sakurai, 1989, pp. 39 ff.; Horvarth, 1992/(2), pp. 142 ff.; Horvarth, 1992/(1), p. 4 ff.]. Another method which includes various criteria is the 'Performance Measurement' method. This method uses quantifying measures in different dimensions (for example cost, time, quality, innovation, customer satisfaction, etc.) to examine the effectiveness and efficiency of a service, distinguished by the organization as a total, per unit, per service, per process, per person, etc. [Curtis, 1994, pp. 18 ff.; Eccles, 1992, pp. 41 ff.]. The approaches of performance measurement vary between different business sectors (e.g. Ernst & Young Performance Measurement-Concept, Shareholder Value Analysis, Quantum Performance Measurement, etc.[71]). The following schedule will give an impression, which criteria could be considered in measuring the performance and efficiency of telepathology systems.

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[70] At this study all monetary amounts were converted in US-$.

[71] Detailed description and comparison of the different methods see Widmaier, 1996, pp. 15 ff.

Quality Measures	Delivery Measures	Manufacturing/Process Measures	Finance/Cost
• customer feedback (patient's satisfaction) • warranty claims by product (by month), e.g. model, number of claims, extended dollars (diagnostic errors and claims) • daily rate of good units produced (by month), e.g. total units produced, good units produced, % for good units built (TP diagnoses per week/month) • inventory control (by month), e.g. raw material, work-in-process in $, finished goods in $, control turns, forward day's supply	• current year production schedule number (tells you number of schedule changes) - increased amount of diagnoses executed • delivery rate, e.g. current schedule rate of units per day, actual units shipped per day, percent of units shipped to schedule • supplier deliveries, e.g. number of early, late, on-time deliveries	• set-up time, e.g. hours and percent to total hours worked • downtime, e.g. hours and percent to total hours worked • material handling time, e.g. hours and percent to total hours worked • finished goods completed per total people (or hours) worked • average bill of material levels (i.e. 2,3,4, etc.) • engineering/process changes, e.g. number of ECS changes • product lead time required for completion (i.e. two weeks, three months, etc.)	• cost of production, e.g. material and conversion cost, value- vs. non-value-added cost

Schedule 2: Performance-Measurement of J.I.Case Company [Widmaier, 1996].

For appraising the performance of a telepathology project, measurable objectives have to be defined (analogue to qualitative variables in social empirical research studies), which have to take reference to the organization's strategy and objectives [Heinrich, 1996, p. 17]. To get more precise results, Gerneth added a weighted point scale to measure telemedicine performance [Gerneth, 1997, pp. 42 ff.]. Doing so, a meaningful measurement system can be created that gives information about the value of new technologies, processes, and their interactions with other sections.

The consideration of qualitative measurement variables may help to get a more realistic view of the efficiency status of telepathology systems for the specific needs and situation of an organization, than a simple cost-analyses would do. Unfortunately such measurement methods are more complex and time consuming. For this study it is not possible to request all these data from the participating telepathology users. That is why it is still focused on simple cost-benefit contemplation, regarding costs like capital equipment costs, recurring telecommunications costs, or ongoing support costs. However at this point at least it has to be highlighted that more comprehensive methods appear more adequate for the efficiency consideration of telepathology systems.

13.4.3 Expenses - Monetary Cost Factors

Analyzing the costs of telepathology, first of all the monetary one-time expenditures for equipment and systems (purchase price or development costs) have to be considered. Then the recurring expenditures for network services, maintenance, or personnel (cost of the pathologist's time - both the referring pathologist, who selects the images, and the consultant pathologist's time viewing the transmitted case) have to be added to the calculation [O'Brien, 1998, p. 157; Poremba, 1998, p. 323; Heckermann, 1997, p. 25]. These direct cost factors have to be enlarged by intangibles such as time spent learning how to use a new service, or inconvenience to health care providers when they must take time out of a busy schedule to leave their offices to use the new service [Williams, 1995; Moore, 1995; Grigsby, 1995/(1), p. 26;]. Giving examples of costs, these are always converted into US-$.

Yet, the given totals can only be taken as approximate values, since prices vary frequently due to currency variations and changed prices.

On the benefit side the most obvious savings associated with telepathology are lower travel expenses or less time taken for diagnoses. It has to be calculated, whether the use of telemedicine systems costs less than flying doctors all over the state or to transport specimen samples. Vice versa one also can regard how much it costs the patient to drive to the specialist, to take a day off from work, paying for lodging and meals? Or how much it costs that the patient is treated at a specialized hospital, instead of a cheaper local one. Unfortunately various benefits of telepathology systems are currently not included in monetary cost calculations. In addition, there sometimes occurs the paradoxical effect that first, the direct medical expenditures of an organization increase, while the monetary savings appear at other segments of the economy [Perednia, 1995/(3)]. Altogether many of the replying users or non-users of telepathology at this study recognized reduced travel effort and the reduced risk for the pathologist of 'being killed on the road' as an important argument for telepathology introduction.

When estimating whether telepathology is cost-effective as a diagnostic tool, one has to ask for the relative utility of a telepathological consultation, compared with a conventional consultation [Bashshur, 1996, p. 80]. Doing so, the total cost of telepathology should be seen as a function of service (intensity of usage) and price of units or service.

Costs of Telepathology	
System acquisition costs	Acquisition costs compared to calculated time of utilization (ROI - return on investment) - e.g. • cost for system/software, microscope, hardware, etc. • cost for rebuilding of rooms, cost to lay cables and other infrastructures
ISDN connection cost per month	Line rate per month Connection rates x minutes of connection time
Operating costs.	Costs for laboratory materials (e.g. for staining, cutting, ...), rent, power, etc. + cost for occupied equipment, e.g. if operation theatre is occupied till result is available)
Maintenance costs	Repair work (material and time) Maintenance service fee per month
Education and training time (salary x time)	Consultant: training to execute diagnoses on the screen, time to handle the system, etc. Client: time to learn to do macroscopy, preparation, and the system handling.
Time to get system ready and to finish the telepathological process (salary x time)	Preparation time: time to go to the room where the system is located, log-on time, focus time... Follow up handling: time for documentation, for back-ups, archiving, etc.)
Labor costs (incl. waiting time, during which the staff is not able to fill it with other work) (salary x time)	Cost for: • pathologist / surgeon / medical technician (client) • telepathologist (consultant) • operation theater team

Costs of Conventional Pathology / Savings	
Acquisition costs / investment	costs for conventional equipment
Equipment maintenance costs	Repair costs, maintenance service
Transportation costs	Cost for transportation (time and money) • cost to sample transfer • cost of pathologist to go to a distant place • cost of the patient to go to a distant location
Processing costs (salary x time)	Material cost (e.g. glass slides, color, etc.) Labor costs (incl. waiting time, during which the staff is not able to do other work) • driver's time • pathologist's time • surgeon's and operation theatre team's time
Cost Reduction Potential	
Faster diagnosis process	salary x time
Less double examinations	cost of examinations
Optimization of patient's treatment time	• faster operation time, faster therapy, • shorter stay in a hospital - saved treatment costs per day / service

13.4.3.1 Cost of Network Usage

One major problem in telepathology is the price for data transmission. In many rural communities, prices for network usage is unusually high[72], distances between consulting facilities are great, and sometimes there is even no local access to the Internet.

That is why many telemedicine projects reported problems with high inter tariff rates. Remote sites even sometimes face the situation that the price of long distance telephone services, which cross local service area boundaries, is less than that within the local service area they have to apply to [Puskin, 1995/(1), p. 62]. The lack of adequate telecommunications infrastructure forces projects not only to pay for installation of the line, but also to purchase the whole line on a 24-hour basis for service at very high costs. Such pricing structures, which do not provide for the purchase of bandwidth-on-demand or which require the purchase of whole telecommunication lines to obtain any advanced service, often place telemedicine services out of the financial reach of many small communities [Puskin, 1995/(2), p. 126; Weinberg, 1996/(1), p. 833]. It would be from great advance if it is possible to modify telenet capacity requirements in accordance with the desired service used, in order to achieve cost efficiency [Eide, 1994, p. 887]. In some countries a further problem is the disproportional high price for broad-band connections. As it has already be mentioned,

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[72] Examples for Transmission Rates [Klutke, 1997]:

Multi point connection - fee per hour (each participant pays for his connection)		**Point to point connection - fee per hour (client pays for connection)**	Mo.-Fr. 8 a.m. -18 p.m.	Special rate
• MCU-usage for audio and video	60 US-$	• City national; 2 B-port (128 kbit/s), (<20 km)	6 US-$	4 US-$
• Additional fee for T.120 communication	30 US-$	• Distance national; 2 B-port, (>200 km)	50 US-$	35 US-$
• Additional fee for quarter-split display	30 US-$	• Euro1; 2 B-port	70 US-$	55 US-$
Fee for ISDN-basis connection / installation	120 US-$	• World (USA)	95 US-$	90 US-$
Fee for ISDN usage per month	30 US-$			

* the amount of US-S is an approximated average value.

telephone lines are available and cheap, but do mostly not offer a satisfying transmission speed, especially at dynamic systems. Another factor for high transmission costs is that small rural telemedicine networks and users lack sufficient market power to negotiate favorable rates and services from telecommunication providers [Flaherty, 1995/(2)].

How could the problem of transmission cost be diminished? One important possibility is that telemedicine providers could access and pay only for as much transmission capacity as they need [Puskin, 1995/(1), p. 62; Moore, 1995]. Another is cost-sharing among multiple users to increase market power. Further telemedicine system users could negotiated special contracts with network providers, to reduce network costs. Unfortunately sometimes state laws include prohibitions on discrimination through special rates or services and therefore do not permit incentive prices for telemedicine.

Transmission costs are depend on the capacity of the network used and on the image size / file volume transferred (resolution of images, amount of images). To lower the duration of communication, images should be compressed [Grigsby, 1995/(1), p. 23; Marsan, 1995, p. 341]. Further it is to recommended that telemedicine users employ the most efficient technology for their telemedical applications because equipment and communication costs are directly proportional to the amount of information to be transmitted [Allaert, 1999; Perednia, 1995/(3); Eide, 1994, p. 882]. Still images could be acquired and transmitted during non-peak hours at a lower rate for review by a specialist - a viable and less costly way of providing telepathology services when real-time interaction is not necessary.

Fortunately many telepathology approaches are running on reduced network costs with special discount rates for telemedicine. In Iowa (USA), even a state-owned fibre optic network, the Iowa Communications Network, can be used for telemedical data exchange, which cut down the cost for a two-way videoconference from US-$400 per hour of commercially networks down to US-$10 per hour [Shoor, 1994]. In Austria, university hospitals use the academic metropolitan area network with a transfer rate of 2-10 Mbit/s. The usage is free of charge for university institutions. An opposite example is Australia. There the ISDN services with data capacity of only 64 kbit/s are not free of charge and very expensive [Giacomuzzi, 1998, p. 41]. Fortunately the competition on the network market increased during the last decade, so that network costs are slowly becoming cheaper.

13.4.3.2 System's Utilization

The volume of patients receiving care through telemedicine systems is quite low. Many well-established programs are reporting between one and five contacts per week, and in some cases there are remote sites that have rarely or never used their system, even though it is readily available. Also users of telepathology systems at this study mentioned the low level of utilization as a problem. The low utilization rates seem to be a function of two major factors; lack of reimbursement (if physicians do not see advantages, they deny usage), and providers' resistance to use telemedicine [Grigsby, 1995/(1), p. 24; Perednia, 1995/(3)].

Overall one can say that it is a waste of resources, if telemedicine systems - even if they are available, are unused. In disaster situations it is essential that resources are managed and shared at their optimum [Anonymous, 1999/(1), p. 9; Dietzel, 1998, p. 29]. However, telemedicine applications should not just be a tool to overcome disaster situation, but a possibility to optimize overall health care resources and by this reduce health care expenses. Well developed health information infrastructures and systems that allow a seamless con-

nection and interoperability between health care resources, may have profound contributions to medical cost savings, access, and quality of care [McDonald, 1995].

High capacity rates are desirable to distribute the enormous human and capital costs involved in start-up of telemedicine systems [Wyman, 1994]. To overcome the situation of low system's usage, some argue that for telemedicine services to reach their full potential, smaller rural communities should develop a consortium of users within each facility (e.g. radiology, pathology, dermatology). If some broadband video conference systems (e.g. teleradiology) are already installed, additional specialties like telepathology applications could be added. In this way a value added effect and an optimized service could be reached without moderate additional costs [Schwarzmann, 1995, p. 213; Puskin, 1995/(1), p. 64; Steffen, 1997/(2), p. 28]. As an example of the telemedicine approach, at the Azores Islands employed video-conference stations used for several telemedicine services. The systems were kept quite simple. The video-conference station, working with ISDN, just had to be switched either to the video-camera of the microscope for pathology, to the video-camera on an illumination stand for telecardiology, to an endoscope camera for tele ORL, or to the video output of the echograph for tele maternal and foetal health care [Goncalves, 1995/(2), p. 287]. A similar multi-service design was set up between the expert in Innsbruck/Austria and Reutte [Mairinger, 2000].

Utilization could further be enhanced by creating systems that can be used for a variety of medical purposes, e.g. for diagnostic, education or medical discussions. Another possibility to enhance rate of telemedicine capacity utilization is to find new participants by more intensive cooperation attempts, and by extensive information and marketing activities to make telemedicine known. Systems would also achieve additional benefits by incorporating connectivity to existing clinical information systems [Wyman, 1995]. Even alliances with external business units may help to increase capacity rates. That is why the St. Vincent Marten House Hotel and conference Center is not just used by the hospital, but by other business communities too [Kaiser, 1994; Anonymous, 1994]. This revenue-generating system sharing will help telemedicine providers to cover its portion of the ongoing operational costs for the network after the trial period and to ensure that an investment pays for itself. Talking about revenues, since many telemedicine services are not reimbursed, this may be another elementary reason that the incentive for telemedicine services is low. Fortunately the current consultants are mostly pioneers, who wish to use their systems. Nevertheless the lack of reimbursement will not be a factor to support for an enhanced utilization of systems.

13.4.3.3 Cost of Systems Compared with User's Need

There are many possibilities to minimizing costs through the use of less sophisticated technologies, yet it appears that the decision makers of most telemedicine programs strive for moderately expensive interactive television as the basis of their networks [Grigsby, 1995/(1), p. 25]. However what is technical possible, is not always desirable and useful for medical purposes. The challenge in choosing telemedicine equipment and services is to match the lowest cost and most accessible technology that will achieve the desired objective with the exact medical needs of the communities to be served [Klose, 1997].

Matching communications technologies to medical needs is important because resources available for medical care are limited. Consequently the use of more expensive telemedicine technologies will reduce the total number of sites that can be installed nationally. Therefore when deciding whether to use telemedicine, in-person consultation, or any other

form of diagnosis and treatment, physicians should choose the method that can provide the desired clinical outcome at the most reasonable cost. In addition, reimbursement policies should favor desired outcomes rather than specific processes [Perednia, 1995/(3)].

Some experts assume that interactive video systems may never be cost effective for smaller hospitals. They believe that low-cost store-and-forward systems may replace interactive video systems as the technology of choice [Wyman, 1995]. This statement cannot be fully agreed, since Wyman does not distinguish between the specific nature and kind of consultation, which may sometimes demand a real-time availability of the expert. Nevertheless, in many cases store-and-forward technology is sufficient to telepathological demands and a low-cost tool to transport specialist expertise to broad areas. That the necessity of interactive systems has to be proved carefully reflects the fact that at almost every telemedicine project, real-time teleconferencing accounts for less than 25 % of system use. The majority of teal-time videoconferencing time is used for medical education and administration [Moynihan, 1995; Perednia, 1995/(3)].

13.4.3.4 Cost Examples for Equipment

The choice of hardware and software depends upon individual needs and preferences. It is difficult to specify a typical standard system, since there is a rapid development of hardware and software for video and image transmission and the kind of usage varies a lot. Nevertheless, some guideline specifications and typical purchase prices will be given [Anonymous, 1997].

System Configuration for a Desktop Telepathology System

The cheapest low cost solution for executing telepathology is simply by employing the mostly available Internet mail for image exchange [examples see Kuakpaetoon, 2000; Rosenthal, 2000]. Yet, such solutions often go along with serious disadvantages (e.g. risk of attaching images to wrong case). That is why as first solution the investment costs of 'desktop telepathology systems' will be described.

Binocular microscope	approx. US-$	8.350
Color video camera	approx. US-$	1.700
MPEG digital capture board	approx. US-$	830
Pentium PC 133 + (or Mac equivalent)	approx. US-$	2.500
High resolution 21" monitor	approx. US-$	3.500
28.8K + modem and net conference software	approx. US-$	670
Windows/MAC OS, Internet connectivity etc.	approx. US-$	750
total	approx. US-$	18.300

The system above will allow the pathologist to transfer telepathology services across the inter-/intranets at image resolution ranging from 640 x 480 pixels to 1080 x 760 pixels. Using net conference tools, like MS Net Meeting, Intel Pro Share, Netscape CoolTalk or Picture Tel[73], the pathologist could conduct an interactive voice/text chat with remote par-

[73] NetMeeting, a inter/intranet desktop conference tool, Microsoft, 1996, http://www.microsoft.com
Intel Proshare, a desktop tele-videoconference system, Intel, 1995, http://www.intel.com

ticipants, too. Using public networks, the disadvantage of such systems often is transmission speed.

Configuration for a Medium Range Telepathology System

Binocular photo microscope or	approx. US-$	42.500
Alternatively: binocular, motorized photo microscope*	approx. US-$	66.700
Color video camera	approx. US-$	8.350
High resolution image capture board	approx. US-$	5.900
Pentium PC 166+ (or Mac equivalent)	approx. US-$	3.350
High resolution 21” monitor	approx. US-$	3.500
ISDN interface	approx. US-$	700
ISDN line installation	approx. US-$	500
Mass storage media	approx. US-$	3.350
Desktop video conference system	approx. US-$	6.700
Windows/MAC OS, Internet connectivity etc.	approx. US-$	7.500
total	approx. US-$	75.600
or total*	approx. US-$	99.800

The schedule above describes the minimum hardware configuration for regular remotely consultations, where a pathologist will most likely want a system providing relatively high resolution images that can be rapidly transmitted. Not included is the use of a motorized microscope, such as the Zeiss Axiophot 2[74], which will allow to remotely control the microscope stage and objectives.

Configuration for a High Resolution Telepathology Server

Binocular, motorized photo microscope	approx. US-$	66.700
Color video camera	approx. US-$	8.350
Hi resolution image capture board	approx. US-$	5.900
SGI workstation	approx. US-$	50.000
High resolution 21” monitor	approx. US-$	3.500
ISDN interface	approx. US-$	700
ISDN line 6	approx. US-$	2.000
Mass storage media	approx. US-$	3.400
Desktop video conference system	approx. US-$	6.700
Windows/MAC OS, Internet connectivity etc.	approx. US-$	750
Total	approx. US-$	148.000

If an organization requires either very high resolution images or a high throughput of cases, the equipment above will be more appropriate. The example is based on a high resolution

Cool Talk, A inter/intranet desktop conference tool, Netscape, 1996, http://home.netscape.com
Picture Tel, A desktop tele-videoconference system, Picture Tel, 1996, http://www.picturetel.com

74 Axiophot 2, The digital revolution in microscopy, Zeiss, 1996, http://www.zeis.de/mi/limi_e/p3/Axioplan2_phot2_e.html

multiprocessor system from Silicon Graphics running the UNIX operating system. Turcan and O'Brien mentioned similar costs. They estimated that acquisition cost to set up a full imaging live telemedicine system, including diagnostic and video components, will probable cost around US-$ 100.000 to 130.000 and US-$ 800-10.000 TI line costs per month, depending on the location [Turcan in Wyman, 1995; O'Brien, 1998, p. 157]. The investment cost of the system in Basel (CH) was approximately US-$ 200.000 (330.000 SFr), and additional US-$ 12 per examination [Steffen, 1997/(2), p. 25]. The costs for the dynamic systems of the microscope producers Leica, Zeiss, Nikon and Olympus are also approximately US-$ 80.000 to 120.000, depending on the system configuration and the specific price set ups of the country (for information see chapter 9, please).

Regarding these system approaches, again not just the price of the equipment, but also transmission costs will have an influence on the selection of the kind of telepathology system, since nowadays speed of data transfer is no more a technical problem but is connected mainly to the financial situation of an organization. Fortunately the cost of broadband connection use will most likely decline dramatically in the near future. This situation is comparable to the high cost of electronic memory some years ago. Therefore it is expected that the discussion of still image systems versus live image transfer could become less controversial at a time when data transfer costs do not play an important role and when robotic equipment becomes cheaper [Kayser, 1996, pp. 476-477]. In the questionnaires of this study some users of dynamic telepathology systems mentioned the high prices as a problem, whereas users of static telepathology systems named the cheap investment prices as a positive aspect of their system. Further two users argued that price of equipment will become a huge problem as soon as telepathology should become introduced at each pathological desk. One user recommended to develop modular systems, where the user can decide which functions are appropriate for him.

13.5 Revenues - Reimbursement

13.5.1 Reimbursement of Investments

Currently most telemedicine systems are in a research situation and funded. Considering the investment of telepathology projects, much of the investment money is not going to be from one source, but mostly from a mixture of various sources. Currently, many telemedicine projects are supported by state level, federal governments and rural health policy offices demonstration grants.

> *„The US government played the major role in promoting and funding the projects, based on the belief that interactive telecommunication provides a way to improve access to medical services and to overcome the restraints of time, distance, and the maldistribution of medical resources." [Weinstein, 1987, p. 647]*

Not rarely monetary assistance is also given from a coalition of providers like federal rural electrification administrations, equipment and telecommunications vendors. Some projects are further subsidy funded by the industry, university, privates or foundations [Puskin, 1995/(1), p. 64; Ziegler, 1994; Lumsdon, 1992]. Altogether the funding from states is the greatest. Some states (e.g. Georgia) are even sponsoring and building state-of-the-art telemedicine systems with large capital investments of their own [Perednia, 1995/(3); Moore, 1995; Moynihan, 1995]. Nevertheless, in this study users as well as non users of telepathology argued that the capital investment situation is too uncertain for them and therefore they prefer to stay in a wait-and-see position. Since interested users of telemedi-

cine often do not know from where to get funding, the Telemedicine Research Center (Portland, OR) maintains a list of telemedicine programs and sources of funding on the Internet[75] [Weinberg, 1996/(1), p. 834].

All these funding sources mostly do not provide stable sources of revenue for long-term viability and clear national policy for funding projects is still not available [Bergman, 1993/(2)]. That is why projects often were folded when funding ran out because they could not be self-sustained. To answer this problem, it is important that the continuing service after subsidies disappear is anticipated and planned, with a careful assessment of sources for ongoing support of operating costs [Puskin, 1995/(1), p. 64; Weinstein, 1987, p. 647].

If international global telemedicine networks across boundaries should be developed, collaborative efforts and cooperative funding from multiple organizations are necessary, including the World Health Organization and other agencies of the United Nations such as the Pan American Health Organization, the Department of Humanitarian Affairs, and the International Decade for National Disaster, the World Bank, the U.S. Agency for International Development, and numerous other international, as well as national, governmental and non-governmental organizations [Ferguson, 1995/(1), p. 37].

13.5.2 Reimbursement of Services

Unresolved reimbursement issues are currently considered to constitute a major barrier to the widespread use of telemedicine. That is why quite often the federal government's and insurer's position on reimbursement for telemedicine consultations is given as explanation for the low level of telemedicine utilization [Moore, 1995; Williams, 1995; Perednia, 1995/(3); Ziegler, 1995; Wyman, 1994; Taylor, 1994]. Why should physicians take all the costs, risk and time needed, when they are rarely compensated for their efforts because insurance companies only acknowledge traditional methods [Flaherty, 1995/(2); O'Connel, 1995; Perednia, 1995/(3); Grigsby, 1995/(1), p. 24]?

> *"You can have the best technology and the best value in the world, but if I've got to pay for it on my own that will certainly slow down its assimilation." [Schneider, senior consultant at Arthur D. Little in Taylor, 1994]*

The lack of clear and consistent policies indeed make it difficult to cover technical, personnel, and professional costs of telemedicine systems at both ends of the transmission. That is why in the absence of reimbursement regulations, physicians and other health care practitioners are unlikely to offer medical services via telemedicine networks. Also in this study the lack of reimbursement was given as an argument against telepathology introduction.

Regarding public and private payers, it seems that they are still reluctant to set universal policies for telemedicine reimbursement. They argue that they first want to have detailed information about the costs and effectiveness of telemedicine procedures and applications for which they should pay for. However, cost analyses are mostly not available, since without any revenues telemedicine cannot prove positive results [Williams, 1995]. This is a vicious circle in which telepathology is situated. Therefore the basic reimbursement ques-

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[75] Retrievable from the TIE on-line database: http://tie.telemed.org; a list of US telepathology sites (1995) and US sources of funding for telemedicine and telepathology is also given by Weinberg, 1996, p. 834

tions still remain unanswered: Who should receive how much reimbursement for which tele-service? And how should payment rates be structured to reflect equipment and transmission costs [Puskin, 1995/(2), p. 128]?

13.5.2.1 Reimbursement Policy of Insurers

Reimbursement Policy of the HCFA in the USA

One task of the Health Care Financing Administration (HCFA) is to assure the quality of care for all who are in the Medicare and Medicaid programs. That is why HCFA studies the usage of telemedicine, and investigates and defines its benefits and its limitations[76] for developing appropriate national policies and reimbursement regulations, based on solid data, regarding when and how to pay for telemedicine services and how to safeguard the quality of care [Smits, 1995, pp. 139 ff.]. The background is that the HCFA wants to construct coverage and payment policies that do not create incentives for practitioners to over-provide services. The fear is that telemedicine services without adequate controls could lead to inappropriately high telemedicine consultation rates [Puskin, 1995/(2), p. 129]. For sure the HCFA welcomes the advent of new technologies to better serve the beneficiaries, but HCFA also wants to make sure that the technology will be used in an appropriate manner that is consistent with medical practices and beneficial to the patient.

To develop broader coverage and payment rules over time, the HCFA encouraged the private insurance industry and other government agencies also to initiate projects for exploring the potential applicability of telemedicine in clinical care [Smits, 1995, p. 141]. A practice which is not new.

> *"Medicare has rarely, if ever, been a leader in the development of new technologies. We leave it to the medical community and marketplace to prove the efficiency, cost-effectiveness and medical appropriateness of applications before Medicare reimburses." [England, project officer of Medicare in Ziegler, 1994].*

Such an attitude causes frustration by telemedicine providers, since they believe that only when the HCFA acts other third party payers will follow suit [Grigsby, 1995/(1), p. 24]. Fortunately one area where reimbursement regulations were already set up by Medicare is in teleradiology. Yet, these regulations are limited and inconsistent, since the HCFA does allow state Medicaid agencies to establish their own coverage policies [Flaherty, 1995/(2)]. Nevertheless, these payments are often 'a light at the end of the tunnel'. That is why some facilities count on teleradiology to help cover the costs of running other telemedicine programs like telepathology [Grigsby, 1995/(1), p. 24]. Others are using existing codes to bill for teleconsultations.

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[76] HCFA projects in telemedicine: HCFA contracted with the Center for Health Policy Research in Denver to conduct a review of state-of-the art telemedicine and to develop a framework to assess the effectiveness and technical effects of telemedicine [Taylor, 1994]. It introduced the continuing education network 'MEDNET'- (also referred to as 'HealthNet') a project of the HCFA in cooperation with the Office of Rural Health Policy. Another HCFA-project for the development of a telemedicine data collection consortium was created in cooperation with the University of Oregon. Together with the Mercy Foundation Hospital Consortium in Iowa, HCFA is testing Medicare payment regulations. A further HCFA-project is evaluating the cost, access and quality of telemedicine with the University of Michigan for two sites in West Virginia and Georgia [Williams, 1995]. The results of the program at the Medical College of Georgia that receives reimbursement from HCFA as a part of its national reimbursement study, will folder into HCFA's national health policy development [Wyman, 1995; Ziegler, 1994].

Reimbursement Policy of other Insurers in The USA

Similar to the HCRA, also many other insurers in the USA think that telepathology systems first should show empirically that they improve the quality of services or increase productivity before they are adopted and reimbursed. That is again why the lack of quantitative data regarding the cost effectiveness of telepathology causes problems to set up reimbursement regulations [O'Brien, 1998, p. 149; Weinberg, 1996/(1), p. 833]. However, some insurance companies in the USA, for example **Blue Cross and Blue Shield** of Kansas, have begun to pay for a few telemedical procedures. However, often only the physician's time is paid, but not the transmission or equipment costs. In summary the policy of Blue Cross / Blue Shield is to wait for figures, which demonstrate whether the use of telemedicine systems costs less than traditional methods. Insurance giant **Aetna** reimburses for teleradiology services. For billing of telemedicine services in general, Aetna plans to make general policy decisions on each procedure once it is deemed appropriate, effective, necessary, safe and cost-effective [Ziegler, 1994]. A strategy to make commercial insurance firms to be positive about telemedicine and to reimburse consultations is, to involve them in the network design and service planning process [Wyman, 1995; Ziegler, 1994]. A strategy, which should be taken seriously by project leaders.

Reimbursement Policy of International Insurers

Regarding other countries than America, insurance companies and other payers also hesitate to set up reimbursement regulations for telepathology, so that the question of reimbursement for telepathology services there is a unsolved problem, too. That is that either services are done for free or that physicians try to overcome the problem of reimbursement by just using existing codes to bill for teleconsultations. For example in **Germany** actually all telepathological consultations are done by the telepathologist for free. In **Switzerland** there are also no special regulations for telepathological consultations available, so that the only fee which can be settled is the one of a traditional glass slide examination. One exceptional country where reimbursement regulations are already available is Japan. In Japan the absence of reimbursement was a problem in the past, but in 1998 the government announced that reimbursement for telemedicine procedures will be instituted [O'Brien, 1998, p. 157; Tsuchihashi, 2000].

Altogether it is recommended that governors should direct their health departments to establish a task force consisting of physicians, other health care practitioners, managed care organizations, third party payers, state insurance commissions, rural consumer groups, federal agencies, and other interested parties to negotiate and set initial state-wide policy on telemedicine reimbursements, including telepathology services [Flaherty, 1995/(2)]. Such committees should set up rules about the kind of telepathology services being reimbursed, and find a solution about how reimbursement should be financed.

13.6 Savings and Process Efficiency

13.6.1 Savings

New technologies and procedures in medicine are often blamed for their role in increasing medical cost. However telemedicine applications, including telepathology may also provide a possibility to save a lot of money, as a study of Arthur D. Little Inc., Cambridge, MA. proved in 1992. Examining Texas projects he found out that U.S. health care costs

could be trimmed by more than US-$ 36 billion annually through telemedicine services [Shoor, 1994; Lumsdon, 1992]. On the whole these savings were often achieved by electronic management and transport of patient information (80%), by electronic processing of health claims (18%), by electronic inventory management systems (1,5%), and teleconferencing for professional training and remote medical consultations (0,5%).

Duplications

These findings indicate, how important integrated electronic medical records and system integration are, since a lot of money could be saved by avoiding duplication of tests, double data input or redundant record keeping. In this way the misallocation of resources could be avoided [Perednia, 1995/(3); Ulsenheimer, 1999/(2), p. 898].

Transportation

The saving rate of 0,5% for professional training and remote medical consultations seems to be out of date, since the price for equipment decreased, and the usage of telemedicine applications for consultation and education increased a lot during the last years that the saving rate may be higher. This rate has to be verified. The basic idea of telemedicine consultation is that of data being transported cheaper and faster than people [Blanton, 1995; Bergman, 1993/(2)]. With videoconferencing cost savings can be achieved by reductions in air fares, hotel fees, meals, and other travel-related expenses [Taylor, 1994; Marsan, 1995, p. 341]. Further the cost for the patient to drive to a specialist, and to take a day off from work would be avoided. Even though manpower is of value to society, such savings are mostly not calculated into third-party payment formulas. Reverse, if the doctor is travelling across the state, his travel time has to be taken into consideration, too. As an example, flying specialists into Harlingen (located 250 miles south of the University of Texas Health Sciences Center at San Antonio) typically costs approximately US-$200 per flight plus the physician's fee, an average of about US-$100 per hour [Braly, 1995/(2)]. One reason that the UTHSC introduced desktop videoconferencing systems for telemedical consultation, including telepathology, was that videoconferencing systems may help to reduce travel expenses and improve communication. This was also discovered at Baptist Hospital Inc., Louisville, KY:

> *"We don't expect videoconferencing to eliminate all travel, but we hope to cut it by 50 percent." [Lumsdon, 1992]*

Faster Processes

Another area, where especially telepathology will help to save resources is the improvement of medical processes. Giving a traditional scenario, a patient would have to undergo one surgical procedure for the sample removal and another procedure if the tumor analysis is positive. Telepathology therefore decreases the medical risk and may reduce costs if used frequently [Braly, 1995/(3)]. Without telepathology systems up to now frozen section examinations have to be transported to another hospital for examination. During that time, the operating team has to wait for the diagnostic result. With telepathology, waiting time would be diminished and the operating theatre would be available earlier for other patients. Diagnoses are available faster. That has the advantage that treatment and therapy process will become more purposeful and efficient. Furthermore specialized experts are able to reduce costs by preventing unnecessary surgery and hospitalization [Ziegler, 1995].

Fee for Hospitalization

Telemedicine will further save hospital inpatient costs by keeping rural patients in rural facilities that have lower costs than urban hospitals [Puskin, 1995/(2), p. 129; Stewart, 1994, p. 40]. For example, if patients are treated as inpatients locally at an estimated inpatient cost per day of US-$ 800, compared to US-$ 1.300 per day at the center (price is an example fee of the Medical College of Georgia), telemedicine could significantly cut costs on a per-patient basis [Shoor, 1994]. James Reid, consultant and president of Innovative Medical Communications, Billings, Montana, stated that estimates of the percentage of telemedicine patient candidates who can be retained by the rural hospital vary between 50-80%. This patient retention has another direct positive effect on the rural hospital or rural physician, since it keeps revenue flowing into the local hospital, which may be struggling to stay afloat [Wyman, 1994]. Treating the patient at the local facility may further have the benefits that come from faster local treatment and consequently increased productivity.

Considering the situation of the medical center at the other side, the available high-tech equipment at the center is not just more expensive, but also often limited. If the patient can be treated at the periphery, the high-tech resources of the center are available for more urgent cases. Again, resources are optimized.

Personal

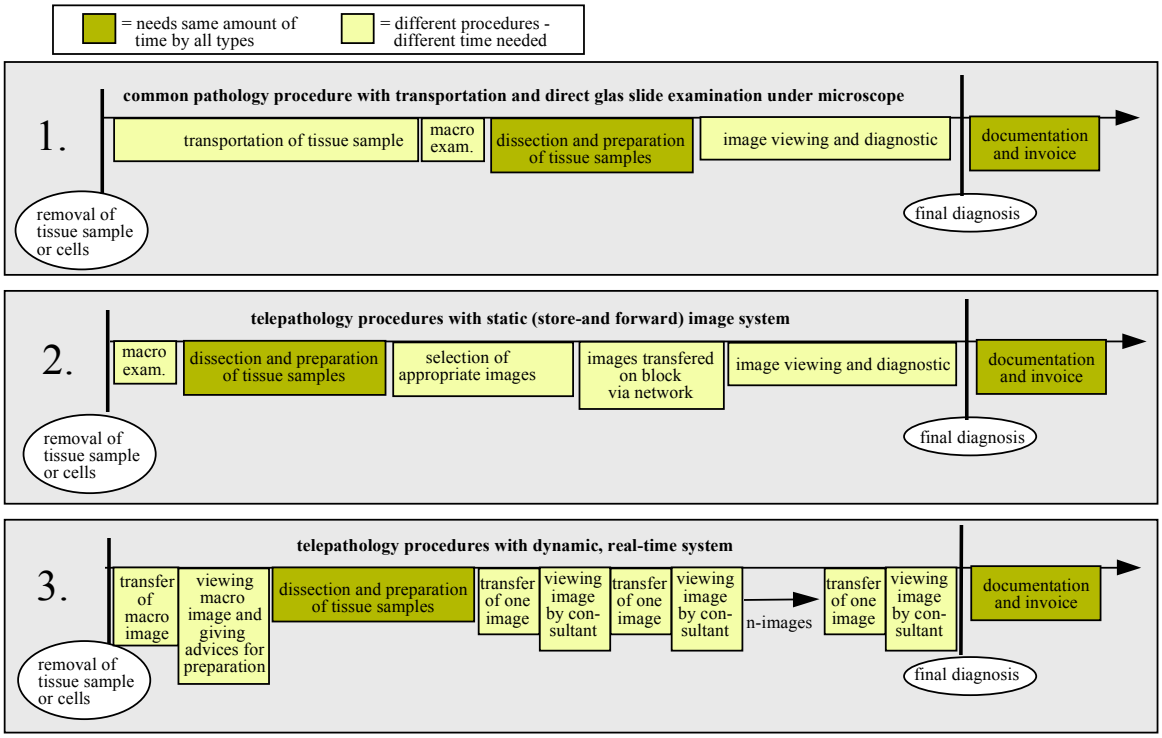
Another idea of telemedicine systems is that costs should decrease because fewer specialists are needed at rural hospitals. If there are only few pathological examinations necessary per day, pathologists could be replaced by surgeons or a medical technician, assisted by telemedicine links. Thereby the pathologists' salaries are converted into cost savings [Almagro, 1998, p. 1162; Williams, 1995; Bergman, 1993/(2); O'Brien, 1998, p. 157]. In Milwaukee there already was a significant salary saving, since the pathologist did no longer have to be stationed at the remote site. Inefficient staff casting was avoided [Dunn, 1996/(2), p. 466].

Telepathology systems may also help to optimize the time schedule and by this lead to an optimization of high quality human resources. For sure that raises the fear of pathologists that with telepathology their working time could be overloaded with too many case examinations. Indeed, telepathology could enhance the workload of pathologists. On the other hand, weekend services could be reduced since a central pathologist could serve for many clients.

13.6.2 Improved Diagnostic Processes

13.6.2.1 Description of the Different Processes

Time frame and activities of different pathological procedures:



Schedule16: Time frame of different pathological procedures.

The figure above shows the processes of traditional glass slide examination (1), of static imaging telepathology (2), and of robotic real-time telepathology procedures (3). The direct comparison allows to recognize the differences between these processes more precisely and to analyze the critical areas of process efficiency. All processes are starting with the removal of the tissue sample and end with the final diagnosis.

Lets first have a look at the **common pathological procedures** (1). After the tissue was removed, it has to be transported (by courier service or mail) to the pathologist. Then, at the location of the pathologist, the sample will be directly macro examined, then dissected, and then examined under the light microscope. As the illustration reflects, the time needed for the dissection and preparation of the tissue sample is the same in all procedures, just the location where it is done varies.

At the **static image system**, the macro examination, the preparation of the tissue sample, and the selection of the appropriate microscopical images are done at the local side. Then images are sent - all at once - to the pathological expert, who is able to examine them when it is most suitable for him. In comparison, using a **real-time system**, both - client and expert - have to be available at the same time, since there is an ongoing communication between both. First the expert is getting images of the whole sample for doing the macro examination. He is giving advises for the dissection. After the sample is prepared and put under the robotic microscope at the local side, images are continuously selected by the remote expert, captured by the camera mounted on the robotic microscope and transferred over the network. This process keeps on going with different tissue magnifications until an accurate final diagnosis can be made.

13.6.2.2 Critical Aspects of Process Efficiency

Conventional Telepathology

The efficiency of pathological procedures is dependent on several parameters, of which the most important is time. Time which is needed from the removal of the tissue sample until the pathological diagnosis result is available. The critical point of the traditional pathology is the distance between the place of the surgeon and the pathologist - that is the time which is needed to transport a specimen to the pathologist or the travel time of the pathologist to the place of consultation. Especially when considering intraoperative frozen section examinations, transportation time is a critical parameter.

Critical Factor of Telepathology Systems

With telepathology systems the time for specimen transportation is replaced by image transmission. Static systems mostly are handled synchronous. That is why the transmission speed and time of images do not matter a lot. The case examination time is distinguished into the time which the client needs for specimen preparation, image selection, and image transmission, and the time the telepathologist needs for his screen-examination. If images are not sufficient to render a diagnosis, additional images have to be selected and transmitted by the client and examined by the expert. This time has to be added to the total examination time.

A dynamic telepathology systems is based on an ongoing image transmission process. That is why image transmission time (speed), the amount of images per case, image viewing time, and case examination time are important parameters to measure the process performance [Dunn, 1996/(1), p. 469; Dunn, 1997/(1), pp. 8-12; Dunn 1997/(2), pp. 1-10]. Regarding transmission speed, there are several variables affecting the operation time for each image: resolution, color quality, microscope magnification, quantification factor, and bandwidth of the link. Higher camera resolution results in bigger images with more pixels and longer time for image grabbing. The color quality and quantification factors affect the amount of JPEG compression. Quantification factors tune the precision of each pixel. As the quantification factor is increased, the amount of compression is increased. Increasing microscope magnification, by rotating the objective lenses, tends to decrease the complexity of an image grabbed from a microscope. Image complexity is thus inversely related to magnification for many pathology specimens [Weinstein, 1995, 222].

Viewing times are considerably longer on a video monitor than on a microscope. One factor for longer viewing time appears to be system inefficiencies inherent in operating a motorized microscope by remote control. Another factor is the relatively small size of the dynamic video-imaging window, which limits the amount of information presented [Dunn 1997/(2), pp. 8, 9]. It also makes a difference whether high quality video images with high spatial resolution, color fidelity, and image stability are used, or whether lower video standards such as NTSC, PAL, or RGB are employed, which demonstrate a limitation in image quality and therefore enhance the viewing time [Weinstein, 1992, p. 402]. The time for the examination of a case is also related to the experience of examining an image on the screen. Examination time will decrease with the experience gained with video image interpretation by the pathologists [Nordrum, 1991, p. 517; Ito, 1994, p. 805]. It is the same with certainty. At several studies, the level of certainty was higher and examination time shorter for the second group of cases. For example the time per case of 8,9 minutes decreased by 30 % for the second half of the slides at the study in Milwaukee [Dunn, 1997/(1), p. 11]. (Studies which consider the examination time needed, see appendix VI).

13.6.2.3 Efficiency with Frozen Section Examinations

Doing frozen section examinations, turnaround time should be kept short. Turnaround time of frozen sections is the time required for the retrieval of the biopsy specimen from the operating suite until the result is available by telephone or a report is generated and sent to the client. An average for efficient frozen section examination at conventional pathology the time for transportation should not last longer than 30 to 40 minutes [Fujita, 1995, p. 105; Steffen, 1997/(2), p. 28]. This time aim can only be reached by common courier services within a distance less than approximately 30 km (with small variations due to road and geographical conditions) [Interview, Oberholzer, Basel/CH, 1999]. If these restrictions cannot be taken for granted, one of the following possibilities have to be chosen: a) do without a frozen section diagnosis, b) change the schedule of the operation in a way to coincide with the day when a pathologist is at the hospital, or request that a pathologist comes to the hospital to make the frozen section examination on the day at which the operation is scheduled, c) treatment of the patient at a hospital with a pathologist, d) expensive helicopter transportation of sample, e) or support by telepathology.

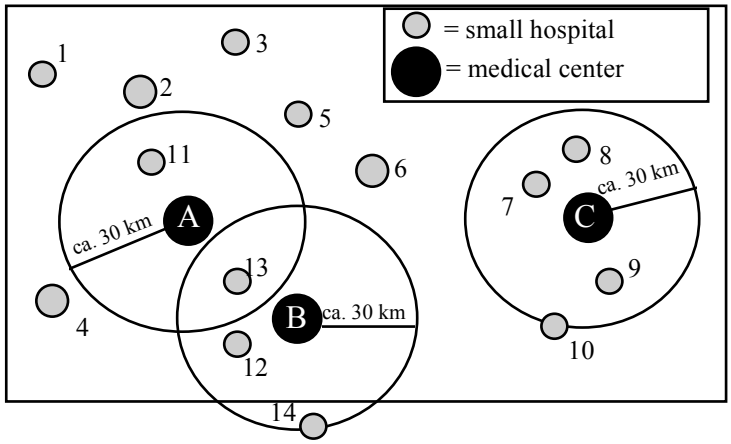


Figure 17: Pathological services, considered by distance.

In our example, the medical centers or pathologists' offices A,B,C cannot be reached within this given time-frame by hospitals 1 to 6. The small hospitals 7 to 14 are able to transport their samples to a pathologist within the acceptable time frame. Hospital 13 can even choose whether to consult pathologist A or B. Hospitals 10 and 14 are at a critical edge, since the distance is around 30 km. Hospital 14 is abroad, but still served by pathologist B. One example is the Hospital of Lörrach/Germany, which is supported by the University Hospital of Basel/CH.

The given example demonstrates that remote hospitals (1-6) are also able to offer surgeries with frozen section examination to their patients if telepathology support is available. In this way the overall hospital utilization rate could be increased. Hospitals which could reach a pathologist within an acceptable time have to calculate, whether it makes sense to invest in telepathology systems (e.g. if the system is also used for education or other services).

In general to complete an intraoperative frozen section examination is acceptable within approximately **10 to 20 minutes or less** [Weinstein, 1992, pp. 401-402; Kayser, 1992/(2), p. 395]. If transportation time of 30 to 40 minutes is added, the tolerable examination time applying the traditional method would be 60 minutes. With telepathology, the direct examination process in most cases is longer than with direct microscope examination, but if transportation time is long, process efficiency is still much better than the conventional method.

Viewing Time With Dynamic Systems

System users reported that viewing times for slides are considerably longer with a video monitor and a robotic microscope compared to conventional light microscopy. Not rarely users are unsatisfied due to the relatively slow response time of the computer-controlled, robotic-motorized microscope, and the time required to digitize, store and transmit selected higher resolution images [Dunn, 1996/(2), p. 465]. Therefore when using dynamic systems due to the number of 'live' images to be transferred, high transfer rate are requested. That reduces the transfer time, but by this drastically increases telecommunication costs. For a realistic calculation of transfer time, the time needed to create a connection and to compress images has to be added to the transfer time and to the time needed for image examination and documentation [Klutke, 1997, p. 71].

To examine a slide on a light microscope takes approximately 1 to 2 minutes. The examination time for telepathology cases vary a lot due to the given reasons. Viewing time is dependent on transmission speed. To give an example, at a study using Intel ProShare and an ISDN line, an image of 176 x 144 pixel size, a data transfer rate of 750 KByte/min, and a compression of 1.7 approximately 10-15 video images per second could be transferred. In comparison, the transfer of an image with the size of 8,5 x 17com (1000x2000 pixel; 1.9 MByte; resolution 300 dpi) would need approximately 70 seconds [Klutke, 1997].

Considering the viewing time at a study in Milwaukee, telepathology took an average of 4.43 minutes per slide and 12.09 minutes per case [Dunn 1997/(2), p. 8]. At another study approximately 70-80 % of the diagnoses were rendered with light and video microscopy in less than 2 minutes, and over 95 % of all the cases in less than 4 minutes in both viewing modes. An interesting result of this study was that the average viewing time for false-negative and false-positive decisions were nearly twice as long as for true-positive and true-negative decisions. This suggests that a pathologist facing an unusually long viewing time on a case may regard this as a warning sign for an increased risk of rendering an inappropriate diagnosis [Krupinski, 1993, p. 84]. For further test results see appendix VI.

13.6.2.4 Second Opinion Examinations

If a second opinion consultation of intraoperative section cases is necessary, and since images are already available with telepathology, the pathologist can access multiple specialists [Dunn, 1996/(2), p. 465]. The additional effort for such second opinion consultations would just needed additional 5 to 7 minutes[77] (with ISDN 3-5 min), including image transfer, image examination and discussion of the case [Kayser, 1992/(2), p. 396]. This time has to be added to the regular examination time. Although the total examination time is increased, surgeons appreciate the possibility of fast second opinion consultations (especially at frozen section examinations) and are willing to tolerate this additional time delay in circumstances to get a very reliable result [Kayser, 1993/(2), p. 397].

[77] Discussion of the images, and acoustic assistance in diagnostic classification or advises lasted for average 3 minutes. Transmission time by telephone for one image was 1-2 minutes, with ISDN 10 seconds [Kayser, 1995/(3), pp. 216-217].

13.6.2.5 Turnaround Time in Routine Cases

Employing medical diagnostic Internet services and advisors, turnaround time is often aimed to be a huge problem [Hottelet, 2000, p. 13]. Considering telepathology, at a study in USA non-deferred cases (97,5 %) executed by telepathology were examined in less than 2 days. For deferred cases 5.5 days were needed. Unfortunately, the amount of deferred cases slightly increased with telepathology.

In comparison, with conventional methods, the turnaround time of non-deferred cases was on average 4.6 days, and much longer for deferred cases [Dunn 1997/(2), p. 8]. Martin even reports about a delay in obtaining an answer with the conventional method of 8 to 15 days [Martin, 1996, p. 459].

In summary, turnaround time could have been reduced by more than 50 % with telepathology. This proves that also in routine cases the efficiency of processes with telepathology systems is much better than with conventional pathology if there is no pathologist at the place and if transportation is long.

13.7 Conclusion of Efficiency

The question of the efficiency of telepathological systems can't be answered at once, since it is dependent on various parameters and has to consider the individual situation of an user. It depends on the system to be used and on the kind of services. One main mistake which often occurred in the past was that high-tech system were purchased, which were rarely used. If for example dynamic-robotic systems produce investment costs of US-$ 100.000-150.000 and only 100 cases or less are examined each year, the average cost per case is far too high. A positive effect in the efficiency discussion is that telepathology equipment becomes continuously cheaper so that reliable telepathology systems start to become affordable at a reasonable price [Taylor, 1994; Grigsby, 1995/(1), p. 26].

In the past one reason for telepathology systems's inefficiency was the lack of reimbursement, which hopefully will disappear within the near future. Insurers are already beginning to set up reimbursement regulations for telemedicine services. Therefore, the probability is high, that reimbursement for telepathology procedures will be available soon. Considering the current situation, none of the existing telepathology projects reported about a positive balance of their services. However, cost recovery of telemedicine applications in general is rare. A project which is often named in literature is the profit orientated project of Harris Corporation, a computer system manufacturer in Florida [Ziegler, 1995]. Another project in Texas (Texas Tech MEDNET) demonstrated a break-even analysis within three years, when the lower costs of treating in rural communities, travel time for physicians and patients, and lost opportunity costs were considered [Moore, 1995]. Canada demonstrated full cost recovery for educational efforts. However for many large projects, potential overall savings remain an open question, especially as long there is no adequate reimbursement.

14 Standardization and Integration

In this chapter the main areas of telepathology's standardization, both technical and practical standards, will be emphasized and discussed. To understand the characteristic of certain protocol and standards, the history of standard setting activities, the name and role of key players and their objectives of standardization will be described. In order to select the most appropriate protocol and standards for the practice of telepathology and communications, differences between similar standards are discussed, and appropriate standards for telepathology information interaction and management are specified.

14.1 Reasons for Standardization in Telepathology

Why are system integration, and the creation of protocol and standards particular important for telepathology? First, telepathology systems are a **part within a whole health care delivery system**. For an efficient treatment of a patient, it is necessary that physicians are able to communicate easily and fast with each other. Fortunately, interactive audio-video teleconferencing systems and high speed computer networks enable a closer 'technically supported' collaboration and data exchange between physicians. With computer technology, health care structures are changing towards a multi-provider interactive integrated health care delivery network. The objective of this system is, to offer equal quality in medicine, independent of the patient's location and to overcome physician's isolation. Standards are needed to enable the creation of such multi-provider health care networks and to avoid the mistake of the past, which is that extensive investments were done for isolated, not compatible system components. That is why providers (e.g. hospitals, doctor's offices) are required to invest in a strong **overriding integrated information strategy,** governed by a strong organizational strategy, and that they have to have the willingness to collaborate with many organizations [Austin, 1995, Judge, 1993, Howard, 1995; Engelhorn, 1996, p. 29].

Second, telepathology systems are working at a distance and therefore depend on the carefully transfer of textual, numerical and graphical data. That is why effective telepathology is only possible, if participants are supplied by a broad variety of equipment connected by far-spread communication lines. These prerequisites can only be fulfilled if **technical and medical standards** are available, obligated for all partners [Kayser, 1992/(1), p. 381]. And last but not least, compatibility between systems avoids the problem that electronical communication between two physicians is dependent on the available system configuration, instead, the telemedical partner can be chosen for his specialty competence [Hufnagl, 1999, p. 95].

A framework of standard agreements between telepathology system users has to be established. To guarantee an efficient workflow process within this framework, telepathology systems need standardized formats in such a way that data exchange between the medical systems is possible without manually interfere [Hufnagl, 1999, p. 95]. The basis of simple integration of telepathology systems and their system environment, is the development of well designed databases and the establishment of standards for data and image formats. Uniformed protocols are needed for the definition, transmission, initial interpretation, organization, storage, management, recall and usage of medical data. Standards also have to be developed to safeguard image authenticity and for the protection of images that become part of the patient's medical record [O'Brien, 1998, p. 151]. For example, to enable successful teleconsultation, the consultant needs specific data and information about the patient. This data has to be accurately identified in kind, extent and format - first, the definition of the kind of data required to judge the patients situation and second, during the online interaction all data has to be in a format that proper recording is guaranteed.

14.2 Areas for Standards and Protocol

One way to integrate telepathology systems successfully is to establish new and optimal standards for all components and then to start with designing the appropriate equipment. However this is not an efficient way, especially since there are already existing standards in use, even if they may be sub-optimal to some degree. Sometimes they are not compatible with each other, and more often additional effort is needed to adapt them to the special demands of telepathology.

> *„The nice thing about standards is that there are so many from which to choose". [Anon in Houtchens, 1995, p. 93]*

Indeed, there are many existing standards in discussion and for someone, who is not familiar with them, it may be quite confusing to find the most appropriate one for his purpose. One possibility to light up the darkness of standard confusion is the distinction of standards by areas for which they are needed - fundamentally these are communication protocol and standards of data formats.

14.2.1 Standardization of Data Formats

14.2.1.1 Types of Health Care Data

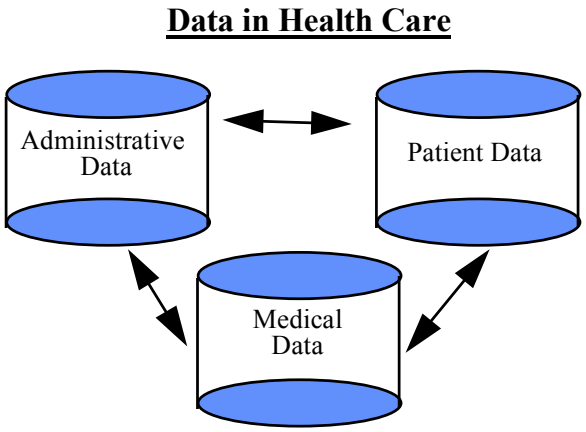


Figure 18: Data Types in Health Care.

Before standards of data formats are discussed, a general overview is given about the main data types in health care. The distinction should allow a correct classification of health care data. The figure above illustrates the fundamental types of health care data and systems. The first ones are the administrative systems. Administrative systems are the most advanced in health care . No surprise, since here is where the data is stored for the management of the 'cash input' such as payment catalogues, insurance regulations and forms, as well as structured data for controlling purposes. The second is the patients data. This is data, as the term is already showing , which is closely related to the patient, like the patient's address, admission and release date, payment data (like insurance of patient), age, sex, etc. The third is medical data. This is case-related, examination-related, diagnosis-related, and physician-related data, for example the medical history of a patient, the entrance diagnosis, physical symptoms, laboratory test data, data about diagnostic and therapeutic procedures and results, drug reactions, outcome - in other words, all data which is needed for proper documentation of the treatment process of a case [Shore, 1994]. Whereas administrative and patient data is mainly in textual form, medical data contain

audio and image data too [Wyman, 1994]. (Rough overview of data fields see appendix II, tables 1 and 2). Most data in telepathology is medical data, in the form of textual data, images, voice, as well as information to control remote equipment. However administrative data and patient data is also necessary for documentation and billing.

There is a data flow between the different data types and storage. For example, the administrative system needs the patient's admission data and medical treatment data to perform the billing. Or the medical system needs the patient data, to create a medical record, in which all medical data of a patient are stored. Unfortunately such data exchanges are often executed in 'paper' form, since the data formats and the participating computer systems are often not compatible. The need for standardization and fast, smooth data exchanges becomes obvious [Wray, 1995, p. 274; Martin, 1996, p. 458]. This was also mentioned in this study; several participants claimed this integration of different sources and applications for the creation of satisfying work conditions.

14.2.1.2 Standardization of Medical Records

Patient information, pathological procedures, results and images have to be carefully documented in a file - the medical record. These data are necessary for the patient's case tracking, for legal purposes as well as for scientific research findings. Altogether pathological data has to be seen in the context of the whole medical history of a patient and as an information source of a comprehensive medical record system. The meaning of medical records for telemedicine - equivalent telepathology - has been described in the chapter about telepathology service introduction (see chapters 4.3.7 and 14.2.1). To summarize, the medical record is the backbone of each telepathology system.

In Europe the development and acceptance of data and medical record standards is less progressed than it is the case in North America. That is why US-standards are often adopted or are taken as a guideline for the Europe standard developments. For example, member countries of the European Committee for Standardization (CEN) have agreed that compatibility with standards specified by the USA Technical Committee addressing medical informatics (CT 251) is a criteria to be used in purchasing medical systems and equipment. These developments are comparable to the introduction activities of electronic medical records in Europe.

Since the US-standards have a huge influence in medical system's compatibility, the activities in the USA are described in more detail.

History of Medical Record's Standardization in the USA

In 1991 the **Institute of Medicine** created an organization - the **Computer-Based Patient Record Institute**, Inc. (CPRI) - to advance the development and implementation of a computer-based patient record. This Organization was set up to solve specific issues, which are problematically for medical record development and management. It also articulates visions of how computer-based patient records could advance information management in health care. In April 1993 the CPRI published a paper[78], where four elementary process categories

[78] Computer-Based Patient Record Institute, Inc., position paper: Computer-based patient record standards; American Health Information Management Association, Chicago, 1993. It describes four elementary categories: first, uniquely identify patients, providers, care sites, and payers; second, specify the patient record content and structure (outline of contents); third, code the content of the record (vocabulary), and fourth, transfer data between computers and across networks (message structure).

were named, and specific standards for each of them were recommended. The recommendations of this report were adopted by the **American Medical Informatics Association**[79] (AMIA). In summary, both, the CPRI and the AMIA recommend the use of the **consensus standard E1384** for the specification of the content and structure of patient records.

Parallel to the activities of the CPRI, in November 1991, the **Secretary of Health and Human Services** and the **American Hospital Association** also set up a 'Work Group on the Computerization of Patient Records', which had the task to define the vision of the computer-based patient record, and to identify practical steps and strategies for the development and implementation of such a record. Two years later this group published a report[80], in which the most important tasks for the implementation of computer-based patient records were described [Houtchens, 1995, p. 98].

Embedded in these frames, several institutions became active in designing a standardized computer-based patient record system. The activities of **Pacific Bell Health Care Market Group** (USA), of the independent **Health Care International Medical Center** (HCI) in Clydebank, Scotland, and the **Rudolf Virchow University Berlin** (Germany, project BERMED), were already introduced.

Unique Identifiers and Standardized Vocabulary

Unique identifiers are codes, which help to clearly identify important parameters of the health care delivery system. The reason for doing so was that the concurrent use of several independent coding systems, and differences in descriptive and diagnostic languages pres??ent opportunity for misinterpretation and misunderstanding and make it difficult for users to link information from different patient record systems.

Unique identifiers are for example the Universal Physician Identifier Number, set up by the Health Care Financing Administration (USA), or the 'prescribers' codes, developed by the National Council of Prescription Drug Programs in collaboration with the American Medical Association. In 1993, the National Library of Medicine developed a Unified Medical Language System (UMLS) - the so called '**Meta-thesaurus**' - in order to eliminate problems created by the existence of multiple vocabularies and coding systems. Altogether this meta-thesaurus included 152.444 concepts and 311.046 terms from 15 different vocabularies [Houtchens, 1995, p. 106]. Another important world-wide accepted code system for diagnoses and therapy is the **ICD-**9, the International Classification of Diseases or the **ICPM**, the International Classification of Procedures in Medicine [Hufnagl, 1999, p. 95]. In France an anatomical diagnostic thesaurus is tested, the so called ADICAP common language coding system, which has the objective to standardize procedures and medical diagnoses in hematological cytology [Flandrin, 1995, p. 258; Flandrin, 1997/(1), pp. 97-104; Flandrin, 1997/(2), pp. 104-109; Klossa, 1998, pp. 207 ff.; Diebold, 2000; Hemet, 2000].

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79 Board of Directors of the American Medical Informatics Association. Position paper; Standards for medical identifiers, codes, and messages needed to create an efficient computer-stored medical record, J.Am.Med.Informatics Assoc., 1(1):1-7; 1994

80 Report of the Work Group on Computerization of Patient Records. Toward a National Health Information Infrastructure, Department of Health and Human Services, Washington DC, April 1993. In an overview, the three basic task were: first, improve the knowledge about the state-of-the-art; second, promote standards for documenting and sharing patient information; third, promote development of computer-based information system networks. For all these tasks information about the lead organization, a time frame and an estimated cost frame was included in the report

For the field of pathology, as early as 1965, **SNOP**, the Systematic Nomenclature of Pathology, was developed by the College's Committee on Nomenclature and Classification of Disease. It systematically describes the symptoms and findings in pathology. In 1974 SNOP was extended beyond the scope of pathology and evolved into **SNOMED**[81]**,** the Systematized Nomenclature of Medicine. SNOMED contains a broad array of clinical terms crossing all specialties of medicine. It was endorsed by the **American Society of Clinical Pathologists (CAP)** and very soon by most of the international pathological organizations, too. In 1993 the CAP and the National Library of Medicine structured a relationship incorporating SNOMED into **the Unified Medical Language System** to facilitate the transfer, integration, and retrieval of biomedical information from different sources. In 1996 a subset of SNOMED micro-glossary terms was adopted in the DICOM standard by the American College of Radiology and the National Equipment Manufacturers Association. In 1997 SNOMED and **LOINC** (Logical Observation Identification, Names and Codes) collaborate on the cross mapping of clinical reference terminology, so that now the detailed names of laboratory tests provided by LOINC will be mapped to more atomic SNOMED procedure terms. In 1997 around 32.000 terms of SNOMED were mapped to the **ICD-9-CM** to facilitate health reporting and statistical analysis, providing one point of reference for the coding of disease categories and billings. In 1998 the CAP started to integrate the work of the Kaiser Permanent Convergent Medical Terminology (**CMT**) into SNOMED and created SNOMED Reference Terminology (SNOMED-RT).

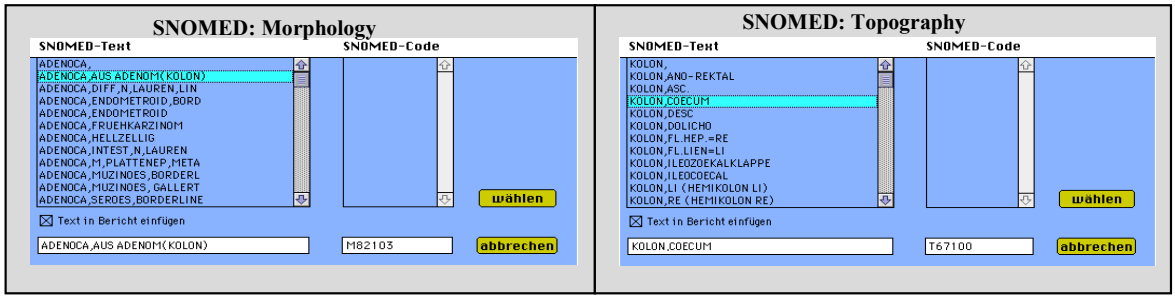

Figure 19: Example of integrated SNOMED-terminology – screen shot of the telepathology system in Basel/CH.

In the meantime SNOMED became a nationally recognized leader in clinical terminology in the USA, and achieved acceptance in most of the health care communities world-wide. Since it includes the most comprehensive standardized language of health, it is a backbone for the integration of computerized patient records. It helps to reach a level of language commonality, avoids misinterpretation, increases diagnosis productivity, and provides guidelines to build-up an efficient database for epidemiology and statistical studies. Currently it contains 13.165 records of topography, a functional anatomy for human and veterinary medicine; 5.898 records for morphology, terms used to name and describe structural changes in disease and abnormal development; 41.494 records for diseases/diagnoses, a classification of the recognized clinical conditions encountered in human and veterinary medicine; and 30.796 records for the classification of health care procedures. A list of further codes (e.g. ADICAP, RESINTEL, see appendix II). All these efforts for standardization are vital for the creation of international telemedicine networks. The improvement of disease standardization will make diagnoses internationally more consistent, accurate and comprehensive [Eide, 1994, p. 888].

81 http://www.snomed.org

Considering the developments in the design of standardized medical records (see appendix II) and the usage of unified coding systems, patient records still differ widely in form and availability, offer varying degrees of quality, and many of them still do not meet the current information needs of health care professionals [Detmer, 1994]. This inadequacies of current patient records (both paper and electronic) and the non-observance of standards lead to a delay in the information system integration process, and to a delay in efficient conversion of care reforms. That is why decision-makers, health care system developers, as well as users must understand that the standardized patient record and codes are vital to improve the effectiveness and efficiency of clinical processes and procedures and that standards are the basis for a satisfying integration process.

14.2.2 Standardization of Images

14.2.2.1 Teleradiology in Comparison with Telepathology

As with pathology, the diagnostic radiologist generally has little or no direct patient contact, and he or she deals primarily with the analysis of visual images. That is the reason that made both most easily adaptable to a telecommunications medium. To guarantee a high quality in radiology, the American College of Radiology adopted standards for image quality, e.g., the Picture Archiving and Communications Systems (PACS) standard, with regards to the minimal technical requirements for performing teleradiology [Tangalos, 1995, pp. 281, 284]. The objective of these standards is to assure a faithful transmission of images of sufficient quality to allow radiologists to render a primary interpretation. Further in radiology, physicians have to prove and to document that they employ adequate technical standards to assure that their consultation is based on accurate data [Swett, 1995, pp. 596, 600].

Yet, no such standards have been formally accepted in pathology. One reason for this is that pathological microscopic images require the highest levels of quality among all other disciplines. However the absolute requirements for spatial and color resolution in pathology digital images have not been sufficiently investigated up to now. Another reason is that the types of images viewed by pathologists are quite different from the gray-scale images viewed by radiologists. In pathology, images are in **real color** and require high resolution at high **magnifications**. Microscopic images have faithfully to be reproduced at various magnifications including minute structures and subtle changes in cellular texture [Okumura, 1997, p. 701; McGee, 1995, p. 33]. Visual clues for pattern recognition have to be provided by a combination of color, texture, and edge detection. Further in opposite to radiology, pathologists primarily deal with the analysis of visual images involving **interactive movements**. Unlike a static image radiograph, which can be viewed all at once, a glass slide is scanned under the microscope using a low-power objective, with selective fields viewed at progressively higher magnifications. Because pathology diagnosis is a dynamic process, involving continuous viewing of microscopic fields under a variety of magnifications, it is more difficult to build up image standards like in radiology [Weinberg D., 1996/(1),
pp. 831 ff.].

In radiology there is some consensus that a 2048 x 2048 pixel matrix and a 10- or 12-bit contrast would provide adequate spatial resolution, while the display of images can probably be done effectively with an 8-bit monitor [Grigsby, 1995/(1), p. 20]. More precisely in 1995 the American College of Radiology recommended that small matrix images be digit-

ized and displayed with a minimum of 500 x 500 pixels x 8 bits per pixel, and large matrix images should be digitized with a minimum of 2000 x 2000 pixels x 12 bits per pixel, and displayed with a minimum of 2000 x 2000 pixels x 8 bits per pixel. Considering different diagnostic areas, for an accurate interpretation of an chest X-ray the American College of Radiology recommended 2000 x 2000 pixels, and 4000 x 4000 pixels by 8 bits for mammograms [Wyman, 1994]. In pathology, standards for the lowest image resolution required and the smallest size necessary for consistent detection and accurate interpretation of most pathological findings are not sufficiently determined yet. As an estimated value, Kayser determines that the maximum spatial resolution is about 4000 x 4000 pixels for the sender and 1000 x 1000 pixels at the receiving end [Kayser, 1996, p. 476].

To set up isolated standards for the quality of pathological image is perhaps not so reasonable, because the image quality perceived by an observing pathologist is not solely based on the resolution, color depth or other physical attributes of the captured image, but also factors like the quality of a histological slide itself, focusing and illumination, rendering devices like display card and monitor, etc. also have a significant influence on the final perceived quality of the image [Azumi[82], 1996, p. 449]. In addition, the value of pathologies as a specialty lies in the ability to detect and accurately interpret findings for which the probability of occurrence or profile of presentation is low, but the consequence of missed or delayed diagnosis is high. To detect abnormalities of tissues or cells that are uncommon or subtle usually demands a certain image quality, perhaps a better one than is required for the detection of those that are common or obvious. This situation again enhances the problem of where to set the image standard, perhaps one more reason for the delay.

Two standards, which surely have an influence in the standardization of pathological image quality are DICOM and MPEG, which are described as follows.

14.2.2.2 DICOM - Digital Imaging Communications in Medicine

Image quality is indicated by contrast resolution, spatial resolution, color and brilliance. As already was described in chapter 16.2.2, one of the most important determinant of digital image resolution is the number of bits (**bit depth**) used to encode the color scale characteristics at each digitized picture element (**pixel**). One elementary standard, which describes the bit depth capabilities of digital imaging and communications in medicine, is the supplier independent **DICOM 3.0+ standard** (Digital Imaging and Communications in Medicine). Responsible for the development of DICOM (previously called ACR-NEMA) were primary the ACR (American College of Radiology) and NEMA (National Electrical Manufacturers Association) [Hufnagl, 1999, p. 95]. In general DICOM 3.0 describes and standardizes the communication of medical images and image related information. It describes interfaces of imaging equipment, physical links, standardized data formats and network communication protocols based on already existing structures. It is often the foundation of HIS and PACS [Schwab, 1997]. One specific parameter of DICOM is the format of the complex image files. DICOM files are subdivided in header, patient, treatment and image information mostly in ASCII-format, as well as image file data in binary format. Further there is additional information about image parameters like pixel size or data about image presentation. DICOM contains a specific protocol for the data access via networks

[82] Azumi is involved in setting up an International Consortium for Internet Telepathology. In his article he describes various equipment combinations and factors of influence for still imaging systems (hardware, software, comparison of camera types, image capturing devices, image quality factors, etc.).

[Thiel, 1997, pp. 132 ff.]. The DICOM standard for the exchange of various medical images exceeds the silver-based film quality, which most diagnostic images currently archive. However since it is more appropriate for radiology images than for pathology, this standard has to be extended for an appropriate usage in telepathology. Parameters such as image size, resolution, color characteristics, gross description and other clinical and textual data should be brought in a standardized format. General recommendations might be developed by the Association of Directors of Anatomic and Surgical Pathology. The College of American Pathologists is actually working on the **PLExCOM standard**, an extension of DICOM for pathology and laboratory medicine, which will soon be published. In parallel, the European Standardization Committee is discussing frameworks for medical imaging, picture archiving and communication systems (PACS), which may have an influence on the standardization of pathological images, too [O'Brien, 1998, pp. 151, 156; Weinberg, 1996/(1), p. 833].

14.2.2.3 MPEG - Moving Pictures Experts Group and H320

Whereas DICOM will most likely be the de-facto standard for the secure transfer of captured images, the MPEG and H320+ standards are rapidly gaining acceptance as the de-facto standards for the transmission of video and teleconference signals across digital networks [O'Brien, 1998, p. 152]. MPEG and H320 define the protocols for video codec (compression and decompression) delivered along telephone lines or digital networks. MPEG is primarily for motion pictures and H320 (previous standard H261) is primarily used at tele-video conferences[83].

14.2.2.4 Design of Image Quality Tests

Diagnostic accuracy **studies in pathology**, for the specification of standards of resolution and quality of diagnostic images, should distinguish diagnostic accuracy of digital still images and the medical utilization of motion video communications - and this by taking a broad spectrum of disease states in consideration. For some kind of examinations a lower image quality will be sufficient, whereas for other examinations the highest resolution monitor image is necessary.

> *„ ...usual monitor with 525 scan lines, resolution is not high enough to observe cellular detail when compared with the microscopic image, for example, mitotic figures and chromatin pattern, so that frequent disagreement on the degree of atypia in dysplasia was noted." [Shimosato, 1992]*

One study concerning image quality was executed at the University of Utah, Department of Pathology. The researchers investigated that when interpreting digitized hematology slides, accuracy could be improved from about 50 % to 90 % if image size was increased from 640 to 1280 line pairs. However, higher quality of images demands more storage capacity, diminishes the speed of transfer and increases the cost. That is why, when standards are discussed, this conflict of aims has to be taken in consideration, too. And, due to the fact that technology is constantly improving, standard settings should be done with a farsightedness, regarding international developments in technology and structural settings.

Visual information is the main basic source of telepathology diagnosis settings. However there are sometimes cases, where the underlying image is not sufficient for an explicit

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83 Anonymous, „Telepathology - a Technical Overview", http://www.pathit.com/telepath/intro_1.html

diagnosis, and additional information is needed in order to draw conclusions from the morphological anomaly. That is why, from the viewpoint of standardization in telepathology not only the transfer of visual and acoustic information should be standardized but the connection between these different information sources, too.

14.2.3 Standardization of Communication

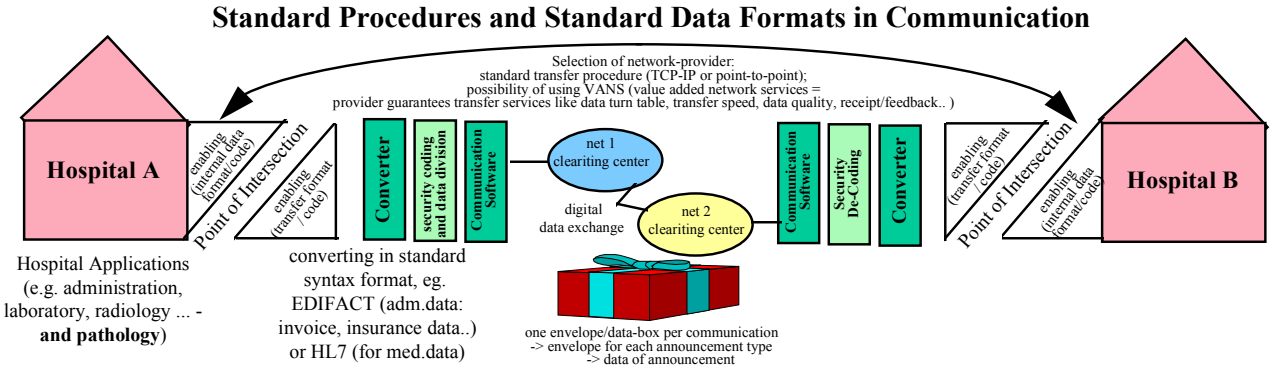

Figure 20: Standardization in data communication.

14.2.3.1 Transfer of Messages and Data

In general the transfer of medical data and images is based on the International Organization of Standardization's (ISO) open system interface (OSI) 'communication protocol layers'. The **OSI model** is an independent abstract model for the communication between different data stations. It was built in corporation with various international and national committees for standardization and is world-wide accepted as the fundamental model for open system communications. These layers, and several competing standards by which they have been implemented, are listed in appendix II, tables 4 and 7. To choose the optimum standard usually depends upon the subject matter and kind of communication. The standards recommended by CPRI and AMIA for the transfer of messages and data in health care, and some of the current users of those standards, are listed in appendix II, table 8 [Houtchens, 1995, p. 106].

14.2.3.2 Communication via Internet (Protocol TCP/IP)

An economically way to support telepathology programs is the use of existing telecommunications networks such as the **Internet.** The Internet is a world-wide collection of cooperating interconnected networks and provides a global information infrastructure for the rapid delivery of documents or the exchange of medical diagnostic images, as well as access to various information sources. A transparent way in which a user on a local area network (LAN) can reach a colleague via one or more intervening wide area networks (WAN) is made possible by a standardized suite of communication protocol, called the transmission control protocol **TCP/IP** (**T**ransmission **C**ontrol **P**rotocol / **I**nternet **P**rotocol), designed by the Internet Activities Board (IAB).

Image Formats and Transfer

Over the last decades there has been an exponential increase in communication services and data transmission. The request for higher network capacities arose. Due to the image intensive data types in pathology and rapid transmission rates required for the different interactive telepathological services, especially real time digital telepathology operations will benefit from the usage of the asynchronous transfer mode (**ATM** and **ANSI/CCITT** standards) and synchronous optical network (**SONET**) services.

At dynamic systems, where a long series of images has to be transmitted, quite often the limited capacity of telecommunication channels is a problem. That is why the image frame rate is improved by appropriate **data coding, compression and data reduction**. The best known standard in this field are for still picture transmission; the **JPEG**-standard, or for image series the **MPEG**-standard. In most countries telecommunication channels are controlled by public authorities (e.g. switched telephone network, ISDN access). Therefore for voice data signals the variety of standards offered by the **PTTs** have to be applied for the electronic transfer of data, images, voice or of electronic control information in health care too [Kayser, 1992; Schmid, 1996/(2), pp. 930-931].

Since the format of transmitted images in telemicroscopy mostly varies a lot, for a proper image transmission, each image needs to have a header identifying the format and the parameters (x- and y-dimension, data type, color etc.) of the following data.

Data Formats for Medical Data - Standard HL7

Within the standardization of medical data communication, many organizations are competing with each other. Therefore there is no unified standard available. ASTM E31.11 and DICOM are concentrated on laboratory and image data. EDIFACT and ASC X12N consider administrative and economical data in health care. Standards which are not focused on a special field are HL7, PIXELS1157 (MEDIX) or CEN/TC251/WG3. HL7 (Health Level 7) is a standard for medical data and the communication in hospitals [Hufnagl, 1999, p. 95]. HL7 contains standards for master data, case data, patient movement data, billing data, document administration, appointment-, treatment- and resource planning, as well as standards for orders and diagnostic results. A HL7-message consists of several segment types like patient identifier (PID - copied from ASTM E31.11), case (PV1), order (ORC), test (OBR), or result (OBX). For test- and diagnostic result data LOINC codes (Logical Observation Identifier Names and Codes), which are compatible with JUPAC and EUCLIDES codes, are added to the HL7 standards. HL7 is accepted by ANSI (American National Standards Institute) and by CEN (European Technical Committee for Normalization) and start to become widely adopted by health care system developers [Schadow, 1997, pp. 143 ff.; Ganslandt, 2000].

Data Communication Standards in the Context of HL7

Considering the medical data standard HL7, it does not describe protocol about data transfer within the ISO/OSI layers five to one. Yet, the communication between institutions demand common protocol standards. There are many technologies available, reaching from **RS232**, the already mentioned **TCP/IP,** or the **CORBA**, which are all well known in standardized communication. The oldest RS232 is used for point-to-point connections by serial interfaces, which only support the OSI-layer 1 and 2. For higher layers TCP/IP represents a network protocol, which is internationally used as Internet protocol. Its classical method is

synchronous (TCP) and asynchronous communication (e-mail / **SMTP**). With PPP (Point-to-Point Protocol) the Internet protocol can be adopted to older serial technologies. OSI-layers 1 to 5 are covered, and common transmission technologies are integrated with modern high capacity (LAN, FDDI, ATM) [Schadow, 1997, p. 150].

CORBA (Common Object Request Broker Architecture), **DCOM** (Distributed Component Object Model) and **RMI** (Remote Method Invocation) are competitive distribution platforms for net cooperation. CORBA is a protocol definition of the open system architecture OMG (Object Management Group). DCOM was realized in windows environment and therefore is a fixed part of this operational system. Fortunately, first CORBA-DCOM-converters are available. RMI is a JAVA-based solution for the usage of services of distributed objects [Bethke, 1998, p. 107]. At the first sight these protocol promise integration and interoperability up to the OSI-application-layer and is competing with the technical concepts of HL7. However the content problematic is not solved in a satisfying way. Therefore for standardized data transmission in health care, especially for clinical chemistry, micro-biology, hematology, and pathology transactions, the **HL7 protocol** together with the **TCP/IP** protocol are most suitable, especially since technology is no more the main problem, but medical content (what?) and the kind of presentation (how?) [Schadow, 1997, pp. 143 ff.].

Protocol XML

Information systems of the health care delivery system are often not compatible. That a data exchange is still possible between these systems, the protocol **XML** (Extensible Markup Language) was introduced by the World Wide Web Consortium (W3C), which is a more specific form of the **SGML** (Standard Generalized Markup Language - ISO 8879). The data exchange by the XML format is more object orientated and simply divided into content, structure and layout. Compared with the HL7 format which is dependent on data groups, XML has the advantage that documents are not content dependent [Bethke, 1998, p. 107].

Technical Standards

When establishing a reliable international telecommunications system, sometimes one will also face technical problems within the telecommunication infrastructures. For example, the interoperability between different technical standards has to be overcome. Ferguson mentioned the problem of different power standards (110 volt/60 Hz and 220 volt/50 Hz), or fluctuating electrical power. He further discovered problems since some countries have national regulations governing telecommunications traffic and the use of equipment. Such regulations often have to be adapted to international standards, which is not simple [Ferguson, 1995/(1), p. 36]. Problems also occur due to different broadcast TV video standards - the National Television Standards Committee (NTSC: 525 lines/picture at 30 pictures/s and 24 bits of color), which is used in USA and Japan, the Phase Alternative Line (PAL: 625 lines/picture at 25 pictures/s) for Europe, and the SECAM for Russia. Yet, with the introduction of the compatible Common Intermediate Standard (CIS: 288 lines/picture at 30 pictures/s), this problem was mainly diminished [Wootton, 1997/(1), pp. 397-398; O'Brien, 1998, p. 153].

14.2.4 System Standards - Video Conference Systems

Most dynamic telepathology systems are designed around a video conference system. For videoconference systems, the ITU-T-standards H.320, which exist since 1990, allows that coding and decoding of data and images, as well as a controlled synchronization is internationally guaranteed [Detken, 1996, p. 103]. Based on such standards, video-conference systems are able to easily communicate with each other. Since 1997 the ITU (International Telecommunications Union) set up an additional standard for data conferencing - the standard T.120 [Klutke, 1997, p. 68]. With this standards, a whole network of videoconferencing systems is able to communicate. However, although video conference systems are compatible with each other, the remote control features are often not. This makes dynamic system integration often impossible.

14.2.5 Compatibility of Platforms and Hardware

Restriction for the integration of telepathology stations can either be very narrow or wide. Narrow in this context means that the concept for the employed equipment and operating software on the different sides are given, with small or no variation possibilities for the participants. In opposite, a **flexible open concept** enables the participants to combine the components that are most appropriate to them. However such a flexible concept does not just demand flexibility in the integration of different hardware components, but standards for all modules. Operating software has to be automatically matched by standard settings to the one of the connected partner. At the open concept, to support the adaptation of different stations to each other, identification procedures may have to be standardized, too. That is that at the very beginning of a connection between two partners, each station would first transmit the own system configuration to the partner and would then receive in return the complementary information from the partner. Then a configuration module could adapt the two stations to each other and start with the telepathology session [Kayser, 1992].

No doubt, such a flexible concept would be desirable for telepathology services, too. Yet, this would demand high agreement between users, equipment manufacturers and software designers. The most progress can be recognized with static imaging systems. Most components are already standardized or quasi-standards have been developed - for example there are standards for TV-cameras, for the computer equipment, or the display screens, etc. That is why such systems can be assembled quite inexpensively using commercial off-the-shelf hardware and software. Compatibility problems among different systems can be easily solved by just setting basic operative standards, such as image formats and communication protocols [Azumi, 1996, pp. 447-448].

At dynamic systems this seems to be more difficult because of the complexities of standardization in controlling the remote microscope. Functions like the scanning stage, objective selection, z-axis control, illumination, filters, or the autofocus equipment have to be coordinated. That is why a standardized protocol for the identification of the configuration of a microscope has to be defined. Such a protocol would describe the microscopic magnification (e.g. x6, x20, x40), or discuss the importance of certain magnifications to the final diagnosis [Kayser, 1992]. Unfortunately, robotic real-time telepathology systems are not standardized up to now. Della Mea supposes that they are therefore not a practical way of doing expert consultation, since only people having exactly the same system can be connected [Della Mea, quotation e-mail from July 1999]. Approaches which try to overcome this problem are robotic microscopes realized by the Internet protocol http [Hufnagl, 1999, p. 97; Binder, 2000]. Simple browsers like Netscape ‘Communicator’ or Microsoft 'Explorer’ could be employed to manipulate the microscopic functions by just clicking the mouse.

14.2.6 Standardization of Pathological Procedures

Standardization of medical procedures to guarantee health care service's quality is not new. One of the first area where cases were monitored and stored on a broad scale was in oncology. For this treatment data was collected and analyzed. Reproducible identifiable criteria were selected and used for standardization regulations and for the development of **standardized therapeutically procedures** [Beinert, 1997, p. 64; Busch, 1992, p. 429]. In America, the American Medical Association or Health Maintenance Organizations developed further standards for the quality of care, which are currently being investigated concerning the issues of telemedicine [Tangalos, 1995, p. 283].

> *„Although histopathologic interpretation is an art, it should be subjected to standardization analysis in the same manner as other laboratory tests. In histopathology and cytopathology, as well as in their normal counterparts, histology and cytology, a collage of forms and designs must be organized in the human brain into a pattern that signals a specific diagnosis. Interpretation of that pattern also must be standardized ..... a protime in Maine should be the same as a protime performed on the same person in Florida." [Hancock, 1996, p. 94]*

In pathology a specimen examination is usually done by one person, who is responsible that all tasks are done correctly. With telepathology such an examination involves at least two person (client and consultant). That is where the correctness of the different activities has to be guaranteed by setting standards. McGee even expects that the development of telepathology systems will enhance the standardization of higher professional examination procedures [McGee, 1995, p. 35]. For example, fixation and staining standards (e.g. 'uniform smears'), minimum size and color of reference tissue cells, or minimum space resolution at various microscopic magnifications [Klossa, 2000]. Users as well as non-users of this study mentioned the standardization of diagnoses and pathological processes as a requirement and an important secondary effect of telepathology. The basis of such standardized procedures is to reduce the variability towards improved quality paradigms [Clemmer, 1995, p. 48]. As an additional effect, standardized processes and structures in pathology may help to improve cost-effectiveness and efficiency, too [Murphy, 1993].

However, different cultures, beliefs and working styles may cause resistance of physicians when guidelines for standardized procedures are introduced. That could be the hardest part in the system's integration process, because „different organizations have different ways of doing things", says Glaser, vice president of information systems at Brigham and Women's Hospital, Boston (USA) [Glaser in Bergman, 1994; Bergman, 1993]. The same experience was made by Hale, manager of media services at St. Vincent Hospital in Indianapolis. „The most significant hurdle is bringing together many people and institutions who are used to doing things their own way, and finding common techniques and protocol that work for everyone" [Hale in Kaiser, 1994]. Therefore it is important to take the human dynamic in consideration, since standards are only of value, when they are accepted and used.

14.2.7 Integration as an Overall Process

> *„The purchase and installation of telemedicine equipment should be integrated in a whole information strategy and not be considered as a standalone act ... any kind of telemedicine system, when routinely used, will have to be linked to the HIS system and this requires a standardized technology, standardized image handling and coupling of different images with alphanumeric data of one patient ... this is where the PACS concept plays an important role. The Picture Archiving and Communication Systems provides a digital image management system linked to a hospital information system." [Coen, 1995, pp. 206, 207]*

Integration of system is not just a **technical** question, but also an **organizational** question and a question about the wish for communication between all participants of the health care delivery system. Unfortunately, the integration between physicians, hospitals and health care research centers is often poor, although the WHO claims the introduction of informatics applications in health care for many years [Rienhoff, 1998, pp. 7 ff.; Spiegel, 2000; Ganslandt, 2000]. The telemedicine project in Regensburg[84], Germany, for example answers this demand with a comprehensive integrated solution. The project design includes a **horizontal integration** of all hospitals no matter of sizes and specialization, a **vertical integration** of all practitioners, an integration of a 'emergency communication system' (NOAH), which gives information about where to transport an emergency patient (free capacity of hospitals and know-how overview), and combines these integrated resources with a telemedicine service center, which is responsible to enrich and support this shared-care system [Stieglitz, 1998, pp. 23-24]. At the Baptist Health Information Network the integrated compatible information flow between doctors' offices, the hospital lab and the surgery suite, including pre-certification with insurance providers, already showed time and cost saving after a short time [Wyman, 1994, S. 11].

Further integration approaches in Germany are designed by 'digital GmbH[85]' in Hamburg, which developed the 'MVB' (Medizinverbundnetz Bundesrepublik) [Lindemann, 1998, pp. 31 ff.; Lindemann, 1997, pp. 105 ff.], the 'DGN Service GmbH[86]' in Düsseldorf, which designed the 'Deutsches Gesundheitsnetz' [Fahlbusch, 1998, pp. 37 ff.], the 'Medical Network e.V.[87]', which provides the product 'Medical Network', a net designed 'by physicians for physicians' [Post, 1998, pp. 46 ff.; Post, 1997, pp. 121 ff.], or the governmental networks created by the Bavarian Government 'Bayern Online' [Bär, 1998, pp. 55 ff.; Brummer, 1996, p. 15] and by the Government of Sachsen 'Modellprogramm Telemedizin Sachsen' [Wedekind, 1998, pp. 59-63]. All of these suppliers offer platforms for the integration of services and communication within the whole health care delivery system in Germany, including pharmacies and administrative offices, but with a focus on practitioners needs. Considering telepathology systems, the University of Muenster, Germany, tested telepathology systems of Leica, Nikon, Olympus and Zeiss in the context of overall compatibility. Unfortunately all products show shortcomings in compatibility to hospital information systems. They are mostly not able to serve a complex telepathology network [Spiegel, 2000; Ganslandt, 2000]. Altogether telepathological systems have to be seen with an integral view towards a '**Health-Network-Architecture**' within the whole health care delivery system, where at each point of a patient's treatment process the results of other areas can be accessed - even from external locations. Based on standardized database structures, Schröder realized at his teleradiology project a synergy effect within his hospital information system (HIS), which further led to improvements of the whole health care quality at his hospital in Krefeld (Germany). The RIS/PACS-system is part of the integrated HIS, which was realized by the **interface HL7**, which allows that the data of a patient is placed at the RIS disposal, and vice versa, that the medical data is handed over to the HIS [Schröder, 1997, pp. 15 ff.]. Telepathology systems have to be integrated in the same way, if quality and efficient synergetic effects should be achieved.

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84 http://www-gz.uni-regensburg.de

85 digital Equipment GmbH, Niederlassung Hamburg, Bereich Gesundheitswesen, Kieler Str. 103, 22769 Hamburg

86 DGN Service GmbH, Heerdter Lohweg 35, 40549 Düsseldorf, Tel: 0049-211-56021570; reinhold.fahlbusch@dgn.de

87 Medical Network e.V., Am Wildzaun 30, 64546 Mörfelden/Walldorf; http://www.medical-network.de; e-mail: c.post@medical-network.de

Since in the past decision makers often were not aware about the need of system integration, nowadays a lot of money has to be spent to link systems. In the USA it is estimated that US-$ 3 billion to US-$ 5 billion capital is needed for the integration of health care delivery systems [Coile, 1995]. Spending such a huge amount of money for integration purpose, again it is vital that these investments are based on technological and data standards, but also on well coordinated national and international telemedical policies of governments, health care providers, international health care organizations and system suppliers.

14.3 Conclusion

Telepathology is an additional area of telecommunication applications and therefore will rather adopt than create most of its standards. Nevertheless, in designing or selecting a system, decision makers are often confused and uncertain which standard (if available) has to be taken. Therefore, in order to ensure an effective and wider use of telepathology, there clearly is a need to define common standards so that vendors will develop telepathology workstations that will be able to communicate with each other irrespective of hardware and software. Protocol and standards will guide the definition, transmission, interpretation, storage, maintenance, access, and usage of pathological data and images, so that compatibility and integration of different systems is eased. The American College of Pathologists is already in the process of defining standards for telepathology[88].

For the selection and the design of appropriate standards, aspects like safety and efficacy, clinical utility, technical capability and reliability, diagnostic accuracy, and therapeutic decisions, as well as cost effectiveness should be kept in the mind of decision makers. Houtchens criticizes that most of the employed telemedicine systems are likely to encounter problems in satisfying each of these criteria [Houtchen, 1995, p. 106]. To give an example how important the ‘factor of standardization’ is to success of telemedicine systems: At the pilot project DOXX in Germany (Baden-Württemberg), not enough physicians could be found to participate, even though all cost would have been paid. As reason many physicians said that the DOXX system is not compatible to the systems they are already using. Second, with the DOXX system, they would have to change actual workflow processes in their organization, which is economically not profitable [Boese, 1997, p. 12].

> *„Whether the new approach is worthwhile and ultimately successful depends on the extent to which such a system can be technically or administratively integrated into the existing environment of one or more communication partners.“ [Oberholzer, 1993, p. 1084]*

That is why specific applications have to fit into or be an extension of an already-existing infrastructure to have any possibility of being accepted and cost effective [O’Brien, 1998, p. 157].

Guidelines and standards for the development and implementation of telemedical networks and health care system’s integration is not just a wish, but a necessity if systems ought to be connected across national and international boundaries. And while standards are necessary, it is equally important to establish mechanisms for their efficient and appropriate modification with advances in technology [Puskin, 1995/(2), p. 126]. International network

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88 American College of Pathologists, http://www.cap.org

systems will arise, which will provide access to specialized services and by doing so will help to raise diagnostic standards of surgical pathology world-wide [Eide, 1994, p. 889].

15 Legal Questions and Health Care Structures

Diagnostic and treatment errors in medicine may cause high amounts of compensation and the physician risks losing his/her professional license. That is why physicians want to be certain about liability aspects before they start to interact, especially if new technologies or procedures are involved. In practicing telemedicine, many legal issues such as liability, confidentiality, privacy, licensing agreements are often not solved.

Telepathology is a new process in pathology where several persons participate. Therefore there is a lot of uncertainty about the laws and restrictions, which have to be followed[89] and concerning the legal and organizational responsibilities, whose are they, the telepathologists (expert)? The surgeons (client)? The employers (hospital)? The second opinion telepathologists? And who will pay for diagnostic errors? How will liability be assigned between primary care physicians, medical entities, unpaid medical specialists, and technology vendors - all of whom have a stake in most telemedicine treatments? Regarding legal issues, how will failures in communication and errors in diagnosis be distinguished and rated? In general one can say that telepathology is not a new specialty, but just a new way of doing things. Therefore it can be assumed that many of the current pathology liability principles are valid for telepathology, too. [Schiffer, 1992, p. 393].

15.1 Liability Principles

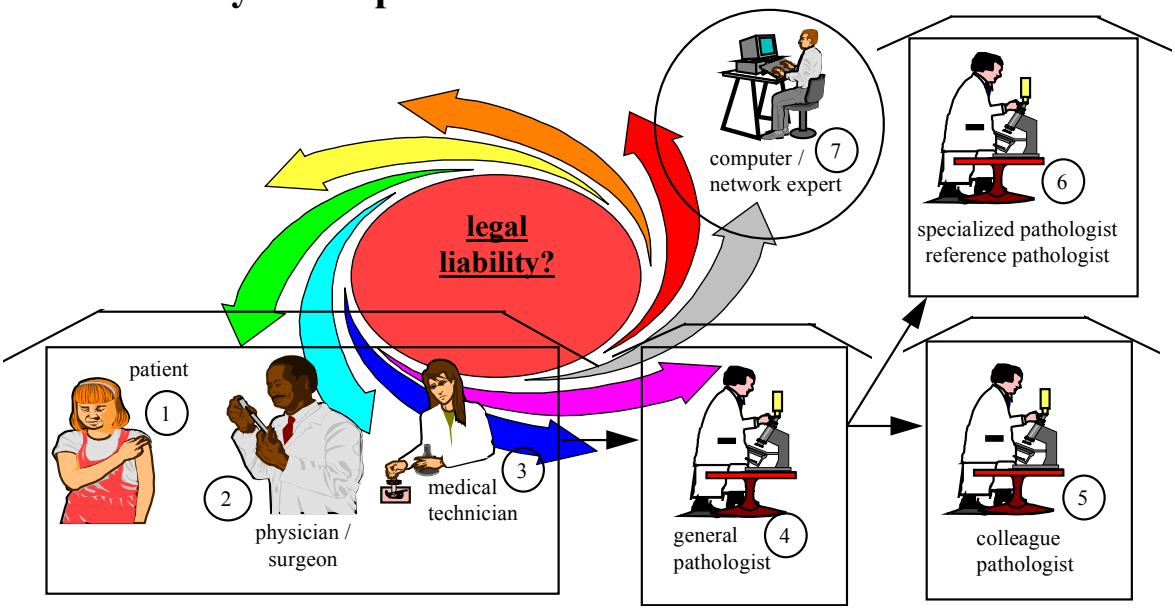

Figure 21: Liability in Telepathology.

89 To reflect, how complex the legal situation in telemedicine can be is demonstrated by the example of teleradiology in Germany: **Berufsordnung** (Aufklärungspflicht, Schweigepflicht, Dokumentationspflicht); **Bundesdatenschutzgesetz** (speichern, verändern, übermitteln, sperren und löschen personenbezogener Daten); Bundesmantelvertrag - Ärzte (Vertretung, Assistenz, persönliche Leistungserbringung); **Bürgerliches Gesetzbuch** (gesetzliche Schriftform, Haftung für eigenes Verschulden, Dienstvertrag, Wesen des Auftrages, persönliche Verpflichtung); **Empfehlungen des BGA** zur Vermeidung gesundheitlicher Risiken (Aufzeichnungen über die Untersuchung des Patienten); **Handelsgesetzbuch** (Führung der Handelsbücher); **Medizingeräteverordnung** (Handhabung und Wartung von Geräten); Produkthaftungsgesetz (Haftung, Fehler); **Röntgenverordnung** (Genehmigung von Röntgeneinrichtungen, berechtigte Personengruppen, Aufzeichnungen); **Signaturgesetz** (Bestimmungen zur digitale Signatur, Vergabe von Zertifikaten); **Strafgesetzbuch** (unberechtigter Zugang zu Daten, Verletzung des Privatgeheimnisses, Fälschung technischer aufzeichnungen); **Teledienstegesetz** (Verantwortlichkeiten); **Zivilprozeßordnung** (Beweisantritt); **Kommentare** zur Röntgenverordnung; Kommentar aus „Handbuch Medizintechnik“; Kommentar aus „Rechtliche Aspekte der Teleradiologie“; Kommentar aus „Arzthaftungsrecht“ - source: http://www.rzuser.uni-heidelberg.de/%7En17

15.1.1 Principle of Professionalism - Organizational Responsibility

To guarantee an actual standard in medicine, the owner of a hospital, and the head of a physicians office or department has to coordinate and organize treatment processes in such a way that there are no risks for the patient, that diagnostic, treatment and therapy procedures are based on common standards in medicine, and that the staff is qualified enough to do their tasks correctly. This principle has priority over efficiency criteria [Ulsenheimer, 1999/(1), p. 200]. Therefore both, the owner of the health care facility and the leaders of the different departments have the organizational legal responsibility to ensure proper medical processes. Consequently they have to prove, whether they could become liable for harms due to telediagnostic procedures.

15.1.2 Liability at Telediagnosis and Consultation

General Liability Situation

In general, clinicians bear the ultimate responsibility for the well-being of their patients, no matter what system they employ [Smith, 1996, p. 34]. That is why the treating physician is responsible to sufficiently inform the patient, and to manage and control the whole treatment process, even if he is consulting other physicians. The final medical authority and responsibility is always in his hand. This has the consequences that he/she is allowed to choose the treatment method, which he finds most appropriate [Dierks, 2000; Bollmann, 2000]. Yet, if more alternatives are available with the same degree of effectiveness, he/she should choose that one which includes the least risk for the patient. Well-being and security of a patient as well as high quality of medicine have priority over efficiency. That is, if a diagnosis should be executed by images on the screen, the advantages for the patient and the diagnostic accuracy should be at least as high as with the conventional method (rule: right of the patient for specialty standard) [Bollmann, 2000]. Treatment activities are measured by standards. When telepathology is executed internationally, the regional standard of the telepathologist has to be taken as foundation instead of the standard at the place of the patient [Dierks, 2000]. This is especially important, when communicating with third world countries.

Ulsenheimer expresses that a patient has always to be informed by the treating physician and to agree about a diagnosis being executed by telepathology. In any case of legal uncertainty, Ulsenheimer and Bollmann recommend to get a written permission from the patient for pathological consultation(s). Ulsenheimer even argues that the tele-expert has to check whether such an agreement of the patient is in existence. For the treating physician a written statement of the patient has the additional advantage that a direct legal relation between patient and telepathologist is created. That diminish his risk of being liable [Ulsenheimer, 1999/(1), pp. 199, 201; Bollmann, 2000].

Liability in the Case of Delegation to Less Qualified Staff

In the case of telepathology the possibility to examine digital images from a distance is critical, since in many cases a less qualified physician (surgeon (2) without pathological specialty training, or even a medical technician (3)) directly handles a specimen, even though he/she is often under the ‘remote control’ of an expert. In some countries, like Germany, it is prohibited that physicians become active outside their specialty field. That is

why intraoperative frozen section preparations have to be done by a pathologist and can't be executed by a surgeon.

In addition there is the principle that a physician has to carry out 'physician's treatment activities' personally[90]. Consequently a physician has the complete legal responsibility for his tasks and is not allowed to delegate the **kernel activities** of his specialty to a less qualified person [Ulsenheimer, 1999/(1), p. 198]. In practice to keep control of the direction of the main treatment tasks, a physician has either to execute such fundamental specialty activities by himself, or if he wants to delegate them to another person, he has at least to supervise this person **personally**. Yet, the term 'supervision' and how it has to be done is not clearly defined. This raises the question about the specific situation of examination splitting in telepathology? Is it legally allowed to delegate macroscopy and specimen preparation to a less specialized person at another location? Is the supervision of the client via camera necessary and sufficient? How is the liability situation, when the telepathologist does not have the legal responsibility of the supervised person? And who carries the legal responsibility of the remotely executed activities?

The actual legal situation is often uncertain, since in many countries decision makers refused to give legal statements. In other countries, the treating telepathologist is clearly declared as responsible for the whole telepathological process and all pathological procedures. For example, in Japan, the Ministry of Health and Welfare decided in 1993 that the pathologist is liable for false diagnoses, no matter whether adequate or inadequate images were transferred. The fact that the client is working in a far distant located hospital out of the supervision of the pathologist and without any legal relations to him does not release the pathologist from the legal aspects of responsibility of diagnostic errors caused by the client [Schiffer, 1992, p. 393]. The telepathologists legal position is the same as that on the conventional direct microscopic observation [Fujita, 1995, p. 109]. Telepathologists face the same legal situation in Germany (e.g. Aurich) or in Norway (e.g. Tromsoe). The telepathologists are fully responsible for the final diagnosis [Bollmann, 2000].

Consequently, if only the pathologist is responsible for all telepathological procedures, the surgeon or another participating person on the client's side would be relief from legal liability in the case of a telepathological diagnostic error. However, since with telepathology the tasks of the surgeon increase, some pathologists wish to split liability. How such a situation of shared legal responsibility should look like, has to be examined carefully. In any case, clear identification of the medical liabilities involved in case of damage has to be transparent and clear [Allaert, 1995/(1), pp. 200 ff.]. Yet, no matter how the final liability will look like, the surgeons at the remote side and the telepathologists are fully aware of the uncertainty and difficulties caused by introducing a new method like telepathology and therefore increased care is taken by both parties to avoid mistakes.

Liability in the Case of Delegation to Equal or Higher Qualified Staff

Physician are obliged to consult a specialist, if their competence or experience does not allow them to make a correct diagnosis of 100%. This is for example, why a surgeon contacts a pathologist (2 with 4) to do the pathological examination. The same it is if a pathologist is not certain with a case. A common reaction is to request a colleague (5) for

[90] Principle of personal treatment - Grundsatz der persönlichen Leistungserbringung §§ 28 SGB V, 32 ÄrzteZV und 13 BMV-Ä, 613 BGB

his ‘second look’. If both do not come to a consensus, an expert, mostly a so called reference expert (6), has to be consulted for his ‘second opinion’ (for definition see chapter 6.1.3.1). Further a physician is obliged (principle of physician’s honor) to request another expert, if a patient wishes to consult an additional specialist to confirm a diagnosis.

The question is, who bears the legal responsible for the final diagnosis in such cases? The requesting pathologist (4) or the second opinion pathologist (5/6)? Some argue that the requested consulting pathologist is responsible for his part. Other however argue that the final decision should be kept in the hand of the requesting pathologist and that he is liable for a case. That is why in UK the referring pathologist is carrying the legal responsibility in second opinion cases [McGee, 1995, p. 35]. Some telepathologist are applying for a shared responsibility. That is why the AFIP stipulates that the pathology consultation report includes a statement: *„This report is not valid until countersigned by the originating pathologist“* [Mullick, 1996, p. 190]. This remark should help to emphasize the shared responsibility between client and consultant. Another group distinguish between ‘second look’ consultations, where another colleague is requested for his judgement, but where the responsibility stays at the initial pathologist, and ‘second opinion’ or ‘reference’ consultations, where the consultant’s opinion is authoritative and where this requested expert is liable for the final diagnosis. Ulsenheimer and Dierks follow the last solution. They come to the conclusion that the person, who sets up the final decisions, is the responsible person [Ulsenheimer, 1999/(1), p. 199; Dierks, 2000]. If the pathologist (4) just asks for another colleague’s advice (e.g. instead of looking up in a book), he keeps the final decision and with it the legal responsibility. If he contacts an expert, who is passing the final decisions, this expert becomes legally responsible This legal statement reflects the **principle of expert reliability**. If a lower experienced physician is consulting a specialist, he is allowed to rely on his/her experience and specialty know-how [Kayser, 1996, p. 477].

Since second opinion consultations are already done with the conventional methods on a regularly basis, it can be recommended that the already existing restrictions and laws are considered for telepathology practice until specific regulations are available. For more legal security, liability could be clarified on a contract basis, too.

Reduction of Risk

What could a telepathologist do to reduce his risk? First of all each physician is legally protected by the third-party insurance of the employer [O’Connell, 1995]. However there is significant uncertainty about whether malpractice insurance policies cover services provided by telemedicine, especially for interstate services [Flaherty, 1995/(2); Schanz, 1996, p. 488]. Therefore it is vital that telepathologists inform the insurance company about the new technical procedures in order to make sure that the use is included in the insurance policy [Schiffer, 1992, p. 394; Bollmann, 2000]. To avoid any financial risk, telepathologists should ask their liability insurance company to confirm the legal situation of telepathology services (by written statements or additional insurance contract) to create a safe situation.

Second, according to most legal experts, an effective way to limit liability is by way of a contract between the participating parties [O’Brien, 1998, p. 159]. However, even though a physician has set up internal contracts or shifts of the diagnostic risk, this does not release him/her from the external claim of the patient. The patient can directly claim against the treating physician in case of false diagnosis from an consulted pathologist. Therefore such a claim has to be covered by his own insurance or the insurance of his employer [Schiffer,

1992, pp. 393, 394]. But at least he has the possibility to pass his liability debt to his contract partner as a next step.

Third, to reduce the risk of diagnostic errors only clear diagnoses should be given by teleconsultation. Especially if static imaging systems are employed, and if these are handled by a surgeon or by a medical technician (e.g. in Germany/Aurich or in Japan/Yonago and Sapporo), the telepathologist has to be extremely carefully with his diagnosis, since he does not have virtual control of macroscopy and preparation activities. To increase diagnostic accuracy, in Norway/Tromsoe it is a custom that two consultant pathologists confirm a telediagnosis on a frozen section and that data and images are carefully documented for assurance and for legal reasons [Eide, 1994, p. 888]. Unclear cases should be deferred and executed by direct light microscope.

In addition, most clients and consultants of telepathology know each other personally and are able to estimate the competence of their partner. That is why physicians mostly ask for the consultants they are familiar with, when asking for support. The **familiarity between the doctors** on two ends or the relationship with the clinics and the hospital is important for the confidence in performing a diagnosis. Again the legal risk can be diminished [Moore, 1995; Smith, 1996, p. 35].

15.2 Break Downs and System Errors

Network Interruptions

At failure in communication, break-down of telephone lines or similar problems the telecommunication providers mostly exclude by law all claims. Therefore the user takes the full responsibility for the claims of patients caused by network interruptions or breakdowns [Schiffer, 1992, p. 393; Kayser, 1992/(1), p. 381]. Consequently, if the security of data transfer cannot be guaranteed, the urgency of a fast data transfer and of a fast diagnostic result should be compared with the risk caused by network or transfer errors.

System Interruptions

What happens, if there occurs a system break down? What happens if a system assigns wrong images to a case? Who will be liable for such situations? The system supplier? The client or the consultant?

> *„Tele-clinicians could be in a poor legal position in the event of a catastrophic telemedical accident if they have no tangible and convincing evidence of having competently assured themselves of the safety of all aspects of their telemedical system.“ [Smith, 1996, p. 34]*

However, since physicians are no computer experts, it may be doubtful that medical staff can be made responsible for technical errors. With increasing frequency, suppliers are held legally and ethically responsible if the technology they recommend does not meet preestablished performance standards and the product quality they promise. They can be held to strict product liability [O'Connell, 1995; Ulsenheimer, 1999/(1), p. 200]. In addition, there is the principle that if experience has proved that usually one can rely on a technique, a physician is not liable for unforeseeable break downs.

Nevertheless, physicians should introduce techniques for safety assurance, which are comparable to those employed in conventional computer-based medical environments, only extended to communication specifications. Usually this is done by quality control and equipment checks. If the physician does not have the know-how to judge safety restrictions, he has to contact expert for support. Equipment should be tested after a given period of time. In addition, emergency concepts should be available to ensure continuity of service in the known or suspected presence of errors or degraded accuracy [Smith, 1996, p. 34].

15.3 License - Factors for Competence

Reasons for Medical Licenses

There are two purposes for license requirements. First licenses help to ensure a high quality of health care services. In general patients are entitled to get competent treatment at all areas of the treatment chain [Ulsenheimer, 1999/(1), p. 198; O'Brien, 1998, pp. 149, 158]. High quality of medicine can only be guaranteed if physicians are competent. This competence is ensured by a license. Therefore physicians and other health care practitioners have to satisfy numerous requirements to obtain such a license to practice medicine in a region, and to be authorized to practice at individual health care facilities.

The second reason is to regulate the commercial activities of individuals that practice health care. Therefore in many states licenses are limited and physicians are only allowed to be active and to write bills in the state, where they have their license [Gasser, 1997, p. 37]. This restriction can also be seen as an advantage for local physicians, since they can use license as a means to protect their market from out-of-state competition [Flaherty, 1995/(2)].

Problems of License Agreement for Telemedicine

The possibility of doing examinations based on digital images transferred from a distance is in conflict with these objectives. One conflict is that telemedicine will often lead to the fact that patients will locally be treated by less qualified staff, which 'just' is remotely controlled or advised by an online expert [Ulsenheimer, 1999/(1), pp. 198-199]. This fact of telepathology may contradict with the basic idea of licenses to guarantee quality standards. New regulations are necessary to assure that both, consultant and client are qualified enough to do their assigned tele-tasks in a satisfying way. Especially the non-expert has to be well trained, since partly he has to take care of tasks, which in the common pathological procedure the pathologist has to execute by himself.

Another conflict is that telemedicine has greatly expanded a physician's ability to practice in several states. That raises the question, whether a pathologist licensed to practice only in New York is allowed to teleconsult for a patient in Virginia [Ziegler, 1994]? Does the consultant have to be licensed in one state, the other, or both? Unfortunately, although many telemedicine interactions are already crossing state and national boundaries, legal precedents for remote liability and license are often not established. In addition the actual patchwork of state regulations, accreditation, and liability is mostly incompatible with the widespread use of electronic medical services.

Previous studies showed that licensing issues are a concern and barrier of telemedicine project acceptance when telemedicine consultations are performed across state lines [Williams, 1995]. If a license is necessary for each state or if users have to consult the state statutes relevant to both sites in determining what specific obligations and duties they have, practitioners are understandably reluctant to use multi-state telemedicine networks because of the costs and administrative burdens of complying with multiple censure and reference rules compared to the expected frequency of network use [Flaherty, 1995/(2); Schanz, 1996, p. 487]. The American Medical Association put forth a recommendation that physicians be fully licensed in each state where they practice telemedicine regardless of where their practice is based [O'Brien, 1998, p. 158]. Such regulations are not satisfying since they are to heterogeneous. Considering the actual situation, most telepathologists who consult across several state or national borders are practicing without a medical license, which is critical if malpractice occurs.

In the USA, there are already few universal cross-state licenses available, e.g. within the Department of Veterans Affairs and the Indian Health Service [Perednia, 1995/(3)]. However, these licenses are restricted to a specific group of users. To solve license concerns in telemedicine in a satisfying way, national and international unified regulations are needed. Previously the G8 states set up a statement where they argued that liability and license issues should in most cases be based on the place of the tele-physician [Dierks, 2000].

Regarding the content, when license regulations are introduced, they should concern about specific telemedicine issues like training for video consultations or about regularly quality tests to assure that teleconsultants are qualified enough to fulfil their tasks [O'Connell, 1995]?

> *„Regardless of legal issues or liability exposure, minimal ethical standards would require that an individual engaged in consultation by telepathology or telecytology be appropriately qualified and use protocols that ensure proper record keeping and protect patient confidentiality. At a minimum, the participating individual should clearly define the extent of participation and consultation and be fully aware of the limitations of the technology. Such awareness should be informed by quality assurance practices that determine the validity and accuracy of each consultation". [O'Brien, 1998, p. 159]*

15.4 Duty of Case Documentation

Why is documentation necessary? A proper documentation is a duty for each physician, because he has to account for all treatment process under his responsibility. A general principle states that the patient does not have to prove a treatment mistake, but the physician has to prove correct treatment processes. It is in the physicians own interest that record and glass slide keeping is correct and complete and that he is able to reconstruct all activities.

If the physician is not able to find a record, he has to take the risk. Unfortunately with in conventional pathology data is neither stored nor utilized optimally because, unlike the situation with telepathology in which an image may be stored permanently, a glass slide must be returned. When the consultant queries about the case at a later time he may only review his report and not the slide [Hancock, 1996, p. 95; Poremba, 1998, p. 323]. In addition, paper records often get lost. That is why automatic electronically documentation in telepathology could improve the burden of legal proof and enrich documentation quality.

Even so several questions of documentation quality can be answered by the common laws, to build up a clear situation, professional organizations of pathologists have to give their statements about **which data** has to be documented, **how** this should be done and for **which period** of time. In general this is between 10 to 30 years. It is to assume that if a medical record will be kept electronically, the same restrictions as for paper records have to be met: correct archiving, comprehension and completeness, invariability, readability, and the integration of all document parts have to be guaranteed during the whole storage keeping time [Geis, 1997/(1), p. 1; Dierks, 2000]. Textual, acoustic and image data have clearly to be matched to the case it belongs to [Ulsenheimer, 1999/(1), p. 200].

In contrast to the glass slide examination, with telepathology, the movements of the cursor, the magnified images or even comments (e.g. markings on a common white board at the screen) could be recorded, so that the pathological examination process could even be more exactly recorded than this is possible with direct microscope examinations. Time schedules, visual impression of images, diagnostic problems, number of transmitted images and magnifications could be recorded by using automated log-files [Kayser, 1995/(1), p. 55; Bolte, 1998, p. 126]. All images should be archived in a database with their x/y coordinates and a time stamp. This allows reconstruction of the pathologist's diagnostic 'trajectory' at a later date [Winokur, 1996, p. 474]. As an additional advantage, the monitoring of slide processing can be used for diagnostic quality improvements [Marsan, 1995, p. 342].

15.5 Electronic Signature

Physicians certify their activities and results by personally signing their reports. That is why when sending data via networks, the physician is responsible for a correct electronic signature. In general he signs his electronic documents with his private key, which enable the receiver of his message to identify the sender and to recognize falsifications. Electronic signatures have an integrity function. The receiver of data has to identify the sender and to control whether data are correct and complete. [Ulsenheimer, 1999/(1), p. 201].

15.6 Location of Jurisdiction

Telemedicine networks that cross state lines create uncertainties regarding the state where a malpractice lawsuit may be litigated. Which state's law will govern the case often has an significant financial implication. Has a lawsuit to be regarded under the laws in the state in which the doctor practiced, or the state in which the patient saw the provider on screen? It is important that insurers develop clear and consistent coverage policies, and that they give guidance to the courts to assist in the resolution of venue and choice of law issues in a telemedicine malpractice lawsuit. Another possibility is that states develop legislation of malpractice liability for out-of-state telemedicine physicians and other health care practitioners [Flaherty, 1995/(2); Ziegler, 1994]. As long as the situation is not certain, Dierks recommends to make a written agreement with the patient. There the place of the telepathologist should be declared as place of jurisdiction, if he/she is making the final decision [Dierks, 2000].

15.7 Data Confidentiality

Medical Secrecy

The oldest principle for data confidentiality in medicine is the principle of 'medical secrecy' and the patient's right of privacy. This principle says that the exchange of patient data is only allowed, if a law gives permission to do so, if the patient agrees (written signature), if it is in the context of the treatment contract between physician (or hospital) and patient, or if a special situation justifies it, for example if the patient is not able to give permission after an accident [Ulsenheimer, 1999/(1), pp. 202, 203; Berger, 1997, p. 160; O'Brien, 1998, p. 158; Eichenberger, 1998, p. 5; Belser, 1998, p. 19[91]]. This principle applies to verbal, written, as well as for digital data exchange.

With communication technologies the problem of data confidentiality increased. Patients cautious of electronic data exchange may be reluctant to telemedicine systems that result in the creation or transmission of confidential information. They **fear a lack of privacy** [Williams, 1995]. As a result, physicians and other health care practitioners with these perceptions may be reluctant to use electronic systems which they believe may increase the risk of breaching patient confidentiality [Flaherty, 1995/(2)]. Since patient's confidentiality is the foundation for a successful treatment process, they take data security very seriously.

Concerns about the confidentiality of patient-identifiable medical data are not unique to telemedicine. As a result, a lot of national and international approaches exist that seek to develop overall privacy **protection laws** for medical information generally or that propose a common uniform model state code to establish a minimum standard of privacy protection which would be adopted by individual states [Flaherty, 1995/(2)]. In summary these laws[92] include the requirement that personal data shall be obtained and processed fairly and lawfully for a specified legitimate purpose. Data has to be adequate, accurate, relevant and not excessive in relation to that purpose. It shall not be used or disclosed in any manner incompatible with that purpose or kept longer than is required. If not absolutely necessary, the patient should not be identifiable. If he/she is, the local data protection laws have to be followed. In addition the sending person has to make sure that the place where the data are transferred to is able to guarantee data protection in a sufficient way [Dierks, 2000].

Data protection restrictions have to be especially regarded by the creation of uniformed standards for the protection of electronic medical records and data exchange in telemedicine communications. States may help to integrate telemedicine confidentiality concerns as

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91 Belser describes the 10 rules of medical secrecy, which are:
1. one has to have a legal right to collect data;
2. the utilization of the data is fixed = data is only allowed to be used for the given treatment activity
3. only as much data as necessary is allowed to be exchanged = appropriateness of the data exchange;
4. data has to be actual and correct
5. the patient has to agree (written permission)
6. patient has the right of a VETO
7. it is only allowed to transmit data to countries, which guarantee all these rules, too;
8. to use data for other activities than the original one (e.g. for medical statistics, educational purposes) demands a permission
9. technical and organizational security of data has to be guaranteed;
10. a patient has always the right to have a view into his medical record

92 For example in UK data transfer is regulated by the Data Protection Act of 1984; Germany has a specific 'telecommunication data protection law' (Teledienstedatenschutzgesetz). It is part of the information and communication service law of 1997 (Informations- und Kommunikationsdienstegesetz) and helps to complete the traditional data protection act [Berger, 1997]. The California Telemedicine Development Act passed in 1996. This act imposes both verbal and written informed consent requirements [Schanz, 1996, p. 487].

well as shape issues such as standards for third-party disclosure of patient-identifiable medical information, informed patient consent for telemedicine services, or regulation of data storage, processing and transfer to limit disclosure of medical information [Flaherty, 1995/(2); Bolte, 1998, p. 126]. An additional important question that has to be solved within the data protection discussion is the ownership of patient records, especially if they are captured electronically [Williams, 1995].

Informed Patient

Individuals have to be entitled to be informed of the existence of their own personal data. They have to be offered access to such data at reasonable intervals [Wotton, 1997/(1)]. In the case of scientific research data exchange or of data exchange over boundaries, mostly special data protection regulations have to be observed. In general these regulations demand that the interests of the patient and the interest of the research project have to be considered carefully, and that patients have to give their **written agreement** [Ulsenheimer, 1999/(1), pp. 200-201].

Data Access by Computer Experts

In the context of internal and external technical support for telepathology systems the question of medical secrecy has to be seen from a broader point of view. In general it can be assumed that it is always in the interest of the patient that the danger of medical technology is avoided, and that the risks and disadvantages for the patient are minimized. This requires that suppliers, operators, and users of diagnostic and therapeutic applications cooperate, and that they get the necessary access to systems. In this case, the permission of the patient is taken for granted [Ulsenheimer, 1999/(1), p. 202].

Access

Although there are data protection acts available, data confidentiality could be hurt if an unauthorized person could easily get access or misuse data. Especially the use of electronic data transmission via network could violate ‘medical secrecy’, since the security of such networks cannot be guaranteed and a third party may be able to access data unauthorized. Therefore, if ‘private key procedures’, cyptograghy , or other used security features are not able to guarantee data being accessed by third persons, the medical confidentiality is hurt [Geis, 1997/(2), p. 3-10]. That is why the patient has to be informed about this risk - in Germany even the patient’s written permission for electronic data transmission is necessary [Ulsenheimer, 1999/(1), p. 202].

Electronic Security Versus Paper Record Security

The opinion about the security of personal information in electronic form varies a lot. Some believe that electronic medical records are more susceptible to unauthorized access and dissemination than are paper charts on hospital wards. Other believe that proper safeguards make electronic patient information more secure than paper records [Flaherty, 1995/(2)].

Hence, electronic data exchange is already a common issue, so that it makes more sense to search for high security solutions, instead of discussing the differences of paper compared to electronic information. Data protection standards and regulations that ensure the medical data exchange in digital networks have to be set up (if not already available) and followed by all telepathology participants. Such regulations mostly demand that organizational and technical measures, such as access control of rooms, cryptography techniques and the digital signature[93], have to be taken to guarantee safety, authenticity and integrity of data [Geis, 1997/(2), p. 10].

15.8 Legal Situation of Reimbursement

Legal Regulation for telepathological diagnoses and consultations are mostly not available. That is why most of the telepathologists try to use the reimbursement rates of conventional pathology catalogues. Fortunately, in teleradiology reimbursement restrictions are starting to be established. For telepathology, first approaches are in discussion in Japan and the USA. In these regulations it has to be clearly identified, who will be paid? And how much will be paid? Payment has also to be distinguished by the tasks of the client (surgeon, general pathologist) and the consultant, and the kind of service that was executed [Dierks, 2000]. (For statements about reimbursement, see chapter: 13.5).

15.9 Conclusion

Several legal question in telepathology are already answered and regulations of common procedures in pathology can be applied. Nevertheless there is still a lot of legal uncertainty for all telemedicine users. Therefore it is of high importance that provider and users of telepathology systems follow the newest publications about legal issues. In the USA even specific newsletters are available, for example the newsletter of Health Information Systems and Telemedicine or the Telemedlaw[94]. In parallel, to minimize the legal risk as long as there is no liability certainty, providers of telepathology services should proceed cautiously increased levels of risk, armed with a proactive **risk management strategy** that **combines professional liability** insurance coverage with assertive precautionary procedures.

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93 The law for electronic signature (SigG) in Germany is a part of the German Information and Communication Law (IuKDG), and was passed in July 1997 [Ulsenheimer, 1999].

94 http.//tie.telemed.org/legal/pubs.as;
Health Information Systems and Telemedicine: A newsletter, prepared by the law firm of Arent Fox, focuses exclusively on legal issues related to advanced health information systems and telemedicine. Subscription information are available from Robert J. Waters e-mail address: rwaters@arentfox.com or (202)-857-6398
Telemedlaw: A quarterly newsletter focused on US-federal and state legislation, reimbursement, liability, licensure, and other legal issues in telemedicine. Publication by Legamed Publishing, Inc., P.O. Box 99526, Raleigh, North Carolina 27624-9526, email: legamed@aol.com, phone: (919)-676-1137

Such a risk management strategy may include the following precautions [O'Connel, 1995]:

- *Establish rigid record keeping and **documentation procedures** and adhere to them faithfully. Physicians should keep complete, meticulous records of all client histories, **assessments** and **treatments**. They should be especially careful to document all conversations with outside specialists and describe in detail specific opinions and recommendations.*
- *Ask **patients** to sign explicit **consent forms** that reflect all the information provided prior to consent, and that fully explain the role of telemedicine in the treatment strategy.*
- *Protect the confidentiality of patient information by refusing to discuss case via cellular phone.*
- ***Investigate** thoroughly the quality of the **communication line** and the company providing the service, and develop a contingency plan.*
- ***Investigate** the **hardware** and **software** used by the facility that will transmit the data, and negotiate a 'hold-harmless' clause in any contract for services.*
- *Ensure that the tele-**partner** is well **qualified**.*
- *Require technology consultants and equipment **vendors** to carry errors and omissions **insurance**.*
- *Establish transmission verification procedures that keep a record at both the sending and the receiving site, and develop a re-send procedure in case of trouble.*

Legal issues of telepathology should be taken seriously, since they seem to be a critical factor of success. When in 1995 the Armed Forces Institute of Pathology introduced their tele-diagnostic services they already experienced that the success of their service is not just dependent on medical, technical, human ergonomics, and administrative elements, but also on legal clarity [Mun, 1995, pp. 159 ff.]. Since diagnostic errors in telepathology may cause high amounts of compensation, each user involved in telepathology is recommended to examine his legal situation seriously.

16 Diagnostic Accuracy

The diagnostic accuracy describes the reliability, reproducibility and validity of a telepathology diagnosis result. Diagnosing a tissue lesion as benign or as malignant tumor is of importance for the adequate treatment of cancer diseases. On the basis of the diagnosis the subsequent treatment will be determined, which may include for example the amputation of a leg, a breast or the removal of a stomach or part of the colon. By a wrong diagnosis, the patient is always affected 100% and that is why tele-diagnostic accuracy is claimed to be 100%, or at least as accurate as the common light microscopes perform. Users of telepathology systems often remark that the diagnostic accuracy carried out with their system, is identically to light microscope diagnoses.

> *„Our data, although based only on an analysis of 300 cases so far, indicates that telepathology, specifically dynamic-robotic telepathology, can provide routine surgical pathology service with a diagnostic accuracy comparable with that of conventional light microscopy." [Almagro, 1998]*

To prove this, several studies have been carried out. Telepathology diagnosis results have been measured and compared with direct light microscope glass slide examinations. Doing so, the following measurements are most common for accuracy performance measurement.

16.1 Accuracy Measurements

Diagnostic accuracy in pathology is mostly measured by the **gold standard**. The gold standard is a diagnosis, which is assumed as the true diagnosis of a case based on pathology, surgery and follow-up [Ferrer-Roca, 1996, p. 13]. In general, doing accuracy studies in telepathology, the gold standard diagnosis is either the identical diagnosis of glass slide examination and telepathology investigation, or an independent pathologist has to examine the sample again to give the final result. For that purpose, he is taking the whole tissue sample material, and not just the sample parts, which were used for the study's examinations. That diminished the risk of incorrect field selection, since the expert is able to select exactly the part of the sample which seems to be most relevant for making his diagnosis. The accuracy problem of field selection will be explained in more detail in this chapter. If the standard diagnosis still cannot be determined without any doubt, often a consensus diagnosis is made. That is that several experienced pathologists are requested to examine a sample and to give their opinion. Their final judgement is the gold standard.

The results of accuracy studies are in general presented in form of a schedule like the following:

	„gold standard" malign diagnoses	**„gold standard" benign diagnoses**	**total**
telepathology malign diagnoses	a) right positive	c) wrong positive	
telepathology benign diagnoses	b) wrong negative	d) right negative	
total			
not conclusive			

One can distinguish five categories of diagnosis results when comparing telepathology diagnoses with the definitive gold standard diagnosis [Steffen, 1997/1]:

Category	Description
right positive	Right positive due to malignity: A malign tumor has been diagnosed right by telepathology as positive malign.
right negative	Right negative due to malignity: A malign tumor has been excluded right by telepathology. Or in other words, the sample has been recognized right as not malign by telepathology. **Attention:** Not malign does not mean 'healthy tissue sample', it just says 'not malign' that is why for example inflammations, cysts or health tumors are also contained in this category
wrong positive	Wrong positive due to malignity: Using telepathology, a malign tumor has been diagnosed wrongly. In other words, a benign sample was diagnosed falsely as malign by telepathology.
wrong negative	Wrong negative due to malignity: A malign tumor has not been recognized by using the telepathology system.
not conclusive	It was not possible to diagnose or to exclude malignity in such a way that further therapy consequences can clearly be ordered.
concordance	Concordance diagnoses are those, where the gold standard and the telepathology diagnosis are identically = a and d.
discordant	Discordant diagnoses. The requested pathologists could not come to a clear diagnostic agreement = b and c. At a discordant diagnosis two types have to be distinguished: Discordant diagnosis that would not have made a difference in the clinical outcome of the case and discordant diagnosis that would have resulted in a significant difference in the management, treatment and clinical outcome of a case [Allaert, 1995/(2), p. 598].

The final schedule for concordant and discordant diagnoses is often represented as followed (TP = telepathology; LM = direct light microscope examination):

Accuracy	TP-Cases	LM-Cases
accurate diagnoses		
incorrect diagnoses - clinically not significant		
incorrect diagnoses - clinically significant		

The most common measurement in pathology are 'sensitivity', 'specification', and 'reliability'. How this is calculated shows the following example:

	„gold standard" malign diagnoses	**„gold standard" benign diagnoses**	**total**	**Measurements**
TP - malign diagnoses	**10**	2	12	**Sensitivity** (measurement for right positive that is malignant tumor found) = **10/18**
TP - benign diagnoses	1	**5**	6	**Specification** (measurement for right negative that is malignant tumor not found) = **5/18**
total	11	7	**18**	**Reliability / Accuracy of diagnoses** (measurement for total of right diagnoses made by TP) = **15/18**

As **statistic measurements** generally Kappa or ROC analyses are used. The difference of both are described by Taube [Taube, 1995, pp. 227 ff.].

It is of great importance to **avoid false positive malignant diagnoses**, especially by frozen section examinations, since the diagnostic result will be followed immediately by surgical action [Eide, 1992/(1), p. 407]. Currently telepathological examinations are confirmed by direct light microscope examinations some days later. If a diagnosis was false negative, it is likely that the tumor will be found by the second examination. However, if by frozen section examination the telediagnosis was false positive, for example the unnecessarily removed breast of a female cannot be corrected.

Accuracy tests in cytology, for example cervical-vaginal smear analyses, are recommended to be analyzed in more details than described above. It is difficult to differentiate between endocervical and endometrial cells. Competence in cytology is much more necessary than for histology [Vacher-Lavenu, 1995, p. 262]. The difference to histological examinations is that the key of cervical-vaginal screening is not the definitive diagnosis, but classification of smears into two categories: those needing review, and those not needing review. That is why diagnostic differences have to be distinguished in steps, describing the degree of malignity. For these several accuracy studies use the criteria of Raab, which also regards the level of agreement based on several categories[95] [Raab, 1996, p. 602; Wakely, 1996, p. 530].

16.2 Factors of Influence for the Accuracy of Diagnoses

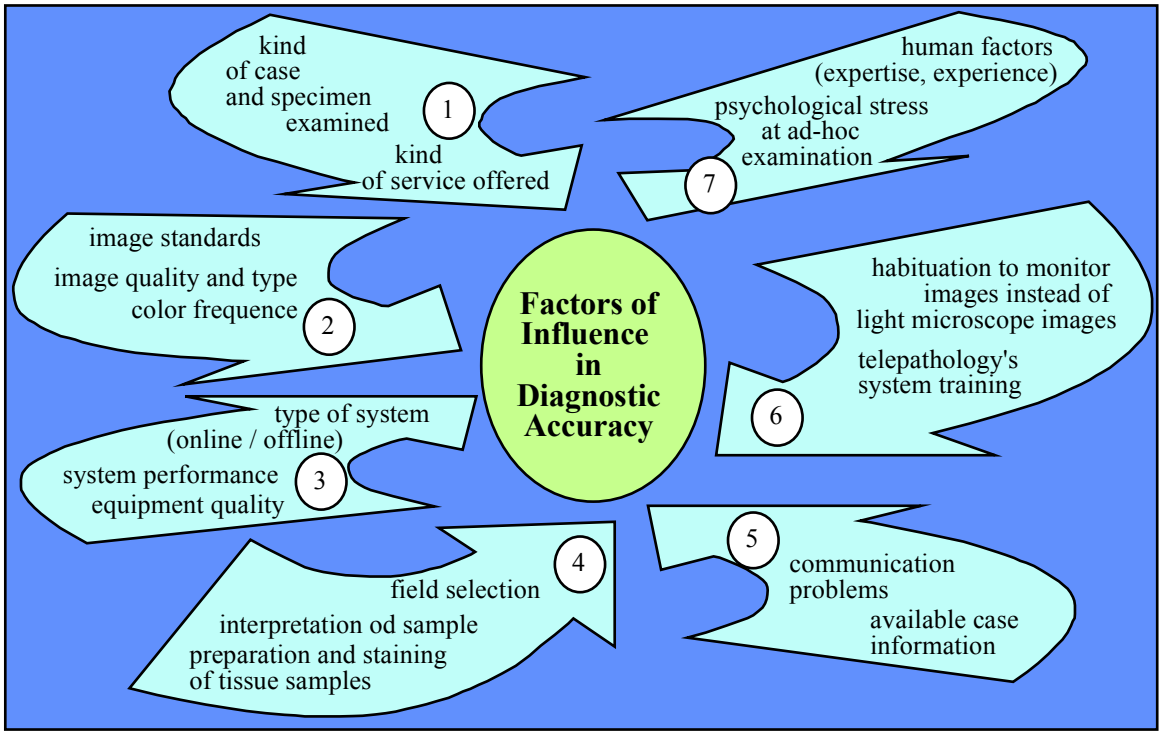

Figure 22a: Factors of influence for diagnostic accuracy.

[95] LGSIL: low grade squamous intraepithelial lesions
HGSIL: high grade squamous intraepithelial lesions
ASCUS: atypical squamous cells of undetermined significance
AGUS: atypical glandular cells of undetermined significance

16.2.1 Influence of Specimen Type and Kind of Service

According to the type of specimens examined, the field 'pathology' is distinguished in the specialties **macroscopy** (examination by just using the eyes), **cytology** (examination of cells), and **histology** (examination of tissue). Out of these specialties, there are some more specific fields e.g. **dermatology** (examination of skin), **neuropathology** (examination of nerves). It is obvious that judging the usage of telepathology services, the kind of specimen examined has to be taken into account. That is why, if one wants to determine where telepathology is most appropriate to comes into operation, to have a closer look at the kind of organs and samples examined.

> *„Very complex or difficult cases may forbid the access of tele-pathology system: tumors exams needing **specific immunostaining process**, such as lymphones, soft tissues tumors, bone tumors." [Allaert, 1999]*
>
> *Results of a telepathology study executed at Milwaukee: „...two of the three cases with clinically important discordant diagnoses involved staging of transitional cell carcinomas. Staging of these cases proved problematic by light microscopy as well." [Dunn, 1997/[1], p. 11]*
>
> *„Although he (Nordrum, project in Norway) felt the image quality was sufficient for frozen-section diagnosis of surgical tissue, it was not adequate for examination of, for example, **lymphomas** or **lymphoid tissue**." [Elford, 1997, p. 7]*
>
> *„Sampling problems are common to all telediagnostic applications, but this problem is especially important in **hematological** cases for which it is necessary to make microscopic observations at high resolution (x 100 oil immersion objective) of a large number of microscopic fields. In peripheral blood smears, the cells which are important for the diagnosis can be quite rare and the time spent to select them long and fastidious. In bone marrow aspiration, informative cells may also be rare and difficult to find ... this does not mean that there is no room for telediagnosis in hematology, but that we have to use this new and fascinating technology with caution." [Flandrin, 1995, pp. 258, 260]*
>
> *„Analyzing the eight specimens which are incorrectly diagnosed, judgement of malignant **lymphoma** should be avoided." [Adachi, 1996, p. 440]*
>
> *„For example, grading **dysplasia of the uterine cervix** or **classifying melanocytic lesions of the skin** is often difficult even with optimal image resolution. Because of the lower resolution of video displays, caution should be exercised in rendering diagnoses using telepathology in these cases." [Callas, 1997, p. 818]*
>
> *„Some lesions are not appropriate for telepathology analysis. For example, it can be difficult to discern some fine details of **nuclear structure** with video-imaging systems. Distinguishing dysplasias from carcinomas can be problematical in some cases ... may require much higher video spatial resolution ... For theses cases, glass slides should continue to be obtained, by courier or mail, and examined by conventional light microscopy to render a final diagnosis. ...Currently, telepathologists are working to identify and catalogue problem areas. It will be important to train future telepathologists to recognize these problem areas and the limitations of video imaging. Telepathologists could be trained to flag and defer the types of cases in which it has been shown that video image quality is insufficient for making a correct diagnosis. For these cases, glass slides should continue to be obtained, by courier or mail, and examined by conventional light microscopy." [Weinstein., 1997/(4), p. 3]*

The idea to create a register of telepathology problem areas and to catalogue cases, where telepathology examination cannot be recommended, could be a possibility to increase accuracy results in telepathology. However, since technology is permanently improving, maintenance of such a catalogue could become difficult.

Influence of Telepathology Service Type on Accuracy

The kind of **telepathology service** may also have an influence of the judgement of diagnostic accuracy. It makes a difference whether the telepathology system is used for primary diagnostic, or for 'second look' diagnoses, or even solely for education and training purposes. Doing primary diagnoses, the effects can be drastically. That is why the demands for accuracy has to be very high.

Conclusion Regarding Specimen Type

At a meeting of different telepathologists in Germany (Berlin, Charité, 20.11.99[96]), experts came to the conclusion that instead of pointing at restrictions for types of telepathological service (primary diagnosis, secondary diagnosis) or telepathological examinations (types of specimens), the **diagnosis responsibility should be given to the expert**. That is for example, if an expert is able to do his diagnosis clearly, even with a static system, why should there be an artificial restriction instead of putting confidence in the judgement of the expert for each individual case. Nevertheless, advises of critical areas for diagnostic telepathology may be welcomed by new telepathology users.

16.2.2 Influence of Image Quality on Diagnostic Accuracy

Already in 1994, the Armed Forces Institute of Pathology proved that a diagnostic telepathology service can be established successfully with minimal resources, at a modest cost and with no significant disruption to the normal operation of a consultation center [Mun, 1995, pp. 159 ff.]. In opposite many of the requested pathologists, who actually do not use telepathology, have doubts about the quality of monitor image examinations. Such pathologists meant that they prefer to do a diagnosis on their own microscope. They did not believe that diagnoses can be made accurately on a monitor.

> *„Even if I am requested for a second opinion examination for my colleague next door, I prefer to use my own microscope. To realize fine details in a sample is so hard to please that this demands high quality images, which I doubt to be available on a monitor." [quotation of an interview].*

Whether the use of the own microscope's images is just a habit or not is difficult to assess. However, image quality is a critical point for telepathology system's success. That is why the establishment of image quality criteria has to be kept in the focus of telepathology system developments, since in pathology image fidelity refers to the accurate reproduction of structural details of a specimen [Mun, 1995, pp. 154 ff.; Krupinski, 1993, p. 75]. The following figure gives a brief overview about the parameters of influence of image quality:

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96 Consensus meeting of telepathologists in Germany, 20.11.1999, Charité, Institute of Pathology, Prof. M.Dietel

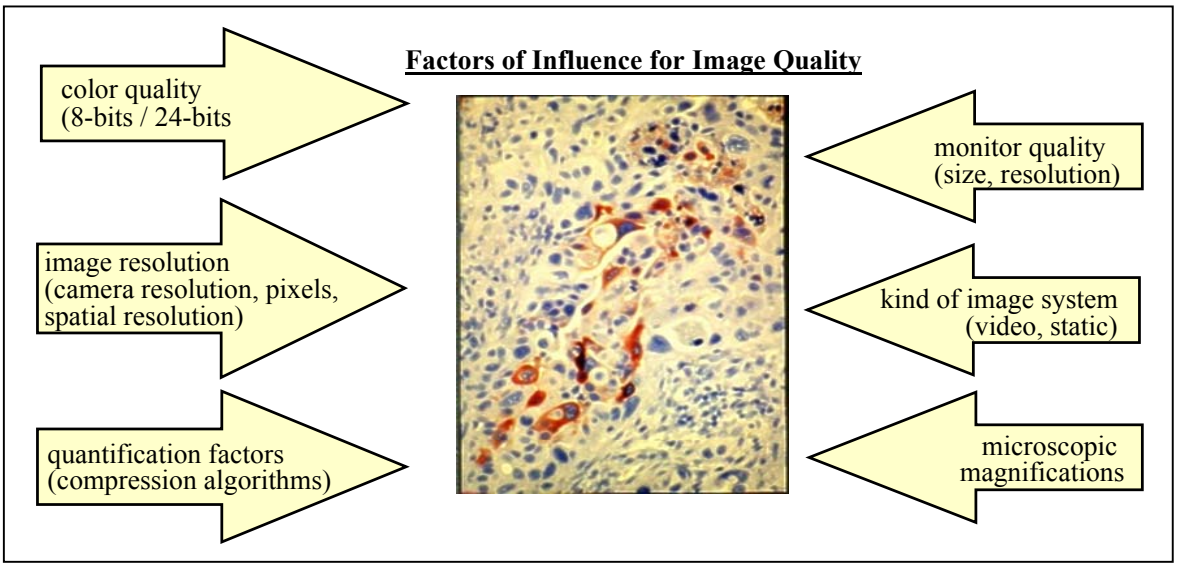

Figure 22b: Diagnostic accuracy – factors of influnece on image quality.

Principle of Image Quality

> *„Specifications for a telepathology system are determined, in part, by the requirement of the production of an image by a camera / monitor system of adequate quality to permit a pathologist to render a diagnosis with the same accuracy achievable using a conventional microscope.“ [Weinstein, 1987, p. 649].*

The basic principle is that the quality of the image at the monitor should be as close as possible comparable to the quality of the prepared specimen image at the direct light microscope, with regards to the available communications infrastructure and system performance. To achieve the same image quality on the monitor as at the light microscope, several aspects have to be regarded and quality standards for digital images acquisition and distribution should be set up [Sternberg, 2000]. Image resolution is one of several factors that can affect the diagnostic interpretation of telepathology images. Further factors are for example color quality, quantification factors (image/video compression algorithms), transmission speed or microscopic magnification. [Galvez, 1998, p. 666]. Considering already executed accuracy studies, 20% of pathologist's uncertainty and diagnostic errors occur due to the insufficient quality of digitized images [Weinberg in Weinstein, 1996, p. 100]. That reflects that image quality is a serious issue of telepathology. Therefore lets first of all have a look at the image capturing process.

16.2.2.1 Image Capturing and Digitalization

Telepathology images are either analogue or digital. While analogue support is still employed in some applications, digital images start to become utilized routinely in clinical diagnostics. Digital images need binary systems to present the processed information. The process of digitizing and visualizing pathologic specimens images involves the capturing of pathologic specimens at the transmitting site through a high definition CCD camera mounted on a light microscope. The digitalization of pathological images is either done by video frame grabbers or images are directly captured by a digital scanner or a digital video camera (see chapter11.1.2). The quality of the transmitted images is, in general, independ-

ent of the communication lines used, but depends mainly upon the quality of the camera and the underlying optical system (microscope[97]) [Kayser, 1993/(1), p. 332].

Most of the available telepathology systems are based on digital images, since the digital format allows us to present information in an exact form. Digital imaging has many advantages over analogue. It provides the possibility to improve image quality but also allows an improved management of data for archiving, retrieval and storage. Large film libraries are now replaced by optical juke boxes. Some authors even think that medical record keeping is considering going film-less (and slide-less) in the near future [Houtchens, 1995, p. 106]. Digital image keeping does not only cut down the amount of space required and improves the management of images, but also reduces the amount of lost or misplaced files [Mun, 1995, p. 156]. **Digital imaging allows for faster, better and easier communication of images** through communication channels and therefore is an important factor for telepathology service improvement. For example, in radiology departments many image generating devices already output their images in digital form such as CT, MRI and nuclear medicine. However in pathology glass slides are still dominating the laboratories and digitized images are more or less an exception.

16.2.2.2 Image Quality Measurements

In order to give quality diagnoses, as soon as a glass slide is prepared and its quality is adequate, it is the task of the pathologist to make sure that the image which he has to diagnose, either directly through the microscope or on the workstation color video screen, shows adequate quality. For reaching a more adequate image quality, a pathologist first of all will set-up **light parameters**, **zoom factors** and various **optical adjustments**. Then the image fidelity and quality can be measured by several important criteria. Subjective rating, and the diagnostic accuracy ratio are taken as measurements in some studies [Foran, 1997, p. 55; Schlesner, 2000]. Another important measurement of image fidelity is the amount of noise in it, quantified by the **signal-to-noise** ratio (SNR) measured in decibels. The higher the SNR, the better quality the image is. The most common measurement however is resolution. Resolution is distinguished into **spatial resolution** and **contrast resolution**.

> *„The accuracy of clinical decisions that are based upon diagnostic images is proportional to image resolution .... The ability to interpret an image accurately and the cost of image management also depend upon image size.“ [Houtchens, 1995, p. 106]*

Spatial Resolution

Spatial resolution is related to the sharpness of the image. It is a matter of the ability to separate two closely placed objects. It is related to the **pixel size** as well as to the **array size** of an image [Mun, 1995, p. 156]. Hence, the size of digital images is classified by the number of horizontal and vertical lines (**line pairs/frame**, e.g. Lp/mm = Line pairs per millimeter) generated by the rows and columns of picture elements that make up the image frame. The bit count for each frame is the product of **bit depth per pixel** and **pixels per frame**. Compared to contrast and color quality, spatial resolution of images has proved to be not sufficient in some studies [Kayser, 1995/(1), p. 55; Kayser, 1995/(3), p. 218]. At a

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[97] Goncalves examined factors of influence of image quality. He had a look at the resolution (contrast and spatial frequency) of the microscope, the video camera and the monitor. Finally he discovered at his study that the main limitation is on the microscope [Goncalves, 1995/(1), pp. 251-252].

study in Sweden, one limitation of the used system was insufficient image resolution [Olsson, 1995, p. 240]. McLaughlin and Weinstein remarked at their accuracy studies that

> *„Telemicrobiology is somewhat different from other telepathology applications, such as histology and cytology, as the spatial and color resolution requirements for video microscopy may be greater." [McLaughlin, 1998, p. 12]*

> *„Adequate study of nuclear structure ... may require much **higher video spatial resolution**." [Weinstein., 1997/(4), p. 3].*

This quotations indicate that the spatial resolution has to be brought in context with the kind of examination executed, especially when standards, like in radiology, are developed for telepathology consultations. An extensive overview of the image properties of systems actually in use is given by O'Brien [O'Brien, 1998, pp. 160, 162].

In 1987 Weinstein discovered in a test study that standard television resolution of 525 lines is inadequate for some pathology diagnostic applications. Image resolution in Georgia was 640 x 480 x 256 colors. Users would have preferred a higher color resolution, but the VTEL software could not handle more than 256 colors (8-bit) properly[98] [Prasse, 1995, p. 261]. The AFIP was pleased with image quality by using cameras with at least 750 x 500 pixels resolution [Mullick, 1996, p. 190]. Fortunately, most cameras incorporate in commercial telepathology systems have even higher resolution capabilities than what the AFIP considers to be minimum [Mullick, 1996, p. 190]. All images used in the TelePath system in Birmingham, Alabama, are 795 x 598 pixels, with a color depth of 24 bits [Winokur, 1998, p. 44]. Weinstein used images of 1024 x 774 pixel.

> *„We verified that **1024 x 774 pixel** images provided **sufficient** resolution to render many diagnoses and that higher quality images, up to 3072 x 2320 pixels, added little in the way of additional diagnostic information." [Weinstein, 1995, p. 225].*

Tucker claims a minimum image resolution of 1.024 x 1.024 pixel size for telepathology to obtain adequate diagnostic accuracy [Tucker in Wakely, 1996, p. 530]. These different estimations of the spatial resolution demands make a final judgement difficult.

Contrast Resolution - Color Frequency of Images

Pathology, especially histopathology, is inherently an art and science of examining 'colored images' and looking for changes in texture, hue, saturation and intensity of the color, and structural alterations in the image(s) being examined. That is why contrast resolution is an important measurement, since it relates to the color scale and the dynamic range of an image. It determines the ability of distinguishing two objects of different composition.

Image Size

The 'size' of an image has two aspects: size of image file (in bytes) and size of image in surface. For diagnostic accuracy, the second one has an influence. That is the size of the monitor screen, or more precisely the size of the image on the screen, supposing that it fills

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98 Unfortunately, low bandwidth (56 to 384 kbps) and poor color resolution led to problems in diagnostic accuracy of motion-related images at the study in Georgia. Entire images were moving. That is why the pathologist who transmitted the image was required to stop moving the microscope stage for several seconds between fields to allow restoration of the image on the receiving monitor. Images appeared blurred and slight variations in color due to unsatisfying brightness, focus and contrast did produce unreliable video images on the display [Prasse, 1995, p. 263].

a smaller window than the whole screen would allow. For example in Basel, the moving video image is a small one, however the freeze frame image, which includes the suspicious magnified parts of the key sample, is a large one.

16.2.2.3 Image Quality Based on Staining Procedures

Some studies (e.g. Tucson/Arizona), showed that if **staining is not optimal**, misinterpretation of images may occur due to unsatisfied image quality. This problem may be minimized by using a well-established stringent protocol for staining. Criteria have to be unified for additional staining techniques, staining standards and quality control to maximize the staining and de-color stages of pathological procedures. Telepathology communications have proved to be very useful in adjusting and supervising the performance of various stainings and in defining corresponding standards [Kayser, 1995/(3), p. 218; McLaughlin, 1998, pp. 14, 15].

16.2.2.4 Reduced of Image Size - Color Reduction

As already has been said, for the accurate rendering of pathology images, the same quality of monitor image as a pathologist would have at his light microscope is desirable. This would require the use of 'true full color' images, which means 24 bits digitized images. Consequently eight bits each for red, green, and blue (256 shades) have to be transmitted. However, using 24 bits images demands a lot of storage capacity. For example, an image with 1 million picture elements (e.g., pixel resolution of 1.024 x 1.024 bytes), with 24 bits of color information for each pixel, would produce a computer file approximately three megabytes (MB) in size. With the actually available technology and network performance, the transmission and viewing time would cause frustration. Therefore at many systems the size of an image file is significantly reduced. Such file size reduction could be obtained by using image **compression algorithms**, by reducing **image resolution**, or by reducing the **numbers of colors** or light intensity levels represented. Diminishing the color in the available palette from 24 bits to 8 bits results in an image file one-third the size of the original file. Fortunately, color quantification techniques are available that can create a 256-colour palette that will closely approximate the original colors, and dithering techniques (e.g. placing several colors in close approximation to provide the illusion of another color) can further increase the range of colors provided by 8 bits.

> *„If it turns out that diagnostic accuracy is not sacrificed by using 8-bit color - which remains to be determined - specification for telepathology systems may be rewritten with reduction in bandwidth and storage requirements. „ [Weinstein R., 1997/(4), p. 5].*

A very interesting study for telepathology's image reduction was executed by Doolittle et al. This research group was driven by the idea that color reduction from 24-bit color to 8-bit color could yield images of such a high quality that they are virtually indistinguishable from the original images, but which occupy one third the 24-bit file size. The color preference of 30 pathologists was recorded and analyzed. Finally there was a statistically significant preference for the 8-bit versions of the color images. Doolittle concludes that, although quantitative methods show an objective measurable difference in image quality, the subjective assessment of individuals is probably of greater importance and value. Another study concerning image quality was executed in Berlin at the 'Rudolph-Virchow-Haus'. They discovered that diagnostic accuracy is not just dependent on the color quality, but on a combination of various factors like screen training, compression quality, band-

width, transmission speed, magnification and resolution, size, but especially on the case and subjective impression of the telepathologist [Doolittle, 1997; Daniel, 2000].

In Summary one can say, increased color scale has to be associated with increased storage requirements and slow image transmission time. A somewhat lower contrast resolution (e.g., 8 bits) may be adequate for monitors, given the limitations of the human eye in detecting differences in color contrast. Telepathology users have to be aware that the chosen resolution requirements will have a directly influence on the equipment design and image transmission costs and, ultimately, the feasibility of telepathology [Weinstein, 1986, p. 433].

16.2.2.5 Reduction of Image Size - Image Compression

The transfer of video images by using small-band channels (64 Kbit/s - 2 Mbit/s) is only possible with coding and compression features. Compression of images is mostly accomplished by applications for codec of images before transmission and decoding of images at the receiver's end. Image compression is a process that can reduce the size of an image or multimedia file to a more manageable scale [O'Brian, 1998, p. 150; Boudier, 1999, p. 133]. Only essential information of an image remain, whereas image details, which are already present at the receiver's end, are filtered out. Storage requirements, processing time and transmission time can be reduced. [Eide, 1994, p. 882; Swett, 1995, p. 596; Grigsby, 1995/(1), pp. 20, 21; Foran, 1997, p. 55]. Especially at pathology images there is a large redundancy because of the underlying staining process with a relative restricted palette of colors, which makes compression efficient.

Image Compression Types

In 1987 the **MUSE compression system** was one of the first one used in telepathology to overcome the problem of network capacity. Bandwidth video signals of 30-MHz were reduced to 8.1 MHz [Weinstein, 1987, p. 651]. Unfortunately MUSE signal compression schemes proved to be unsatisfactory for telepathology due to motion-related blurring [Weinstein, 1989, p. 41].

Nowadays moving images are often compressed by coding standards like **MPEG** (**M**oving **P**hotographic **E**xpert **G**roup), H261 and the H120 umbrella CCITT standard compression, as well as algorithms for inanimate pictures like SG3, HVQ or the CCITT-standard H320 [Richter, 1995, p. 296, 297; Ferrer-Roca, 1996, p. 14; Anonymous, 1997]. Still video images are often compressed and coded by **JPEG** (**J**oint **P**hotographic **E**xpert **G**roup). JPEG is a still-image coding standard, where image data are simplified before coding. Another widely used (lossless) compression method for still images is the **T**agged **I**mage **F**ile **F**ormat (TIFF).

At a first glimpse MPEG/H.261 seems to fulfil the problems of telemicroscopy better than JPEG. But the most important point of view in telemicroscopy is **optimal image quality** and **not minimum frame rate**, which is a characteristic feature of MPEG. Nevertheless, JPEG is often employed by telepathology systems. Unfortunately JPEG very soon showed weaknesses, so that JPEG-2000 is already in development. Yet, because JPEG has difficulty in handling color coding and is dependent on the existence of redundancy in the image, wavelets have proved to be more appropriate for pathological images. That is why the DICOM 3 standard is already based on wavelet transforms [O'Brian, 1998, pp. 150-151].

At the Humboldt-University of Berlin[99], Germany, a **bimodal wavelet-based compression** method is being tested for teleradiology images. The reason for the compression trials in Berlin was the fact that teleradiological images could not be sent within a acceptable time by the actually available telecommunication infrastructures. Such wavelet-based image compression, with an average compression ratio of 23:1, and multiplex technology connected by four modems to the leased dial-up telephone lines was also used successfully at a teleradiology trial between the United Arab Emirates (Abu Dhabi), the Kingdom of Saudi Arabia (Riyadh) and consultants at Cambridge, MA. Yet, for the transmission of telepathology images at this trial JPEG algorithm at compression ratios from 7:1 to 15:1 were employed [Goldberg, 1994, pp. 1496-7].

Compression Rate

One thing distinguishes lossless and lossy compression methods. Lossless compression are fully reversible without deficits in image quality, but compression ratio is only 3:1 or less. Lossy compression is achieved by methods such as JPEG, MPEG, wavelets or fractals. These algorithms are capable of up to 20:1, 30:1 or even higher ratios [Foran, 1997, p. 55; Mun, 1995, p. 157]. Compression up to 30:1 will produce deficits, but still seem to produce an acceptable image quality for diagnostic [Detken, 1996, p. 103; Azumi, 1996, p. 450; Teixeira, 1996, pp. 934 ff.; Marpe, 1998, pp. 136 ff.]. DNA ploidy analysis cells images could be JPEG compressed even up to a level of 70 without affecting the results [Phillips, 1995, p. 295; Phillips, 1996, p. 233].

Using MPEG video coding image compression Teixeira discovered that to obtain a good trade-off between compression ratio and quality, more than just the reduction of the spatial redundancy in the images is necessary. Regarding matching criteria, computational complexity, and search window size he therefore developed valuable algorithms to improve and simplify MPEG compression procedures [Teixeira, 1996, pp. 934 ff.].

If JPEG is utilized, the compression factor is easy to calculate because the JPEG compression factor is highly dependent on the image content. Special focus has to be kept on spatial frequency and color distribution of images, since pathological microscopic images are more concentrated in specific color components and have much wider chrominance-component spectrums (spatial frequency) than are general images. Many systems use the advantage of JPEG to offer the opportunity to select the resolution required and to adapt the frame rate accordingly. This allows us to exploit trade-offs between frame rate and image quality. The compression factor in JPEG coding thus becomes dependent on the selected resolution and the image content [Schmid, 1996/(2), p. 931]. Nevertheless, a test at the Kyoto Prefectural University of Medicine, Japan showed that using current JPEG algorithms for pathological image compression is not always sufficient [Okumura, 1997, pp. 701 ff.].

A few studies have already addressed the problem of compression rate by asking pathologists what level of compression is acceptable. Unfortunately no consensus has been reached for the acceptable degree of compression [Winokur, 1998, p. 48]. Therefore it is no surprise that various discussions and experiences in telepathology end with the realization that the use of **lossless compression techniques for pathology images should be pre-**

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[99] Humboldt-Universität Berlin, Campus Virchow-Klinikum, digitale Radiologie, Augustenburger Platz, 13353 Berlin

ferred [Allaert, 1999]. Many practitioners choose lossless algorithms to avoid medical liability and responsibility issues [Mun, 1995, p. 159]. For example, at the hybrid system trial in Birmingham, no image compression is used. In opposite, in Italy a still imaging study was executed between the University of Udine and the Hospital of Trento. Using JPEG image compression ratio of 1:1, 8:1, and 15:1, no significant difference in image quality by the consulting pathologist was recognized, so that finally a compression level of 15:1 was adopted [Della Mea, 1996, p. 25]. Using static imaging in the USA, Weinstein said that relatively high JPEG compression ratios does not seem to affect diagnostic accuracy or image quality in any bothersome way [Weinstein, 1995, p. 225].

Yet it is obvious that image compression has a huge impact on image quality and due to this to diagnostic accuracy. To overcome the actual uncertainty, Foran tries to set up guidelines for telepathology compression ratios to indicate how much compression is tolerable before the diagnostic essence of an image is compromised. One of his findings was that remarkably high compression ratios are tolerable in diagnostic telepathology but that the tolerance for compression varies across sub-specialization[100] [Foran, 1997, p. 59]. Schwarzmann defines the question of image resolution quite simple:

> *„If for instance the human eye will be the final receiver of the image data, all reduction can be tolerated which are not visible for the human observer.“ [Schwarzmann, 1992, p. 387]*

16.2.2.6 Image Quality Related on System Type

Bandwidth does not limit the quality of still microscopic images. That is for microscopy, if the interpreter works essentially with motionless images and does not attempt to observe productively while the transmitter moves the stage of the microscope, bandwidth will have no effect on image quality [Prasse, 1995, p. 265]

This is not the case with dynamic systems. The requirements of pathologists are exceptionally demanding, since the microscopic field must remain sharp and in focus while the specimen is moving. Routine light microscopy involves the panoramic scanning of histopathology and cytopathology slides. A pathologist's tolerance is low for blurring of images during the scanning process. Unfortunately, this blurring is still inherent in many commercially available video systems. However, image instability from any source will limit specimen resolution. As a consequence, the acceptability of telepathology could become ultimately negatively influenced. Therefore image stability has to be an important consideration when selecting a video microscope imaging system [Weinstein, 1989, p. 41].

16.2.2.7 Image Quality Related to Magnification

In microscopy different image contents are achieved at different magnifications. Images captured using the x2 and x10 objectives should at minimum be able to provide the pathologist with texture and orientation of the tissue/lesion, information about main cell types involved in pathological change, and the 'severity and extent' of the lesion in the tissue being examined. Images captured using the x40 objective should at minimum be able

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[100] The experiment about investigating compression ratio for an acceptable 'diagnostic accuracy' showed that the hematopathological images, histopathological images, and the liver biopsies could be compressed by factors of about 35, 20, and 25, respectively, without compromising their clinical usefulness. The factor 'just noticeable difference' of the experiment showed that the hematopathological images, histopathological images, and the liver biopsies could be compressed by factors of about 22.9, 13.9, and 16.7, respectively without decreasing subjective image quality [Foran, 1997, p. 59].

to provide the pathologist with information about cellular topography or the extent of cytological change [Anonymous, 1997].

Images with low magnification (e.g. 2,5 x) have an extremely high content of small image details, whereas images with a high magnification possess only few image details. Many problems arise for both cytology and histology with low and intermediate magnification images. There the resolution that was satisfactory for high-power images conferred blurry outlines on small objects. Single cell resolution is often lost. Such images contrasted unfavorably with the sharpness and clarity of the image available to the microscopist [O'Brian, 1998, p. 149; Ito, 1994, pp. 802-803]. Whilst cameras and monitors with an resolution of 500-700 lines will be appropriate for high magnification images, low magnification images should present an image resolution close to that observed through a microscope with 2.000-4.000 lines. Yet, to meet such demands will be very expensive [Eide, 1994, p. 887].

To overcome this problem, **hybrid systems** (e.g. Tromsoe, Basel) with low-resolution digital video image transmission for field selection, but with high-resolution images for diagnostic evaluation are employed. These hybrid systems use a combination of live video moving images with a lower resolution for slide orientation and field selection, and static high resolution strongly magnified microscopical images for interpretation [O'Brien, 1998, p. 156; Allaert, 1999; Dunn, 1995, p. 256; Oberholzer, 1993, p. 1084]. This flexibility in image capturing allows the telepathologist to choose the image quality and magnification which is most appropriate for the examination of a certain case.

16.2.2.8 Amount of Images Transmitted

Response times affect the quality of diagnosis because they interfere with the number of inspected images. Up to 200 fields of view at various magnifications are inspected during a frozen section diagnosis, which is usually done in five to seven minutes[101] [Wolf, 1998, p. 131]. That is why for accurate viewing of tissue specimens via video-microscopy a high resolution monitor, high speed data transmission (if one desires to view moving images without artefact), and rapid monitor refresh rate (e.g. the speed with which images on the monitor are replaced by new images) are desirable [Grigsby, 1995/(1), p. 21]. That is that diagnostic accuracy is closely related to the transmission of images, which is the **speed** and the **amount of images transferred** [Interview, Prof. Oberholzer, Basel].

> *„Some consultations may **need only a few images**, when these all appear to be of the same type prior to classification ...**others need a larger amount of transmitted information**, as the expert has to classify the lesion 'as a whole', taking into account all of the cellular material present to access the proportions of dyskaryotic cells of different grandees, diagnosis being based on the most severe abnormalities." [Marsan, 1995, p. 341]*

Fortunately the final diagnosis mostly is rendered based on a small number of images (the kernel of the tumor) [Krupinski, 1993, pp. 69-71]. Usually, about 7 to 10 images are necessary to enable the consultant to achieve a precise diagnosis. If no definitive conclusion is reached after the first examination, a second set of images may be required from the requesting site [Marsan, 1995, p. 340]. Surprisingly studies showed that many telepatholo-

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[101] It is estimated that digitally imaging a specimen covering about a $1cm^2$ area using the standard microscope objectives (x2, x10, x40) and a tele-video conversion 'eyepiece' of x 2,5 would create over 50 images. As pathology specimens often occupy areas greater than $1cm^2$ area, and since there may be more than one section for analysis necessary, the amount of images could even increase up to 200 images and more [Anonymous, 1997].

gists do not **request additional video images**, although they frequently asked for sections from additional blocks of tissue or deeper sections from tissue blocks in their regular consultation practice [Halliday, 1997, p. 20].

If transmission speed is poor, clients tend to keep the amount of images to be transferred low. In other words, the greater the delay between field selection and image display, the more limited is the extend of sampling that is practiced [Weinstein, 1997/(2), p. 22]. At a accuracy study at Tucson, Arizona, errors were caused when attempting to precisely characterize lesions from a limited number of static video images. The telepathologist hesitated to request additional video fields, and therefore could not identify the diagnosis definitely [McLaughlin, 1998, p. 14; Weinstein, 1997/(1), p. 34]. Another accuracy study of Weinberg with a static imaging system showed that 17 % of diagnostic uncertainty occurred due to insufficient numbers of digitized images [Weinberg in Weinstein, 1996, p. 100]. At an accuracy study of a static imaging system at Tokyo, only approximately three images per case were transmitted due to low data transfer rates by using ISDN (64 kbit/s) and telephone lines. Again, this small number resulted in reduced diagnostic accuracy [Shimosato, 1992, pp. 413, 416]. And as a last example with a still imaging system, at a study of telecytology images in Sacramento, USA, discordance of cases was chiefly due to insufficient images showing to less details, so the pathologist did not obtain a good 'feel' for the case [Galvez, 1998, p. 665]. In Stuttgart, Germany, a field test with a dynamic system showed similar accuracy problems. Employing higher bandwidth (comparing one ISDN line and 8 B-ISDN channels) lead to improved accuracy rates, because more bandwidth allowed the telepathologist to scan the image more precisely. Low bandwidth can cause a long respond time and therefore the telepathologist tries to keep the scanning process restricted [Schmid, 1996/(1), p. 480].

16.2.2.9 Summary

There is still little known of the impact of image quality demands such as resolution or field size on diagnostic performance and accuracy. In some situations diagnostic accuracy can be ensured even with resolutions below the current video standard of 640 x 480 effective digital pixels. Altogether experts assume that cytological diagnostic requires higher image quality than histological interpretation, since resolution has to be sufficient enough to discriminate fine cellular detail and nuclear textures [O'Brien, 1998, p. 153]. However, the final decision whether an image is sufficient for an adequate diagnosis has to be given to the consultant. Considering the problem of image amount, powerful computers and high bandwidth communication links could diminish accuracy errors caused by the image amount. Using static systems, if a pathologist is not certain he/she should not hesitate to request further images.

16.2.3 Influence of Sample Handling on Accuracy

16.2.3.1 Description of the Microscopy Process

Adequate field selection is the foundation of a correct pathological diagnosis. Field selection is not just a problem of telepathology, but could increase if the field selection is executed by a less experienced client, like it is the case in telepathology. The following figure shows the process of step by step narrowing down suspicious cell-structures.

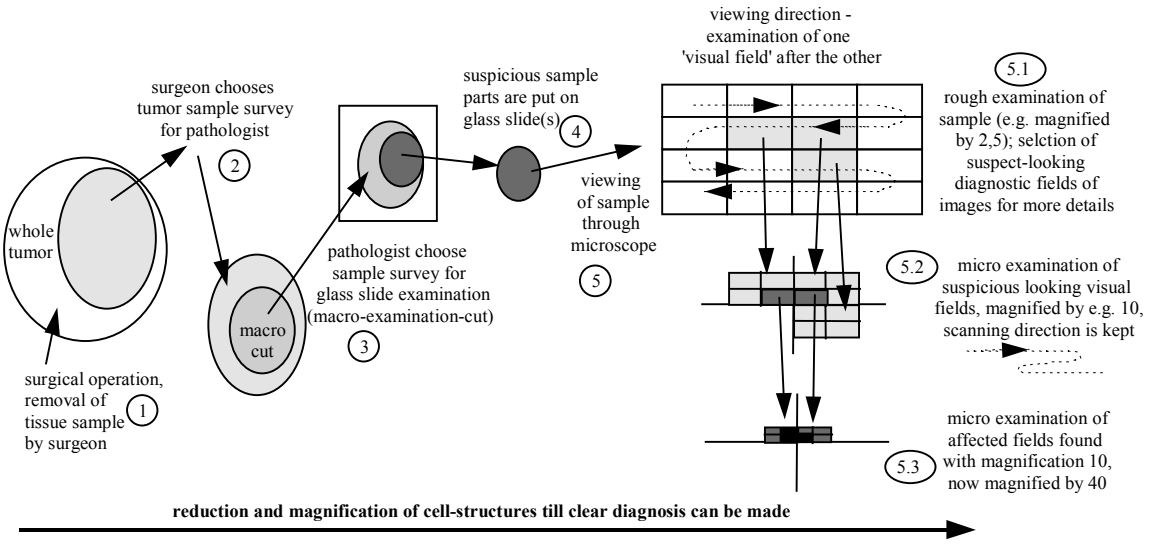

Figure 23: Pathological procedures for narrowing down suspicious cell-structures.

This figure of the narrowing down and scanning process in pathology already reflects how difficult but also how important it is to select the right fields for examination. How will the consultant recognize malign tumor cells, if the client does not show him the affected parts of the sample. That is, if the client does not cut the specimen at the right place, he probably will miss showing the malign cells on the glass slides. Analogue, supposing the client uses a still image system, if he does not select the right images, the consultant will come to an incorrect result. Users of **static systems** already remarked that such systems provide too little control over the selection of microscopic fields to serve as a useful primary diagnostic tool [Weinstein in Grigsby, 1995/(1), p. 21; Allaert, 1996, p. 29]. For the demonstration of the importance of field selection Azzopardi reported about a case, where an incorrect field selection led to an incorrect diagnosis:

> *„Severe epithelial hyperplasia in a fibroadeoma was diagnosed by an inexperienced pathologist as infiltrating carcinoma. Insufficient attention had been paid to the circumscribed margin of the lesion, and the fact that it was a fibroadenoma had been completely missed. In this instance the hyperplasia was unusually exuberant but benign.“ [Azzopardi, 1979]*

That incorrect field selection in fact is a problem for accurate telepathology diagnoses, especially if static systems are employed, has already been realized:

> *„The video pathologist likely did not see the invasive area because this was not shown by the sending pathologist, who had not seen it .... because the sending pathologist (whose diagnosis was ‘atrophy’) did not see the focal carcinoma and consequently did not show it. ... however, ...remote control systems are more technologically complex and expensive.“ [Callas, 1997, p. 818]*

16.2.3.2 Accuracy Problems with Static Imaging Systems

Problem of Field Selection

Evaluations of static-image telepathology systems did not show a level of diagnostic accuracy that would be acceptable for the routine practice of surgical pathology due to the errors of field selection that have been reported [Dunn, 1997/[1], p. 8, Almagro, 1998, p. 1162, study of Allaert, 1995/(2), pp. 596 ff.; Weinstein, 1997/(2), p. 22]. Studies that have attempted to attribute the source of errors showed that image selection or sampling

are one of the most important causes of disagreement between the transmitted images and diagnosis based on glass slide review [O'Brien, 1998, p. 156].

Capturing and archiving of high-resolution static digital images is time-consuming and expensive. It is not possible to screen an entire slide. Therefore the most important problem in store-and-forward telepathology is that of image sampling. The transmitting operator at the remote site selects images that seem representative of the whole case and this causes limitations and problems [e-mail from July 99, Della Mea; Weinstein, 1997/(1), p. 30; Marsan, 1995, p. 341; Ito, 1994, p. 805; Adachi, 1996, p. 440; Galvez, 1998, p. 666]. For example, to store all of the information in surgical pathologic specimens, a sample of 1.7-mm would demand up to 174 static images. The number of images necessary for a 10x objective lens surveying would even demand 1.141 images. These reflect the difficulty of field selection at static systems. For example in bone marrow aspiration, informative cells are mostly rare and difficult to find. Therefore the pertinence and quality of expertise in selecting the abnormal from normal cells is very often the crucial issue in the diagnostic procedure, which may be difficult to achieve by telepathology. Studies show, if direct microscope examination is executed, more or different fields surely would have been scrutinized than were sampled by telepathology [Flandrin, 1995, p. 258; Hancock, 1996, p. 93].

At the study with the static imaging system at the AITN, Tucson, USA, field selection by the referring pathologist caused diagnostic errors in 6,3% / 9 cases, including all five cases with clinically important discordance [Halliday, 1997, p. 18; McLaughlin, 1998, p. 14]. Another study of prostate needle biopsy specimens rated 8% of its errors attributable to field selection. Other tests showed an error rate of 5 % specifically attributable to field selection [Halliday, 1997, p. 21]. Unfortunately this reflects that referring pathologists, who might benefit the most from telepathology services, also may be the least skilled in field selection for video imaging [Weinstein, 1997/(3), p. 5]. To reduce this problem, at a static imaging trial in Hungary so called 'image pyramids' are introduced - a method where the relationship of changed pixel size at different objective lenses or magnifications is employed [32] [Gombas, 2000]. In Germany experiments with a so called 'patchwork-method' is tested [Schmitz, 2000]. A similar 'patchwork' approach is already used in Zagreb, Croatia. And last but not least, at the University of Trento, Italy, 'virtual cases' are generated. These are fully digital representations of the entire specimen by means of a series of TV resolution static color images taken at low (2,5x), medium (5x, 10x) and high power objective (20x, 40x) [Demichelis, 2000].

Besides low experience of the client in field selection, a further problem which often occurred with static systems is that the **referring pathologist captured video images that support his own diagnosis**. At the study in Tucson, check up of the case with the microscope showed that fields that were ambiguous or did not support the diagnosis of the referring pathologist were not included in the video image files [Halliday, 1997, p. 20].

It remains to be tested if rules or other activities can be established that will enhance diagnostic accuracy for specific applications, such as proficiency testing. At a minimum, special measures could be developed to guard against tissue sampling errors that may be unique to static imaging [Weinstein, 1996, p. 101]. In addition new technological approaches should be introduced to address the issue of selective sampling in static image consultation. Also the use of **artificial intelligence software** as an adjunct to enhance the accuracy and reproducibility of diagnosis of digital images in routine and consultation settings would be from advantage [O'Brien, 1998, pp. 149, 156].

Regarding the actual situation of static imaging systems, they are often called '**slave systems'**, because the submitting person is selecting the images so that the remote observe is the slave of the process [Azumi, 1996, p. 447]. However, although image selection is a problem at static imaging systems, they still are valuable tools as an 'interim solution', for second opinion consultations, where a sample is already prepared by an experienced pathologist, and for the exchange of opinions among pathologists [Krupinski, 1993, pp. 69-71; O'Brien, 1998, p. 155]. For primary diagnostic, in any case a second examination executed directly at the microscope is compulsory.

16.2.3.3 Accuracy Problems with Dynamic Imaging Systems

From the accuracy point of view for primary diagnoses dynamic systems with a robotic microscope should be preferred, even so such systems are more expensive.

> *„Dynamic imaging systems have shown accuracies as good as or nearly as good as those from conventional microscopes" ... however ... „perfect accuracy is not achievable." [Callas, 1997, p 814]*

What Callas is pointing at is that by using a dynamic system, the expert has the possibility to **control the pathological procedures**, to instruct the client in preparing the tissue sample and where the consultant is able to select the microscopical sample fields and magnifications by himself.

Macro-Examination

When talking with pathologists, who yet do not use a telepathology system, the external handling of the tissue sample by the client was often mentioned as extremely critical. One pathologist even said:

> *„As pathologist, I am responsible for an accurate diagnosis. Macroscopy is an important step of the diagnostic procedure. Therefore I put a lot of effort in teaching my students to do that well. I have to feel the tissue sample and to check it carefully to find out, where it is suspicious and where I have to take the pathological cuts. Are you crazy to give this out in the hand of another person. Perhaps even to a person I do not know, or who is not well experienced in doing pathology examinations, or - even worse - who is not a pathologist? Most of the pathologists in Germany have served a long education at a clinical center followed by several years of experience at a hospital. That is why they know a lot about the appearance and condition of tissue samples. Experience is the main factor for doing satisfying macro-examinations. Do you want to be responsible, for example, for a leg being taken off due to a wrong diagnosis? Are you telling such a patient: „Sorry, but the client did not present me the right parts of your tumor"? I do not want to be in your position then. I am glad that I will be retired - hopefully - before this pathological practice will become established!" [Quotation of an interview at this study]*

This argument was not just made once, but from many pathologists.

> *„I think that the risk of an incorrect diagnosis will increase with telepathology. If the preparation of a histological tissue sample is not done by an experienced pathologist, and if I am not able to check the sample with my fingers, to feel where it is probably malignant, small tumors may be overlooked.. Come on, if you are honest, telepathology is a phase of fashion, but not practicable if you want to put it in practice". [Quotation of an interview at this study]*

One should have in his mind that the cut off of a tissue sample is a injury of the integrity of the organism, which only is allowed to be executed based on a clearly defined indication. Doing so, the patient has the right to demand a correct histological examination of his tissue sample. [German Association of Pathologists, letter 1, appendix I].

The examination of pathological samples requires a lot of **experience and concentration.** That is not just a fact for telepathology, but for pathology in general. The comment above therefore very critically points at the division of the pathological process, which so far was only done by one (specialized) person. It denies the involvement of a person at the client's side, who is not very experienced in pathology. That pathological examinations are very complex and that they have to be done extremely carefully, one will understand when reading the article of Azzopardi about diagnostic errors in pathology (see appendix I) [Azzopardi, 1979].

Macroscopy is an important part of histological tissue examination and an integral part of surgical pathology. Macroscopy claims special know-how about morphology and pathogens of various diseases. One should not forget that a thorough gross examination of specimens with accurate documentation and proper selection of tissue blocks for microscopy remains a part of surgical pathology even with telepathology. The pathologist will analyze the consistence of the entire sample, the color, yet even the smell of it. It is a process where he has to use all his sense organs. The pathologist has to be very experienced to recognize the parts of a sample, which probably show malign cells. Obviously with telepathology the consultant is just able to 'see' the sample as a camera image on his monitor, but has then to rely on the description and perception of the client [Poremba, 1998, p. 320; Schwarzmann, 1996, p. 15]. The missing of senses is a loss of information and may improve the risk of inaccurate diagnostic how a study in Berlin proved [Oberbarnscheidt, 2000]. It also offends against the pathological rule: „**Never report without examining the gross specimen**" [Azzopardi, 1979].

In opposite to this rule, for example, when regarding intraoperative frozen section examinations, pathologists state that to feel a tissue sample is not always elementary. Often there are indications which are so clear (e.g. malignant mama carcinoma or lymphatic gland cancer) that the feeling of the sample is not absolutely necessary [Almagro, 1996, p. 470].

Nevertheless, dynamic telepathology systems mostly offer device with **a gross workstation equipped with cameras and video devices** that allow real time teleconferencing to support a proper gross examination. Telepathology users report that with a reliable good visualization features of video images of gross surgical pathology specimens, preferably combined with a real-time, face-to-face video teleconferencing between the personnel performing the gross examinations and the interpreting telepathologist at the receiving site, satisfying gross examinations can be executed. The consultant advises the technologist how to dissect the specimen and where to cut blocks for microscopy. Images are electronically stored as part of the surgical pathology record. For example, at the telepathology system in Norway, bimodal acoustic and video communication, together with integrated mobile screen arrows are integrated in the system to provide support in the sampling of tissue for sectioning. Thus the gross examination of specimens is fully covered [Eide, 1994, p. 887; Almagro, 1998, p. 1163; Dunn, 1996/(1), p. 469; Grigsby, 1995/(1), p. 25].

> *„With dynamic-robotic telepathology, the services of an onsite pathologist at the remote transmitting site is not necessary ... with proper guidance from the interpreting pathologist at the receiving host workstation.." [Almagro, 1996, pp. 470, 472]*

A similar gross station is used in Basel, Switzerland. Nevertheless, although macroscopy was controlled by the pathologist via video camera, at two of 93 cases a **wrong tissue block** was chosen for examination, so that malignancy was only found at the direct exami-

nation in Basel. Steffen recommends to educate and sensitize the laboratory assistant in Samedan to improve the macroscopical procedure [Steffen, 1997/(2), p. 28].

Indeed, remote telepathology clients have to provide **competent** and **well-trained** personnel to ensure proper **gross examination** of surgical specimens**.** Laboratory technicians have to be **educated** for fully understanding the imperative of maintaining close communication with the interpreting pathologists in regard to the handling, description, dissection and sectioning of specimens. They are instructed to seek advice from the attending pathologist whenever an unfamiliar resection or biopsy specimen is grossly examined [Schmid, 1996/(1), p. 480; Hartviksen, 1994; interview with Oberholzer in 1999].

Another problem of tele-gross examination is the missing possibility to discuss tissue attitudes of cases with other pathological colleagues. Therefore at some organizations, like in Tromsoe, it is a regularly habit that frozen section cases which are not clear, are discussed with colleagues [Eide, 1992/(1), p. 407].

16.2.3.4 Adequate Tissue Processing

Since preparation of specimens is done at the remote place, the teleconsultant has to rely that the staining, shock-freezing, and cutting of 10 x 10 mm frozen tissue parts are executed correctly. The client has to be aware about the staining techniques which he has to use for specific specimen types. A study in Tucson, Arizona, showed that if **staining is not optimal**, misinterpretation of images may occur due to unsatisfying image quality (gram-negative cocci were miss-classified as gram-positive cocci). This problem may be minimized by using a well-established stringent protocol for staining to maximize the staining and decolorizing stages of the whole process [McLaughlin, 1998, pp. 14, 15].

One special area which may be problematical is the preparation of **intraoperative samples**, since frozen section examination has to deal with certain disadvantages. The specimen analysis has to be performed under enormous time pressure. The staining techniques are usually only performed on HE-based procedures. That is why intraoperative sections are usually of poorer quality compared to paraffin-embedded tissue sections [Kayser, 1992/(2), pp. 396, 397]. Image transfer via the Internet may lower the anyway poor image quality due to fixation or staining artefacts, or weak contrast. Therefore the staff at the remote side has to be well trained for enabling proper preparations of samples.

16.2.3.5 Microscopy

Dynamic image systems are often called '**master systems'**, since the remote observer is the master of the robotic features and of image selection. With a dynamic-robotic master system, the teleconsultant serves as the telepathology system operator who controls all microscopy functions including stage movements, X- and Y-coordinates, changing of objectives, color, contrast and light, as well as panoramic scanning and zooming. He is able to view all sections on all glass slides in their entirety. Dynamic systems allow the consultant telepathologist to apply the full range of pattern recognition and cognitive skills to the diagnostic problem at hand [Azumi, 1996, p. 447; Halliday, 1997, p. 20; Joyez, 1995, p. 304; Weinstein, 1997/(3), p. 3]. This is in contrast to static-image telepathology, in which the referring pathologist captures a small set of digital images, which then are transmitted to the consultant, who views them on a video. Accuracy of dynamic systems is much higher than that of static systems:

„Evaluation of static-image telepathology has not shown a level of diagnostic accuracy that would be acceptable for the routine practice of surgical pathology in the United States. Pathologists using dynamic-robotic telepathology systems may achieve a higher level of diagnostic accuracy by circumventing errors of field selection that have been reported by pathologists using static-imaging telepathology systems." [Dunn, 1997/[1], 8]

16.2.3.6 Keeping the Orientation of the Scanning Process

A pathologist is very experienced in scanning a glass slide sample by the microscope, and in magnifying the parts of the sample, he finds strange. A process, which demands fast image movements within the process. Delay time and keeping control over the specimen scanning process are problems which have to be solved when a dynamic robotic telepathology system is utilized. If a telepathology system is not very fast in image transfer, the consultant could lose the orientation within the whole image. A study in Berlin proved that insufficient overview in an image was a reason for diagnostic errors [Oberbarnscheidt, 2000]. That is why fast image transfer time and a system that allows a permanent orientation in the whole sample examined, is important for diagnostic accuracy.

Carr investigated the effects of time delays on user interfaces when tele-operating a remote controlled microscope. He compared and tested keypad interfaces, trackball interfaces, joystick and touch-screens for different commands like 'move-and-wait' or 'in-out-stop'. Systems, like the one of Corabi Telemetrics International, were examined using short, medium and long times of delay. He describes strategies which may help to best compensate delays. The results of which interface worked best was 'feedback', and keypad interfaces were preferable to trackball interfaces [Carr, 1992, pp. 256-260].

16.2.3.7 Interpretation

Another source for diagnostic errors is wrong interpretation [O'Brien, 1998, p. 156; Almagro, 1998, p. 1162]. Interpretation can be influenced by factors like image quality, access to additional information for the patient's symptoms, history results of medical examination, knowledge of the pathologist, access to related information, etc. [Kayser, 2000]. Again, interpretation is not a phenomenon, which just attributes to telepathology, but also occurs in common pathological diagnosis procedures on a similar scale. Even the Association of Pathologists in Germany is pointing at this when they explain that intensive studies have proved that - comparing the clinical diagnosis (e.g. of an surgeon) with the histological diagnosis of an pathologist - not rarely a quite unexpected diagnosis was finally made. They claim that one should keep in his mind that even if a previously 'harmless' appearing sample was taken, not seldom a serious result was presented at the end [letter 1, appendix I]. Azzopardi even puts the problem of interpretation down to a rule:

„If the macroscopic appearance is benign, beware of diagnosing carcinoma. Think again. The microscopic interpretation is probably wrong. (Certain in situ carcinomas are the exception.)" [Azzopardi, 1979]

Being aware that incorrect interpretation is known as a considerable factor for incorrect pathological diagnoses in general, it is not obvious that this problem will increase with telepathology. Yet, it also will influence diagnostic accuracy.

„In four cases in which the telepathology diagnosis was incorrect, the pathologist's diagnosis ... was identical to that rendered by telepathology. These represent errors of interpretation and cannot be ascribed to telepathology." [Dunn, 1997/[1], p 8]

> *„Diagnostic accuracy continues to be an issue even though it is evident in our experience ... that many of the diagnostic errors resulted not from technological inadequacies but from individual interpretation, interobserver variability, and inherent difficulty of cases." [Almagro, 1998, P. 1161-1162]*

At a study in Tucson with a static-imaging system, from 144 tested cases seventeen were discordant. Twelve of these seventeen cases (8,3%) showed problems in interpretation. In eleven of the twelve cases the telepathologist's diagnosis was concordant with the referring pathologist's incorrect diagnosis, but discordant with the 'true' diagnosis rendered by the review panel. Again, this high level of disconcordance may reflect an influence of the referring pathologist's diagnosis on the telepathology diagnosis [Halliday, 1997, pp. 19-20; McLaughlin, 1998, p. 14]. These results indicate that the receiving pathologist should avoid any tendency toward over-interpretation of the histological findings [Weinstein, 1997/(1), p. 34].

16.2.3.8 Summary of Sample Handling

Considering macroscopy procedures in telepathology many pathologists are skeptical. One solution to overcome problems in gross examination would be the creation of a negative or positive catalogue of cases, where telepathological macroscopy is sufficient or prohibited. Another more flexible possibility is to give the responsibility in the hand of the telepathologist. Unfortunately the professional organization's statements about gross examinations in telepathology are still not made up to now.

To guarantee diagnostic accuracy experienced users of telepathology systems like Della Mea (Italy) suggest to **identify sectors where telepathology is not suitable**. He further recommends to specify **guidelines for a methodical acquisition** of images to reflect the architecture of a lesion - especially with static systems. Images should be selected in an established order towards standardized telepathology procedures [Della Mea, 1995, p. 241]. The Europath Work Group[102] also claims **guidelines** for the users for setting-up and selecting images appropriately. [Binder, 2000] The aim of these guidelines is that the user may select the best regions of interest and ideally that the whole selection process becomes operator independent. For example, centrifugation for cytology exams may lead to operator-independent flowcharts. In the case of frozen section examinations, the process of sample preparation has to be sufficiently documented and guided to significantly reduce the risk of operation dependence and to guarantee a proper field selection.

Regarding the problems of sample handling, the decision about which system should be chosen is not simple. Callas recommends that if the purpose of telepathology is to replace rural pathologists with technicians or to make pathology services available in locations where there are none, then the receiving pathologist certainly should control the slide (utilization of a robotic-dynamic system). However, if telepathology is being used to enhance the expertise of pathologists in rural areas by providing access to subspecialists, then it may be more appropriate for the sending pathologist to retain control [Callas, 1997, p. 818].

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[102] Allaert F.; Dusserre L.: „Europath Work Group - guidelines for telepathology practice", http://europath.imag.fr/EUROPATH/Path_W...th/Path_Telepathpractice/practice1.html

16.2.4 Influence of Case Information and Communication

Transfer of information in pathology (telepathology) cannot be limited just to the transfer of images, but has to include all medical aspects of a (histo-) pathological diagnosis. At the common pathological procedure vital information will be gathered in a direct communication at the face between the treating physician/surgeon and the pathologist, especially if a case is not certain [Kayser, 1993/(1), p. 331; Adachi, 1996, pp. 436, 440]. For example, if the microscopic pathology does not fit the macroscopic description or the clinical history, vital information could be missed. The pathologist requests the surgeon for further information. In histopathology, several quite different diseases can induce similar or identical images. Therefore again, additional (higher order) information is needed in order to draw conclusions from the morphological anomalies.

Considering the communication in telepathology, many telepathology systems use forms where the client is requested to fill in the most important clinical data of a case. Such data are for example the patient's age, the precise site of the lesion, the symptoms and signs (the presence of nipple inversion or a discharge, the size of any lump, its mobility or attachment and its consistency), any history of trauma, whether the patient is or has recently been pregnant, or whether she had previous surgery to the same or to the contralateral breast, etc. Hence using online forms, the client even is guided to check all necessary data. Nevertheless, some accuracy studies found the lack of background information and the limitation of clinical information as a reason for diagnostic errors in telepathology [Marsan, 1995, p. 341; Ito, 1994, p. 805]. For example, at a accuracy study with a dynamic telepathology system at Tokyo, misdiagnosis in seven cases (from 158 cases) could have been avoided with sufficient information of the examined cases [Shimosato, 1992, p. 415].

To overcome this problem, client and consultant have to build a team with a good working relationship, since they have to rely on each other. Intensive communicate with the client during a consultation session by teleconferencing systems (often with a microphone and a headphone, visual and acoustic information exchange can be simultaneously performed by use of ISDN networks) or telephone is elementary. That is that the transfer of information in telepathology is not limited just to image transfer, but combines simultaneously the transfer of visual and acoustic information [Kayser, 1993/(1), p. 331; Kayser, 1995/(1), p. 54; Adachi, 1996, pp. 436, 440]. If a asynchronous static tele-examination is executed, patient and case information has to be available in written form. In addition, it would be of value if the telepathologist is able to directly access the medical record of the patient at the client's side to retrieve the history of the patient. Yet, privacy and data protection restrictions still have to be guaranteed.

16.2.5 Influence of Human Factors

16.2.5.1 Training of the Remote Client

In general it is obvious that for a medical technician it is difficult to do a proper macroscopy and to recognize and select highly informative microscopic fields for pathologists review, since he/she does not have the **training** and **experience** of a pathologist. That is why a remote client who has to operate teleconsultation features needs considerable know-how in order to be able to certify the selection of specimen fields and the expertise to answer the questions asked by the consultant [Eusebi, 1997, p. 16; Weinstein, 1997/(1), p. 34]. In other words, if pathologists are to relinquish control over the microscope, they must

do so with confidence that the transmitting operator is well trained to orient the tissues, recognize important parameters such as the surgical margins, and discern normal histology from pathological processes [Weinstein, 1997/(1), p. 35]. In general it is desirable that a pathologist is available at the client's side when using static systems. Nevertheless, using a static imaging system in Sapporo, Japan, a cyto-technician is doing the field selection. This technician is so talented in communication with the consulting pathologist that no diagnostic error occurred up to now [Fujita, 1995, pp. 105-110]. However, this may be an exception and has to be seen very critically, especially since the tele-consultant is (legally) responsible for the final diagnosis in Japan. Further investigation would be desirable (e.g. to investigate the extend of training).

Altogether there is the principle that in any case the **expert know-how** of all at the diagnostic and treatment process involved people has to be guaranteed in a secure and efficient way. It is also vital to develop **good personal relationships** that foster mature confidence between the remote-site clinicians and hub-site experts [Dunn, 1996/(2), p. 466].

16.2.5.2 Experience

Teleconsultant's Ability of System Usage

Several accuracy studies already have shown that the experience in using telepathology systems and in examining images on the monitor have an influence on the diagnosis accuracy, as well as on the viewing time of images [Birmingham/Alabama see Winokur, 1998, p. 47; Sapporo/Japan, see Fujita, 1995, p. 105].

> *„There is evidence that video pathology is a skill that improves over time ... experience using a telepathology system is important both for accurate reading of video images and for effective communication between sending and receiving pathologist ...." [Callas, 1997, p. 817]*

> „Telepathology *diagnostic accuracy could be related to the telepathologist's prior level of experience with video monitors such as those of computers and video games"*
> *[Weinstein, 1997/(3), p. 2]*.

This was also discovered in accuracy studies by Shimosato:

> *„It was also found to be important for the observer to become accustomed to examine images on the TV monitor, including magnification. The diagnostic accuracy rate in the very first experiment, which was lower than expected, is partly due to not being accustomed to making a diagnosis on the monitor ... Making diagnoses via a video monitor is qualitatively different than directly viewing images through a microscope. There is evidence that video pathology is a skill that improves over time .... accuracies were low during the first part of their study but improved as the pathologists became accustomed to viewing microscopic images using a video monitor." [Shimosato, 1992, pp. 415, 417]*

The examination of images on a monitor is a new way of pathological practice. Using interactive digital displays will need adequate skills, **training** and **experience** with the system to use its post-acquisition image enhancement and manipulation capabilities to optimal advantage [Elsner, 2000; Illyés, 2000; Kuakpaetoon, 2000; Wyman, 1994; O'Brien, 1998, p. 156; Ferrer-Roca, 1996, pp. 13, 14; Adachi, 1996, pp. 436, 440]. Considering the training effort, again it has to be underlined that systems have to be as simple and as user-friendly as possible to diminish the time needed to get familiar with the system.

> *„The training period for the new tool (a dynamic system) can be restricted to some 20 specimens." [Schwarzmann, 1999]*

User studies showed that there are great individual differences in ability to adapt to the viewing of video images.

> *„Examination of individual performance indicated that one of the four pathologists was responsible for almost half the total discordances and errors on diagnosis ... there may be great individual differences in ability to adapt to the viewing of video images." [Allaert, 1995, p. 600]*

The ability to make a diagnosis from a digital image varies from user to user. This is not dependent on the user's level of experience as a practitioner, but of the user's level of computer literacy [Coen, 1997, p. 207]. That is why some teleconsultants require a greater amount of training than others to acquire the necessary visual skills [Allaert, 1995/(2), p. 600; Galvez, 1998, p. 666; Coen, 1997, p. 207; Wakely, 1996, p. 530]. In contrast to the professional experience, which increases over the years, an older pathologist may eventually have more problems in adapting to new telecommunication technologies, as telepathology is, than this is the case with a younger colleague, who grew up with computer games.

To increase the certainty in making diagnoses on a monitor, well designed education and train programs for users of telepathology system are necessary. Telepathology users get the possibility to familiarize themselves with the system to the point that they understand its image manipulation procedures thoroughly, and that they can use their system more or less automatically [Martin, 1996, pp. 459, 461]. In addition, to reduce the barrier of telepathology usage, telepathology systems could already be used at universities, so that pathology students become familiar with monitor image interpretation and robotic system handling. If pathologists are familiar in using telepathology systems Eide assumes that video-microscopy could achieve a quality of diagnoses similar to that of direct light-microscopy [Eide, 1992/(1), p. 405].

Improved Experience of Client

Not only the performance of the teleconsultant will improve with experience, but the one of the client too. At the study of Weinstein the second set of test cases showed a more accurate diagnosis than the first one. The explanation for the difference in accuracy was the experience of the capturing (sending client) pathologist in working closely with the interpreting pathologist [Weinstein, 1997/(2), p. 28].

16.2.5.3 Psychological Stress

> *„The time factor tends to be more critical for cancer cases, since the **intraoperative diagnosis** of a malignancy by a pathologist may set in motion the performance of a definitive operative procedure. On the other hand, the establishment of a benign diagnosis usually heralds the end of an operative procedure, and thus limits the exposure of the patient to anesthesia." [Weinstein, 1992, p. 402]*

Professor Oberholzer, telepathology expert in Basel (CH), pointed at the same human factor, which will especially occur with frozen section examinations: Stress at ad-hoc examination due to time pressure [interview, 1999]. The pathologist is quite conscious about the fact that his diagnosis will have strong therapeutically consequences. At frozen section examinations, the patient at the client's side is still under an anaesthetic and as soon as the telepathologist gives his diagnostic result, the surgeon will continue to cut - or not. Yet, the stress factor always will be in existence by frozen section examination. The only difference is that the telepathologist has to do his diagnosis on the monitor. The previous users of telepathology systems (e.g. in Norway or Switzerland) already proved frozen section examinations by telepathology successfully. Nevertheless a general rule should be kept in

ones mind, which is: „***Never report on a frozen section when you are mentally or physically preoccupied with something else***“ [Azzopardi, 1979]. This rule is valid for common pathology as well as for telepathology.

16.2.5.4 Diagnostic Behavior of Consultants

The study in Iowa with cervical-vaginal smears showed that many observers were conservative when using the video monitor and reluctant to make a dysplastic diagnosis but tend to under-call dysplasia. They preferred to diagnose a false-negative result instead of risking a false-positive result [study in Sacramento/USA see Galvez, 1998, p. 665].

> *„One reason that telecytology had a lower accuracy was that most of the observers tended to under-call dysplasia. Low grade squamous intraepithelial lesions were classified as benign smears and HGSILs (high grade squamous intraepithelial lesions) were classified as benign or AGUS (atypical glandular cells of undetermined significance) smears.* ***This indicates that for most observers, there may be a certain reluctance using the video monitor to make a dysplastic diagnosis****.“ [Raab, 1996, p. 602]*

Other studies showed excellent diagnostic accuracy but an increased tendency to defer diagnoses. This behavior could be recognized with static as well as with dynamic systems [Winokur, 1996, p. 474].

16.3 Improved Accuracy Due to Telepathology

16.3.1.1 Accuracy Improvement by Image Comparison

Weinstein came up with an interesting finding by using telepathology. Many of the serious errors at his study were cases declared as ‘carcinoma’ by video diagnosis and as ‘atypical’ by direct diagnosis. Some of these cases were shown within month to have cancer on follow-up biopsy. Thus, Weinstein assumes that there may be a potential for video diagnosis to increase accuracy. His explanation for this is that the possibility to view multiple images simultaneously on the video display offers fundamental advantages. Different magnifications of the same focus can be compared, or images of different foci on separate slides or cuts can be matched side by side. In contrast, conventional direct microscopy requires comparison of images by memory, since only one field can be viewed at a single magnification at a time [Weinstein, 1997/(2), p. 28].

16.3.1.2 Accuracy Improvement by Fast Second Opinion Contacts

A accuracy study in France with a static imaging system used by a specialized and general pathologist showed that a non-specialized pathologist can offer an accurate diagnosis in 86% of the cases in 3 to 5 minutes and on 3 to 7 images. Additional 2 to 5 images allow even a correct diagnosis in 92% of the cases. In comparison, the expert rendered a correct diagnosis in 98 % of the cases [Martin, 1995, p. 194]. These results prove how useful it is to be able to access colleagues, but also to have the possibility to immediately access experts via Internet. Especially the online contact with highly specialized pathologists will lead to an fundamental improvement in diagnostic accuracy. In addition, fast and easy access to knowledge databases and to for example DNA-analysis features may further increase the accuracy and certainty of diagnoses.

16.4 Summary of Accuracy Judgement

In some cases, telepathology examination has already proved to be adequate and accurate for doing pathology diagnoses. However for other cases, like inherently high interobserver variability tissue samples, a fast diagnosis by telepathology should be denied. The same will be recommended by Callas, when the consultant has any degree of uncertainty:

> *„If there is much uncertainty about what is being seen over video, a definitive diagnosis should be deferred until the glass slide can be viewed directly." [Callas, 1997, p. 818]*

Many pathologists refuse to employ telepathology systems at all. Although there are benefits like decreased costs by greatly reducing turnaround time for consultations, or reduced professional isolation of rural pathologists, they deny the use of telepathology systems if accuracy is less than achieved by using a conventional light microscope. Until this is proved, they prefer to send their specimens the common way (e.g. mailing), even though it will take a day or two to reach the consultant's destination [Shimosato, 1992, p 417].

To turn telepathology down with the argument that correct diagnosis is not guaranteed is quite simple, but would fail to put the advantages and potentials of this technology into consideration. Pathologists should always keep in their mind that they are able to go back to common light microscope examination, if they are not certain about a case, but that with telepathology they may have the chance to speed up the pathological process, to contact a colleague within seconds or even to show the video image to a subspecialty pathologist, and to access valuable information resources.

Since diagnostic accuracy seems to be an important factor for telepathology success, it is necessary to do further accuracy studies, to specify the sources of diagnostic errors and for reducing the risks. In addition, potential users have to be informed, to overcome the immense fear of diagnostic quality reduction.

Critical Factors of Success of Telepathology Systems

Results of the Study

17 Statistical Method and Factor Analysis

In this chapter various criteria of the questionnaire are summarized concerning statistical factors. These are the different aspects of influence on telepathology system's success, the advantages and disadvantages, the interest of participants in utilizing telepathology services, and variables referring to diagnostic accuracy. Then the ratings of participants are considered statistically by referring to specific personal characteristics such user/non-user, age or computer experience.

17.1 Statistical Factor Analysis

17.1.1 Description of Method

As it was discussed in the chapters before, the success of telepathology systems can be influenced by various aspects. Therefore a factor analysis was executed to investigate relations within the ratings of variables, and to simplify statistical significance calculations of the heterogeneous amount of criteria used in the questionnaires. Factor analysis allows us to explain a high number of variables by a smaller amount of factors. In other words, the accumulated factors are constructs, which try to illustrate a correlation between the investigated variables of the study. The validity of the construct are confirmed by the calculation of the convergent and discriminate validity. The method, which was used to execute this analysis is called 'principal components analysis - PCA'. The factors of the PCA are called 'principal components - PCs'. At the calculation of the PCA with the standard analysis program (SPSS), the missing values were replaced by the mean of each group. Then the item analysis was executed by calculating 'Cronbachs Alpha'. Cronbachs alpha reflects the relation of a single value to the overall average of all values [Schnell, 1995, pp. 147 ff., 438 ff.].

Finally the following factors were analyzed (for values of the statistical analysis see appendix nine, please).

17.1.2 Factor Analysis of Interest in Telepathology Services

17.1.2.1 Current Interest of Participants

Participants were asked to rate their interest in various telepathology services. The single results of these judgements are illustrated in chapter 18.2.3. Executing the PCA the twelve telepathology services could finally be summarized into two factors.

Interest judgement of several telepathology services – compressed from 12 variables to 2 factors	**Factor**	**Factor**
1. Quality improvement due to improved know-how (EDUCA_6)	**1**	**2**
2.5.7 Interdisciplinary cooperation and **communication**	66702	
2.5.8 External centralized pathological **case archiving** of data and images	68295	
2.5.9 Distance learning and **online education**	79286	
2.5.10 **Group (expert) discussions**, consideration of difficult cases, forums	75422	
2.5.11 **Quality assurance** and control, proficiency testing (DNA-cytometry)	55324	
2.5.12 Information retrieval in **databases** (e.g. MEDLINE) or **Internet** (WWW)	71772	
2. Fast and accurate diagnoses (DIAGN_6)	**1**	**2**
2.5.1 Primary diagnosis in **emergency cases** (e.g. catastrophes)		68085
2.5.2 Primary diagnosis for **frozen section** examinations		76315
2.5.3 Primary diagnosis on a **routine basis**		82002
2.5.4 Request of colleagues opinion in uncertain cases (**second look**)		71936
2.5.5 Specialized expert consultation in difficult cases (**reference diagnosis**)		59765
2.5.6 Centrally organized '**on call' services** (e.g. weekend services)		55015

The first column gives the name of the factors and variables, whereas the 2nd to 3rd column give the factor loading values. Explained variance: 55,8 %; VARIMAX by Kaiser Normalization converged in 3 iterations; rotating matrix of components for the 12 variables to 2 factors. For detailed tables and analysis-values see appendix IX, please.

Schedule 3: Summarized factors of actual interest in telepathology services.

The first factor contains services, which are suitable to **improve the know-how** of pathologists. It contains the possibility to participate at online education lessons and discussion groups. Also the cooperation and communication with other medical disciplines is included, which enable a pathologist to gain a broader knowledge about the whole spectrum of a disease. And last but not least, the access to quality assurance services, to image archives, as well as the access to online-information on the Internet belong to this factor, too.

The variables of the second factor describe mainly services, which are appropriate to support a fast and more **accurate diagnosis**. First of all it includes the utilization of telepathology systems to execute primary tele-diagnoses and second opinion consultations. And second this factor contains 'on call' services, which does not just improve the efficiency of weekend and holiday staffing, but also enable remote sites to contact the central 'on call' service for a fast diagnostic assistance.

17.1.2.2 Judgement concerning the Importance of Telepathology Services in the Next Five Years

Interest judgement of several telepathology services – compressed from 12 variables to 2 factors	**Factor 1**	**Factor 2**
1. Quality improvement due to improved know-how (EDUCA_6)		
2.6.7 Interdisciplinary cooperation and **communication**	70703	
2.6.8 External centralized pathological **case archiving** of data and images	64446	
2.6.9 Distance learning and **online education**	80641	
2.6.10 **Group (expert) discussions**, consideration of difficult cases, forums	72176	
2.6.11 **Quality assurance** and control, proficiency testing (DNA-cytometry)	60824	
2.6.12 Information retrieval in **databases** (e.g. MEDLINE) or **Internet** (WWW)	77259	
2. Fast and accurate diagnoses (DIAGN_6)	**1**	**2**
2.6.1 Primary diagnosis in **emergency cases** (e.g. catastrophes)		66543
2.6.2 Primary diagnosis for **frozen section** examinations		76446
2.6.3 Primary diagnosis on a **routine basis**		80066
2.6.4 Request of colleagues opinion in uncertain cases (**second look**)		70687
2.6.5 Specialized expert consultation in difficult cases (**reference diagnosis**)		61257
2.6.6 Centrally organized '**on call' services** (e.g. weekend services)		62491

The first column gives the name of the factors and variables, whereas the 2nd to 3rd column give the factor loading values. Explained variance: 56,8 %; VARIMAX by Kaiser Normalization converged in 3 iterations; rotating matrix of components for the 12 variables to 2 factors. For detailed tables and analysis-values see appendix IX, please.

Schedule 4: United factors of expected interest in telepathology services in the next 5 years.

The PCA of the ratings for the expected service settlement in the next five years testifies the same results as the PCA of the actual interest of participants in various telepathology services showed. Again the different variables are summarized to the factor 'fast and accurate diagnoses' and 'quality improvement due to improved know-how'.

17.1.3 Factors of Success - Compression to Ten Factors

The original PCA analysis of the 39 criteria of telepathology's success analyzed twelve factors. Yet, the scree plot (see appendix IX) justified an array of 10 and of 5 factors, too. Since the analysis of five factors was found to be too rough, for further statistical examinations the PCA of ten factors was taken[103].

Various Factors of Success – compressed from 39 variables to 10 factors	**Factor**	**Factor**	**Factor**	**Factor**	**Factor**
1. Surrounding (Surr_2)	**1**	**2**	**3**	**4**	**5**
4.1.2 External **acceptance** (e.g. insurances, **HMOs**, politicians)	55109				
4.1.3 Internal **acceptance** of **top management** (director)	67691				
4.1.4 Internal **acceptance of physicians** and medical staff (users)	70616				
4.1.5 **Acceptance of patients**	53547				
4.2.1 Influence of **health care politics** and **health care laws**	44669				
4.2.2 Internal **institution politics** (institution's objectives)	71859				
4.2.3 Influence of **geographical factors** (population, landscape)	57209				
4.2.4 Influence of **cultural factors** (structures, ethic...)	47706				
2. Standards (Integ_2)	**1**	**2**	**3**	**4**	**5**
4.8.1 Compatible **technical standards**		72657			
4.8.2 Compatible **data and image formats**		70527			
4.8.3 **Internal system** integration (e.g. integrated HIS)		72186			
4.8.4 **External** system **integration** (other TP-systems)		83304			
3. Legal factors (Legal_2)	**1**	**2**	**3**	**4**	**5**
4.4.1 Explicitness of **legal liability regulations**			80099		
4.4.2 Qualification (**licensing agreements**)			73311		
4.4.3 **Reimbursement** regulation (per contract or law)			62004		
4.4.4 Regulations about data exchange and **data protection**			64921		
4. Equipment (Equip_2)	**1**	**2**	**3**	**4**	**5**
4.1.1 Availability of advisory desks for system selection				42626	
4.7.1 Quality of **medical equipment** (microscope)				75466	
4.7.2 Quality of **computer equipment** (PC, monitor size, etc.)				77678	
4.7.3 Influence of **network connections** (bandwidth, stability)				77552	
4.9.2 Quality of **monitor images** (resolution, color, contrast)				60038	
5. Workflow (Workfl_2)	**1**	**2**	**3**	**4**	**5**
4.11.1 Influence of **fast respond times** / image transfer					69450
4.11.2 Influence of **system stability** (short interruptions)					36675
4.11.3 Influence of **user support** (training, help menus, hotline)					59369
4.11.4 **Simplicity of system use**, user-friendly system					76877
4.11.5 Influence of **system flexibility** to support the workflow					76401

[103] The PCA factor analysis confirms the aspects which were described as problematically in chapter ten to sixteen:

- 1 Political aspects are discussed in chapter 10.1 and 10.2;
- 2 Standards are discussed in chapter 14;
- 3 Legal aspects see chapter 15;
- 4 Equipment see chapter 11.1 and 11.3 to 11.5;
- 5 Important interface and workflow aspects see chapter 11.2;
- 6 Accuracy factors see chapter 16;
- 7 Financial and efficiency criteria see chapter 13;
- 8 Management aspects see chapter 10.3;
- 9 Reliability /security see chapter 12;
- 10 Image handling aspects see chapter 16.2.3 and 16.2.4.

Various Factors of Success – compressed from 39 variables to 10 factors	**Factor 6**	**Factor 7**	**Factor 8**	**Factor 9**	**Factor 10**
6. Accuracy of diagnostic (Accur_2)	**6**	**7**	**8**	**9**	**10**
4.5.1 Accuracy of **macro examination** (correct gross exam.)	79009				
4.5.2 Accurate **sample preparation** and precise field selection	79956				
4.5.3 Accuracy of **micro examination**	82779				
7. Cost efficiency (Effic_2)	**6**	**7**	**8**	**9**	**10**
4.6.1 Influence of **investment and subsequent cost**		71937			
4.6.2 **Cost effectiveness** of telepathology services		75983			
4.6.3 Health care **efficiency** (e.g. shorter treatment procedures)		65073			
8. Management aspects (Manag_2)	**6**	**7**	**8**	**9**	**10**
4.3.1 Influence of **structured project design**			68580		
4.3.2 **Coordination** of system utilization			73390		
4.9.1 Quality of **textual data** (patient and case data in advance)			-56516		
9. Reliability (Relia_2)	**6**	**7**	**8**	**9**	**10**
4.10.1 Influence of **system reliability** (total break downs)				83071	
4.10.2 Influence of **access control** (access to system and data)				64162	
4.10.3 **Data security** (no misuse or loss of data by exchange)				51659	
10. Image handling (Image_2)	**6**	**7**	**8**	**9**	**10**
4.9.3 Quality of **image handling** (orientation, focusing, etc.)					75771

The first column gives the name of the factors and variables, whereas the 2nd to 6th column give the factor loading values.
Explained variance: 67,8 % by Kaiser Normalization; VARIMAX converged in 15 iterations; rotating matrix of components for the 39 variables to 10 factors. Exceptions: #4.10.3 was put to factor 9 instead 10. For detailed tables and analysis-values see appendix IX, please.

Schedule 5: PCA result of the 39 variables relating to the success for telepathology.

The first PCA factor includes variables which consider the **surrounding** of telepathology. That is the promotion of telepathology by external groups like insurance companies or responsible health care politicians. It also contains the internal acceptance of the top management of an institution, of users (pathologists and other physicians), as well as the acceptance of patients. It further summarizes variables, which apply to general health care politics and laws, to internal institution politics and strategies. Variables that regard cultural and geographical aspects also belong to the first factor due to the PCA[104].

The second accumulated factor includes variables referring to **system integration** and standards. That is first of all the availability of technical standards and compatible data formats. Further the integration of telepathology systems with other internal and external systems ranked with this factor, too.

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104 Considering the factor analysis of 12 factors, the factor referring to surrounding aspects is divided up to two factors (see appendix IX, page 12).

Factor 4	**Factor 11**
4.1.2 External **acceptance** (e.g. insurances, **HMOs**, politicians)	4.2.1 Influence of **health care politics** and **health care laws**
4.1.3 Internal **acceptance** of **top management** (director)	4.2.3 Influence of **geographical factors** (population, landscape)
4.1.4 Internal **acceptance of physicians** and medical staff (users)	4.2.4 Influence of **cultural factors** (structures, ethic...)
4.1.5 **Acceptance of patients**	
4.2.2 Internal **institution politics** (institution's objectives)	

The third factor contains variables, which concern the **clarity of legal structures**. The most important aspect for pathologist is the question of liability, since inaccurate diagnostic result can lead to high compensation penalties. Factor three also includes the setting of licensing agreements, reimbursement regulations and data protection definitions.

The fourth factor describes variables, which can be summarized under the term '**quality of equipment**'. It includes aspects referring to the quality of medical and IT equipment, to network performance (e.g. bandwidth, network stability and security) and to the quality of monitor images (resolution, color, contrast). Since it is often difficult for users to select the right system for their specific needs, independent advisory desks would be helpful. The PCA calculated this variable also to factor four.

Factor four contains the performance of the computer equipment employed, whereas factor five regards aspects which concern the **comfort of system** utilization. This are first of all the simplicity and user-friendliness of the telepathology system. A telepathology system has to support the workflow of a pathologist. That is that instead of the pathologist has to following the system's commands he should be able to do his tasks in an efficient way. Factor five further includes fast respond times and the demand that systems are stabile. Again, both factors refer to a smooth telepathological workflow. As a last aspect the PCA analyzed the criterion user support (e.g. training in system utilization, help menus, 24-hour support hotline) to factor five.

All the variables of factor six refer to a **smooth and accurate examination process** of specimens. It claims that systems have to be designed in a way, that an accurate macro and micro examination is guaranteed. Clients have to be qualified enough to do the sample preparation and field selection of a specimen correctly.

Factor seven applies to **cost efficiency**. That are first of all investment costs, which are still quite high at dynamic telepathology systems. It further incorporates the demand of an overall cost efficiency of telepathology services. This aspects refers to the amortization of investment costs by savings and revenues in combination with high utilization rates. It also includes the demand that telepathology systems should increase the overall health care efficiency by for example faster diagnoses and shorter treatment procedures.

Factor eight is directed to **management aspects**. It considers the management of the telepathology selection and introduction process (project management), as well as the coordination of the system's utilization. Especially real time sessions have to be well matched to avoid unnecessary and unproductive waiting times. The variable 'quality of textual data' points in the opposite direction of the first two criteria. That is, if a telepathology session is well coordinated, the need of the availability of patient and case data in advance is no more as important, since firstly most telepathology systems include a patient record where most of the data is stored. And secondly most telepathology sessions are accompanied by an intensive audio-communication, where the expert can request the specific case information he is interested in.

Factor nine applies to **reliability and security aspects**. The first variable points to the overall reliability of the telepathology system. That are total break downs where the system is no more usable at all. In contrast, factor five includes short system interruptions, which claim a rebooting of the system and just disturb the workflow of the telepathological process. Factor nine further contains security criteria like the access security of systems and

data, the need of safe data back-ups, or the data security at the exchange process (loss of data, data misuse).

Factor ten only contains the variable referring to the **quality of image handling**. That is the orientation in a specimen slide, focusing of areas of interest, or the comfort of objective changes. The PCA emphasized that the specimen scanning process is one of the most essential parts of a pathological examination.

17.1.4 Factor Analysis of Advantages and Disadvantages

Advantages and Disadvantages – compressed from 24 variables to 6 factors	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**
1. Fears (Fear_3)	**1**	**2**	**3**	**4**	**5**	**6**
5.3.1 **Higher expenses** and unnecessary investments	50255					
5.3.2 **Accuracy of diagnoses** isn't guaranteed	57427					
5.3.5 **Loss of jobs**, examination shift to other medical centers	73749					
5.3.6 Reduction of pathologist's **education quality**	72947					
5.3.10 This technology is **not reliable**, far too error prone	72931					
5.3.11 **Loss of information** due to task splitting	72539					
2. More efficiency (Effic_3)	**1**	**2**	**3**	**4**	**5**	**6**
5.1.1 Improvement of **diagnosis quality** (faster diagnostic results)		54994				
5.1.2 Improvement of patient **treatment process**		64053				
5.1.3 **Same quality** of patient treatment, location independent		71668				
5.2.1 **More efficiency** in procedures and structures		81032				
5.2.2 **Cost reduction, savings** (less tissue sample transportation)		72127				
5.2.3 **Additional revenues** due to telemedicine services		48904				
5.2.4 Survival of pathology department (capacity utilization)		42753				
5.2.5 Improvement of **reputation** of pathology department		45481				
3. High quality medicine (Qual_3)	**1**	**2**	**3**	**4**	**5**	**6**
5.1.5 Better **communication** between treating physicians			43149			
5.1.6 Improvement of **research findings** (data storage + analysis)			82604			
5.1.7 Improved **access to medicine**, reduction of doctors isolation			80982			
5.1.8 Improvement of **know-how standards**, online education			82606			
4. Uncertain situation (Uncer_3)	**1**	**2**	**3**	**4**	**5**	**6**
5.3.7 Uncertainty of **legal questions**				62431		
5.3.8 Uncertainty of **data security** and data privacy questions				69441		
5.3.9 Uncertainty of **reimbursement**				76950		
5. Background services (Oncall_3)	**1**	**2**	**3**	**4**	**5**	**6**
5.1.4 Efficient **on-call-services** (24-hour-service)					70400	
6. Workflow inefficiency (Workfl_3)	**1**	**2**	**3**	**4**	**5**	**6**
5.3.3 **Overtaxing** of pathological experts						64977
5.3.4 **Inefficient work routine** due to real-time coordination						84135

The first column gives the name of the factors and variables, whereas the 2nd to 7th column give the factor loading values. Explained variance: 67,8 % by Kaiser Normalization; VARIMAX converged in 17 iterations; rotating matrix of components for the 24 variables to 6 factors. For detailed tables and analysis-values see appendix IX, please. Due to the scree plot the variables could also be summarized to 4 factors. Yet, since 4 factors were found to be too unspecific, finally the distinction in 6 factors was chosen for further significance calculations. How the accumulation of the variables to 4 factors would look like can be seen in appendix IX.

Schedule 6: PCA result of 24 factors relating to advantages and disadvantages.

The first factor describes several **fears related to telepathology**. It accumulates the fear that telepathology will demand high expenses. Some pathologists further expect that telepathology will cause unnecessary investments, which will increase the overall health

care costs. It is to assume that pathologists are especially reluctant to invest in telepathology systems, if they believe that 'this technology is not reliable and too error prone'. Factor one further refers to the fear of inaccurate diagnoses and the of lost information due to the splitting of tasks between client and expert. And finally the PAC also summarizes the criteria 'fear of reduced education quality' and the 'fear of telepathology being a job-killer' to factor one.

The second factor refers to **efficiency improvements** in pathology and with this to the improvement of the whole situation of a health care provider. It includes advantages like the 'improvement of diagnostic quality', 'the improvement of treatment processes', and the advantage that the 'same quality of medicine' can be offered by an institution independent of its location. All these advantages are suitable to improve the 'reputation of a pathological department'. As a consequence the utilization rates can be raised. This will lead to 'additional revenues', 'cost reductions and savings' and with this guarantee the 'survival of the pathological institution' in an environment of competition.

The third factor calculated by the PCA summarizes criteria, which expect an overall **improvement of the quality in pathology**. First of all it is assumed that with telepathology the communication between pathologists, but also between pathologists and other physicians will be improved. Isolated pathologists get access to highly specialized resources. They can communicate with experts, take part at online education sessions and discussion circles. And last but not least, factor three includes the advantages by which telepathology data can be gathered and analyzed, which will lead to an improvement in research.

The fourth factor calculated by the PCA points to **uncertainties** in telepathology. This is first of all the uncertain legal situation, since most countries do not have specific regulation for telepathology. Further it contains the uncertainty of data security and data privacy aspects, as well as the uncertainty of reimbursement.

The advantage of **on-call services** is put to factor five by the PCA. That is that a centralized, specialized pathological center could offer its services on a 24-hour basis. This way staff shortages during holiday seasons and weekends could be diminished. Pathologist have the chance to contact an expert whenever they need advises.

The last factor '**workflow inefficiency'** points to specific problems of telepathology. The first is that experts can be easily contacted by telepathology. This includes the risk that experts are overtaxed by simple cases. Another aspect is, that real-time consultations are difficult to coordinate, which could lead to inefficient waiting times.

17.1.5 Factor Analysis for Accuracy Variables

The PCA accumulated the different variables referring to diagnostic accuracy to four factors. The scree plot would also justify an analysis of two factors (see appendix IX, pages eight and fifteen). Yet, for the final significance calculations the more specific distinction of four factors was taken.

Accuracy variables – compressed from 12 variables to 4 factors	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
1. Examination Process (Exam_5)	**1**	**2**	**3**	**4**
6.5.5 Errors with tissue sample (**sampling errors**)	76971			
6.5.7 Inaccurate **field selection**	83782			
6.5.9 Insufficient quality of **video images**	82802			
6.5.10 Not enough **images** available (transfer time of images)	71408			
6.5.11 Not enough **case information** available	62264			
2. Know-how of examiner (Exper_5)	**1**	**2**	**3**	**4**
6.5.1 Low **expertise** (e.g. specialized know-how is not sufficient)		93592		
6.5.2 Insufficient **diagnostic experience**		90142		
3. Insufficient education in telepathology (Educa_5)	**1**	**2**	**3**	**4**
6.5.3 Not enough **education in practicing telepathology**			54266	
6.5.4 Not enough experience with **video image interpretation**			59351	
6.5.6 Incorrect **preparation** or staining of tissue samples			83813	
4. Interpretation at stress situation (Inter_5)	**1**	**2**	**3**	**4**
6.5.8 Incorrect **interpretation**				74815
6.5.12 Psychological **stress** factors by ad-hoc examinations				75873

The first column gives the name of the factors and variables, whereas the 2nd to 5th column give the factor loading values. Explained variance: 72,6 % by Kaiser Normalization; VARIMAX converged in 11 iterations; rotating matrix of components for the 12 variables to 4 factors. For detailed tables and analysis-values see appendix IX, please.

Schedule 7: PCA result of the 12 variables relating to diagnostic accuracy of telepathology.

The first factor refers to variables which describe reasons for an '**incorrect examination processes'**. Two variables point at difficulties within the pathological tele-examination process, which are 'sampling errors' and 'errors in field selection'. The other three variables emphasis difficulties, which occur due to the examination by employing networks. One of it is 'insufficient case information' since there is no more a face-to-face communication between the treating physicians and the pathologist, and because the examination process is divided in parts which the client has to execute and parts which the consultant controls. The other two variables are 'insufficient quality of screen images' and 'not enough images available' (e.g. due to insufficient network capacity only a certain amount of images will be transferred).

The second factor includes variables, which refer to the '**lack of experience'**. These are 'low expertise' (specialty know-how) and 'insufficient diagnostic experience' (due to low examination rates). These two aspects may not only be a reason for inaccurate diagnoses in telepathology, but in pathology in general. Yet the accuracy studies in telepathology (see appendix VI) analyzed it as a reason for incorrect diagnoses in telepathology, too. Especially with static telepathology systems the client should be experienced enough to execute his tasks of the tele-examination correctly, which is questioned by many non-users.

The third factor relates to the '**lack of education and training'**. It contains the 'lack of training in executing examinations with telepathology systems' and the 'lack of education in staining and sample handling' of the client.

The last factor points at variables which apply to '**stress at ad hoc decisions'**. Telepathology systems are often used to execute frozen section examinations. At frozen section examinations the pathologist is always under pressure, since his diagnostic result has immediate therapeutic-cally consequences. With telepathology this stress factor may be increased, since pathologists as a whole do not have a lot of experience in tele-examinations due to the low utilization rates.

Another reason is 'incorrect interpretation'. If the client is under pressure he may not take the time to consider his own diagnostic impression critically. The experience of accuracy studies in telepathology showed that due this pre-diagnosis clients tended to select the wrong tissue parts or influenced the tele-pathologist to follow their impression instead of executing a more comprehensive examination.

17.2 Significance Calculations

Variables Describing Characteristics of Participants

Participants were requested to give some data about their personal situation. It was assumed, that these criteria have a significant influence on the judgement of the factors of success of telepathology's systems. They were used for statistical significance calculations with the factors of the PCA factor analysis.

The first very obvious distinction of participants, which the whole study was focused on, was into '**users and non-users**' of telepathology. But there are various other criteria, which could also have an influence on the judgements. These are for example participants' '**age**', '**computer experience**' or their '**attitude when facing new technologies**'. To investigate the data for the last variable users were asked about their attitude towards new technologies in general, to telemedicine and telepathology, as well as to Internet-services. The PCA for these four criteria could be summarized to one factor (see calculation in appendix IX). Other aspects of distinction are the '**kind of institution**' where a participant is employed (university hospital, small clinic, doctor's office), the '**department size**' (how many employees, how many examinations per year), or the '**pathological area** where he/she is active' (macroscopy, histology, cytology). Another expected factor of influence on the judgement of the factors of success was assumed in participants' intensity of the '**wish to cooperate**' with other pathologists and institutions. For this participants were asked about their own interest in cooperation and about their supposed meaning of cooperation in the future (rating from +4 to zero). Finally the two variables could have been summed up to one factors when referring to the PCA. It is also to assume that the distinction in '**static and dynamic system users**' will have an influence on the ratings of the success factors and on the ratings of diagnostic accuracy criteria. In addition, the '**profession of the client**' (pathologist, surgeon, medical technician) could have an effect on these ratings, too.

All these characteristics were used for significance calculations[105] by employing variance, correlation and Chi-square analyses. This analyses prove whether the difference between groups / variables is caused by chance or significant (error probability calculations). Considering the executed correlation analyses by Pearson, the 'value of the significance'

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[105] Significance = value of a statistical test procedure (in our case variance, correlation and Chi-Square analysis), which shows whether the differences between values are based on coincidence or whether they are due to a statistically significant difference. If there is a significant difference, a statistically proved general conclusion can be made. There are four different degrees of significance [Zöfel, 1988, p. 74 ff.; Wonnacott, 1977, p. 248]:

highly significant	=	statement can be done with >=99,9% security	(p<= 0,001 ***)
very significant	=	statement can be done with >=99% security	(p<= 0,01 **)
(simply) significant	=	statement can be done with >=95% security	(p<= 0,05 *)
statistical trend	=	statement can be done with >=90% security	(p<= 0,10 T)

Probability-value (p) = the sample value would be as large as the value actually observed if Ho is true.
It is an excellent way to summarise what the data say about the credibility of Ho.

Correlation are distinguished by values: 0-15=correlation could have been caused simply by coincidence and therefore does not have a statistical meaning; 15-30=low statistical correlation; 30-60=average statistical correlation; 60-90=high statistical correlation.

reflects the probability of a correlation, whereas the 'correlation value' itself gives the quantity of the correlation.

The significant relations can be seen in the following schedule in summary:

Line number	Criteria in the schedule below	Line number	Criteria in the schedule below
1	User / non-user	8	Wish to cooperate with other institutions
2	Age of participant	9	Department size by employed pathologists
3	Kind of institution	10	Department size by examinations per year
4	Area of pathology (histology, cytology)	11	System type: static or dynamic
5	Kind of occupation (general pathologist, specialized / reference pathologist)	12	System type: robotic or non-robotic
6	Computer experience	13	Clients qualification
7	Attitude towards new technologies	14	Recommended strategy of TP introduction

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Key	**Telepathology Services**														
DIAGN_6	Improved diagnoses	x	0	x	0	0	T	x	x	x	0	0	0	0	x
EDUCA_6	Improved know-how	x	0	x	0	x	x	x	x	x	0	0	0	0	x
	Interest														
DIAGN_7	Improved diagnoses	x	0	x	0	0	x	x	x	0	0	0	0	0	x
EDUCA_6	Improved know-how	x	T	x	0	0	x	x	x	x	0	0	0	0	x
	Factors of success														
SURR_2	Surrounding	x	0	x	0	0	0	x	x	T	0	0	0	0	x
INTEG_2	Integration	x	0	0	0	0	0	0	0	0	0	0	T	0	0
LEGAL_2	Legal clarity	x	0	0	0	0	0	0	0	0	0	0	0	0	x
EQUIP_2	Equipment quality	x	0	0	0	x	0	0	0	0	0	0	0	0	0
WORKFL_2	Workflow (user-friendliness)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ACCUR_2	Accuracy of diagnosis	x	0	0	0	0	x	x	x	0	0	0	0	0	x
EFFIC_2	Efficiency of telepathology	0	0	0	T	0	0	0	0	0	0	0	0	0	0
MANAG_2	Management aspects	x	0	x	0	0	x	x	x	x	x	0	0	0	x
RELIA_2	Reliability and security	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IMAGE_2	Image handling	x	0	0	0	x	0	0	0	0	0	0	0	0	0
	Advantages / disadvantages														
FEAR_3	Fears	x	0	x	0	0	x	x	x	0	0	0	0	0	x
EFFIC_3	More efficiency due to TP	x	0	x	0	0	x	x	x	0	0	0	0	0	x
QUAL_3	Improved quality of medicine	x	0	x	0	x	x	x	x	x	0	T	x	x	x
UNCER_3	Uncertain situation	x	0	x	0	0	0	x	x	0	0	x	x	0	x
ONCALL_3	Background services	x	0	0	0	0	0	x	x	0	0	0	0	0	x
WORKFL_3	Workflow inefficiency	T	0	T	0	0	0	0	0	0	0	x	x	0	0
	Accuracy 4														
EXAMIN_5	Incorrect examinations	*	0	*	0	0	0	*	*	0	0	0	0	x	*
EXPER_5	Lack of experience	*	0	*	0	0	0	*	*	0	0	0	0	0	*
EDUCA_5	Lack of training	*	0	*	0	0	0	*	*	0	0	0	0	x	*
STRES_5	Stress	*	0	*	0	0	0	*	*	0	0	0	0	0	*

x = significant values; 0 = values are statistically not significant; T = statistical trend; * = a) accuracy was only requested by users; b) it does not make sense to distinguish accuracy judgements by: kind of institution, attitude towards new technology, wish to cooperate, or introduction strategy.

Schedule 8: Overview of significant values

18 Statistical Analysis of Users' and Non-Users' Ratings

Already in 1987 Weinstein discovered that the attitude of health care professionals is playing a great role for the success or failure of telepathology systems. In his opinion, the problem of telemedicine applications is often not technology, but getting people to use it in the first place [Weinstein, 1987, p. 647]. However, not rarely physician's acceptance is even more difficult to obtain than patient's acceptance [Moore, 1995; Appleby, 1995; Martin, 1996, p. 459]. Therefore the research study in Constance investigated the most essential factors of success of telepathology systems by distinguishing between users and non-users judgements. At the opinion poll 112 questionnaires were returned to Constance. Forty users and seventy-two non-users have replied the questions. In this study 'users' of telepathology systems are persons, who use their telepathology systems for examination purposes (telediagnostic and teleconsultation). In opposite, 'non-users' do not use their computer systems for tele-examinations.

In the following, first of all the reasons for telepathology introduction and the interest in various telepathology services are discussed, by distinguishing between the user's and non-user's ratings. Then various factors of success and the ratings of the advantages and disadvantages are investigated. Also comments of participants, and their experience and expectations of telepathology are integrated, amplified by the findings of recent literature.

18.1 Reasons and Objectives of Telepathology Introduction

At the study in Constance the forty participating telepathology users were asked to give their reasons for telepathology introduction. The results are as follows:

„What are the reasons and objectives for the introduction and use of your telepathology system?"	**User (total)**	**User (%)**
1. Strategic decision (e.g. threat of competition, improvement of institutional reputation)	23	57,5
2. Quality improvement (better examination, shorter procedures, increased know-how)	23	57,5
3. Wish of cooperation (e.g. closer cooperation with institutions and doctors of the region)	23	57,5
4. Participation in a research project	19	47,5
5. Internal engagement of physicians (e.g. pathology director wanted to test such a system)	11	27,5
6. Wish of more efficiency and cost reduction (internal cost saving, economical decision)	10	25,0
7. Avoiding that patients have to be transferred or treated at other clinics	5	12,5
8. Pressure of cooperation (medical association - to meet the demands of a partner clinic)	3	7,5
9. Wish to increase the number of examinations (e.g. higher utilization of equipment)	1	2,5

Schedule 9: Objectives of telepathology introduction.

The most often used reasons for telepathology system introduction were strategic decisions, quality improvement, the wish of cooperation, and the participation at a research project. At several projects the internal engagement of physicians or the wish of cost reduction caused telepathology's introduction. Only rarely the causes were to avoid patient's transfer, the pressure of cooperation or the wish of increased examination numbers.

Over 50% of the users said it was a **strategic decision**. There basic objectives were to improve the quality in pathology and to increase the cooperation with other medical institutions. Analyzing the results in more detail, of the users who were keen on **quality improvement**, sixteen (70%) used a dynamic system and only seven (30%) a static one. Seventeen (74%) used their system for primary diagnostic and nineteen (83%) for second opinion diagnoses. Thirteen (57%) of these users employed their system for educational

purposes, ten (43%) for medical discussions, and thirteen (57%) for Internet information retrieval. This reflects that the objective of quality improvement is closely related to the wish to **support remote physicians,** to **improve medical education,** and to access **online information resources**.

78% (18) of the 23 users, whose objective was to **improve the cooperation** with other partners, judged their interests in cooperation as very high (rating +4) and three as high (rating +3) out of a scale from +4 (great interest) to zero (no interest)[106]. At the question 'how do you assess the importance of cooperation in the future', 87% (20) of the 23 users rated it as very important and 9% (2 users) as important (rating +3). The one user, whose reason for telepathology introduction was 'wish of cooperation', but whose judgement of the meaning of external cooperation was low (rating +1) just wanted to use his system for telepathology services within his hospital, whose buildings were distributed all over the district. Yet, although the wish of cooperation of most users is high., 52% of them only use their system with one to three cooperating participants. That may reflect that even though telepathology systems are available and there is a wish for cooperation, it is still difficult to set up telepathology partnerships. On the other hand 17 users (74 % of 23) employ a dynamic telepathology system and 15 of them use it for primary diagnostic. Since dynamic systems are more complex and the accuracy of a primary diagnosis is more demanding, the set up of telepathology cooperation takes time and has to be introduced step by step. These may also be an explanation for the slow distribution of systems. That the current situation of telepathology cooperation may positively change in the future indicates the interest of non-users in cooperation. 72% (51 of 72) judged their interest in cooperation and the meaning of cooperation in the future as high (rating +3 / 20%) most of them even as very high (rating +4 / 52%).

47,5% of the responding users answered that telepathology was introduced as part of a **research project**. Most of the telepathology systems currently available, especially the dynamic-robotic ones, are located in hospitals, and this mostly at university hospitals due to their scientific research task. 27,5% meant that telepathology was introduced because of the **internal engagement of physicians**. Indeed, the first telepathology users were often described as pioneers with a strong vision of medical cooperation. 25% (ten users) named efficiency and cost reduction as a reason for telepathology introduction. Interestingly seven of them are using a dynamic-robotic telepathology system, although such systems are quite an expensive investment. These users seem to expect that the high investments may pay for itself by savings (e.g. travel time and labor cost) and improve process efficiency (e.g. shorter hospital treatment processes). That telepathology is introduced to avoid the need for patients have to be transferred or treated at other clinics does not seem to matter a lot. Also the pressure of a partner to do pathological services via network seems to have a low impact. And last but not least, only one user recognized telepathology as a tool to increase the overall number of examinations.

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106 The ratings of participants' wish of co-operating with other institutions is discussed in more detail in chapter 19.2.3.

18.2 Interest in Employing Telepathology Services

18.2.1 Current Utilization of Telepathology Services

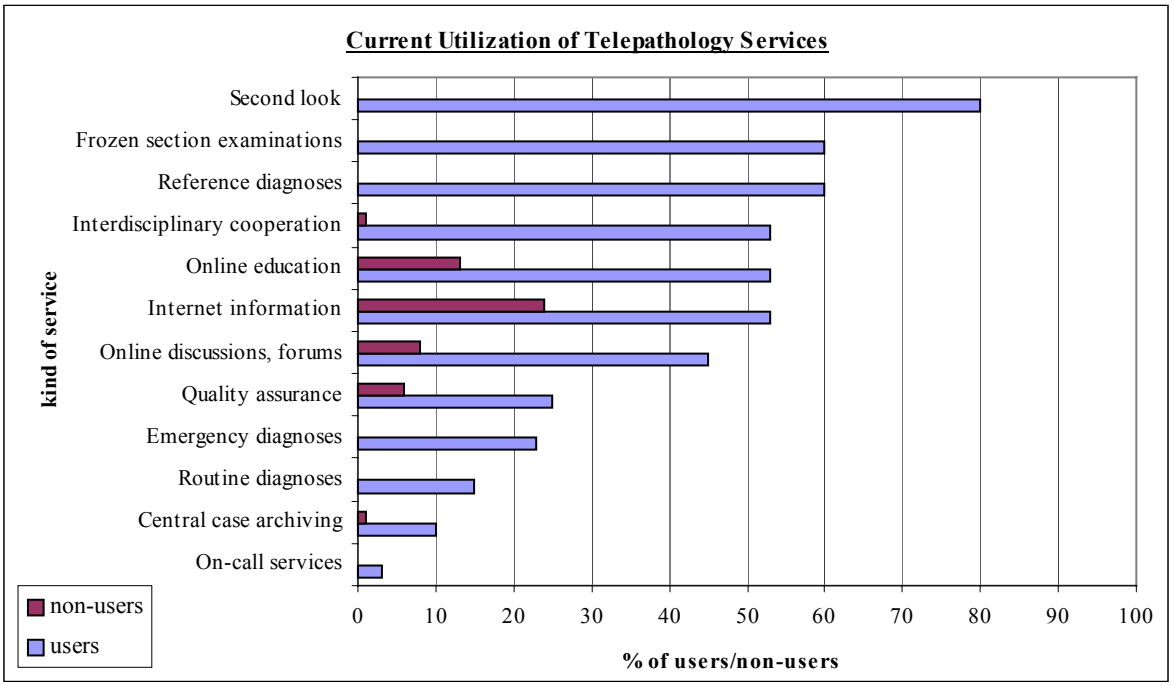

Figure 24: Current telepathology utilization.

Telepathology systems[107] are employed by 80% of the users to request a 'second look[108]' opinion of colleagues for a diagnosis. Frozen section examinations and reference diagnoses are executed by 60% of the participating users. 53% are using their system for online education services and distance learning, for interdisciplinary cooperation and communication with physicians, and for Internet services like information retrieval. The employment of telepathology systems for discussion groups (symposiums of difficult cases) is done by 45 % of the users. Far less users (25%) are executing quality assurance activities and proficiency testing by telepathology (e.g. DNA-cytometry). 23% have used their system for primary diagnoses in emergency cases. The utilization of telepathology systems for primary diagnoses on a routine basis is only done by 15% (6) of the users. Central archiving by telepathology support is executed by 10% (4), and only 3 % (1) employ their system for 'on call' services' (e.g. weekend services) to optimize their services and personal resources.

In comparison, 23% of the non-users are already using their computers for information retrieval in databases like 'MEDLINE' or for Internet information access (www). The utilization of computers for education and distance learning is done by 13% of the non-users, and 8% are participating at discussion groups where difficult cases are reviewed. Already 6% of the non-users are doing quality assurance and proficiency testing, mostly for DNA-

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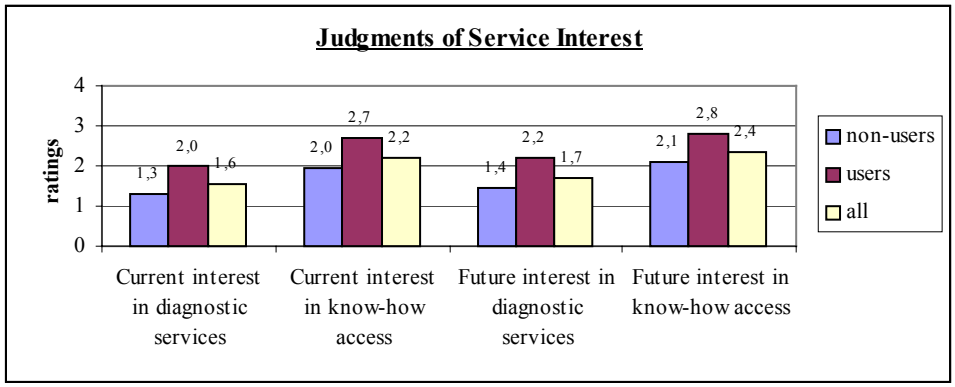
[107] The distribution of system types used by the users is as follows: thirteen of the participating users make use of a static system, five of a dynamic non-robotic system, and twenty-two are operating with a dynamic-robotic system.

[108] There are basic differences between 'second look' consultations in comparison to 'reference diagnostics': a) in the liability and b) in qualification. At a reference diagnostic the client is asking for a second opinion by a highly specialised expert. He can legally rely on the expert's final diagnosis. Therefore reference experts require the whole tissue sample to be sent for examination. In contrast, at a second look diagnosis a pathologist asks another colleague for his opinion. The liability remains at the client's site.

cytometry. One non-user is employing his pathological system to do central case archiving and another one is using his computer to improve interdisciplinary cooperation and communications with colleagues (e.g. exchange of patient reports). These results indicate that also non-users are already on the way to discover the advantages of being online.

18.2.2 Judgement of Service Interest – Values of Summarized Factors

Participants were asked to rate their interest in telepathology services and to give their judgement about the meaning of certain telepathology services in the next five years. The following graphic shows the results of the accumulated ratings divided in users, non-users, and the mean of both (=three columns).



Ratings: +4 = high interest in service; zero = no interest at all;
Significance comparing users / non-users:

Current interest in diagnostic services	F (1.110)=16,28, p<0,000 ***
Current interest in know-how access	F (1.110)=15.01, p<0,000 ***
Future interest in diagnostic services	F (1.110)=20.95, p<0,000 ***
Future interest in know-how access	F (1.110)=14.17, p<0,000 ***

Figure 25: Mean of ratings, referring to the factors calculated by the PCA factor analysis.

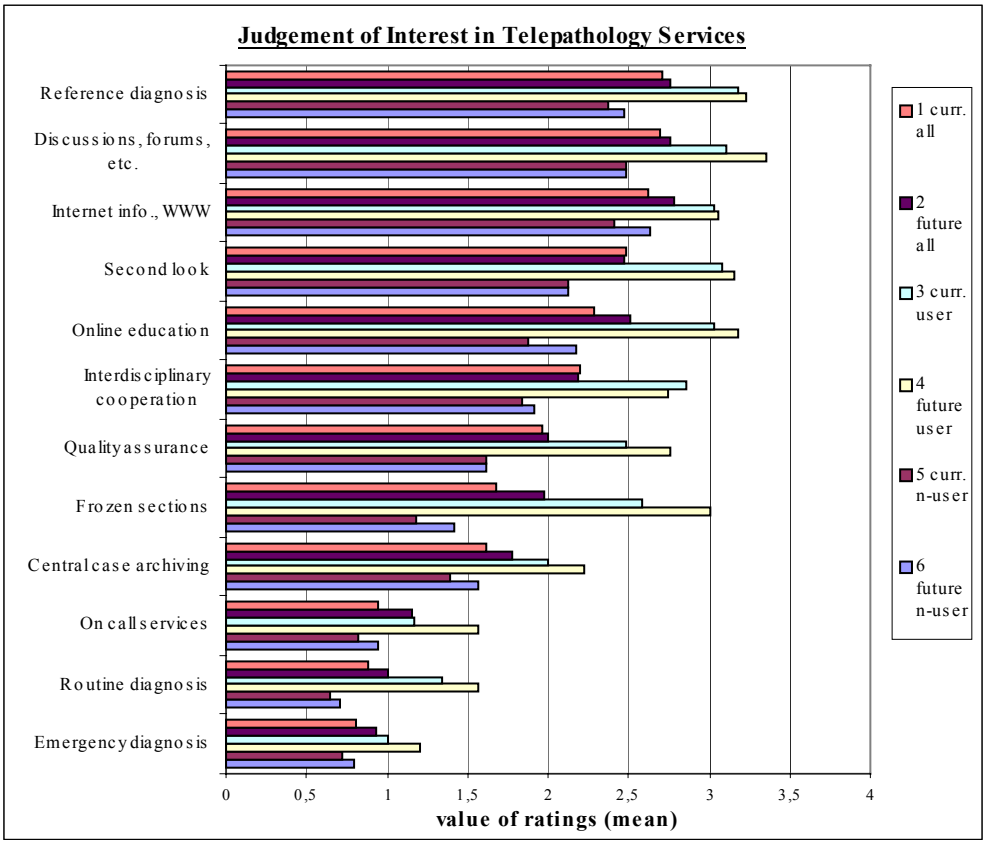
As it was already described in the previous chapter, the PCA-factor analysis has summarized the twelve variables of each group to two factors. The graphic shows that the ratings of the current and future interest in telepathology services is always approximately 0.7 points lower at the non-users compared to users. This difference is highly significant. Comparing the ratings of the interest in ‘diagnostic services’ with the ratings of the interest in ‘know-how access’, the interest in ‘know-how access’ is again in average approximately 0.7 points higher. The future interest is in average judged 0,1 point higher than the current interest at both groups.

18.2.3 Judgement of Service Interest –Single Values of Services

To give a more detailed analysis, at the following graphic, schedule and description the single judgments of the interest in the different services are compared and discussed.

Interests in Employing Telepathology Services	Particip. Utilization			Current Interest (means)					Future Meaning (mean)				
	pl.	user % and total	non-user % and total	pl.	n-user rating	user rating	all rating	F(1.110) p<.	pl.	n-user rating	user rating	user rating	F(1.110) p<.
Factor 1: diagn. support					**1,31**	**2,02**	**1,57**	**0,00*** **		**1,96**	**2,70**	**2,22**	**0,00*** **
Reference diagnosis	2	60% (24)	0	1	2,37	3,18	2,71	0,00***	3	2,47	3,23	2,76	0,00***
Second look	1	80% (32)	0	4	2,13	3,08	2,48	0,00***	5	2,13	3,15	2,47	0,00***
Frozen sections	3	60% (24)	0	8	1,18	2,59	1,68	0,00***	8	1,41	3,00	1,97	0,00***
On call services	12	3% (1)	0	10	0,82	1,17	0,94	0,17	10	0,95	1,56	1,16	0,04*
Routine diagnosis	10	15% (6)	0	11	0,64	1,34	0,88	0,01**	11	0,71	1,56	1,00	0,00***
Emergency diagnosis	9	23% (9)	0	12	0,72	1,00	0,81	0,25	12	0,80	1,21	0,93	0,09
Factor 2: high know-how					**1,43**	**2,18**	**1,70**	**0,00*** **		**2,09**	**2,78**	**0,00**	**0,00*** **
Internet info., WWW	4	53% (21)	24% (17)	3	2,41	3,03	2,62	0,04*	1	2,63	3,06	0,78	0,17
Discussions, forums, etc.	7	45% (18)	8% (6)	2	2,49	3,11	2,70	0,02*	2	2,48	3,35	2,76	0,00***
Online education	5	53% (21)	13% (9)	5	1,88	3,03	2,28	0,00***	4	2,17	3,18	2,51	0,00***
Interdisciplinary cooperat.	6	53% (21)	1% (1)	6	1,84	2,86	2,20	0,00***	6	1,91	2,74	2,19	0,01**
Quality assurance	8	25% (10)	6% (4)	7	1,62	2,49	1,96	0,01**	7	1,61	2,76	2,00	0,00***
Central case archiving	11	10% (4)	1% (1)	9	1,39	2,00	1,61	0,056*	9	1,56	2,22	1,78	0,04*

The following schedule first of all shows participants' utilization of various telepathology services, sorted by the two accumulated factors of the factor analysis (shadowed lines) and by the judgement of the future meaning (last column 'all'). The first block of columns shows the current utilization of services. It consists of 'pl.' (place of utilization rating), the utilization of the 40 users in % and total, and the utilization of services by the 72 responding non-users in % and total. The second block of columns shows the judgements (mean) of the interest of participants in using telepathology services (scale from +4/very interested to zero/no interest). And finally the last block of columns gives participants' estimated meaning of the different telepathology services in the next five years. At the columns 'all' not only the rating, but also the significance value is given..



- The columns above show first the rating (means) of the current interest in service *of all* participants (first column) and
- second the judgement of the meaning of telepathology in the next five years – ratings of *all* (second column).
- The next two columns show the *ratings of users* (first the interest, second the future judgement), and
- the last two columns show the *ratings of non-users* (first the interest, second the future judgement)

Services are sorted by the value of the 'future meaning of services – all'. Ratings: +4 / very interested to zero / no interest.

Figure 26: Graphic about participant's interest in telepathology services.

The highest ratings of the current interest were given to the **utilization of Internet services**, to the participation at symposium groups for **online-case discussions** and forums, and to the possibility to ask for a qualified second '**reference diagnosis**' of an expert via network. Considering future interest, users expect that online discussions of difficult cases will increase in its importance, whereas non-users meant that Internet information may increase its meaning for pathologists in the next five years. Regarding the current utilization, users are already heavily enjoying forums (45%) and the communication with colleagues, whereas non-users are mainly using Internet information (24%). All differences are significant, except for the ratings of the future interest in Internet information. The reason may lie in the high variance (users: mean=3,06, standard diviation=1,39; non-users: mean: 2,63, standard diviation=1,42).

Also an increased interest was expressed in '**second look**' tele-consultations in uncertain cases and in **distance learning and online education** sessions. Especially non-users expect the meaning of online education to be enhanced in the next five years compared to their current interest (mean of current interest: 1,88; mean of future meaning: 2,17). All judgements of the users are significantly higher compared to the non-users' ratings.

The judgement of **interdisciplinary cooperation and communications** was a little bit lower in both groups compared to the services discussed before (mean of current interest: users=2,86, non-users=1,84; mean of future meaning: users=2,74; non-users=1,91). Yet, the results are still quite positive. Its surprising, that users expect the future meaning to be slightly lower than their current meaning[109]. The different judgements between both groups are very significant.

The next highest meaning of telepathology services was seen in **quality assurance** activities and in the possibility to execute **frozen section** examinations by telepathology. These services were rated between a mean of two to three and with this in the midfield of the overall interest judgements. Considering the meaning of frozen section examinations via telepathology, especially users expect an increased importance of this service in the next five years (mean of current interest: users=2,59, non-users=1,18; mean of future meaning: users=3,0; non-users=1,41). Conspicuously, users' judgements are more than 1,5 points higher than the one of non-users. All group differences are highly significant.

The last four service opportunities got a rather low rating in the importance judgement. External centralized pathological **case archiving** of data and images, and the possibility of organizing '**on call**' **services** within a telepathology network were rated with an importance judgement below two. The lowest judgements were given to telepathology services for **primary diagnoses on a routine basis**, and to the utilization of telepathology to do primary **tele-diagnoses in emergency cases**. However, users and non-users expect an increasing interest at all of these telepathology services in the next five years, compared to their own interest. Especially the request for 'on call' services is seen to be increased by the users (mean of current interest: 1,17; mean of future interest: 1,56). The differences of the ratings between users and non-users are significant at the services 'central case archiving' and 'routine diagnoses'. Also the variety in the future meaning of 'on call services' is significant. The difference in the future meaning of 'emergency diagnoses' just shows a significant trend, whereas the variety in the ratings of current interest in 'on call services' and 'emergency diagnoses' is not significant between the two groups.

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109 The single ratings can be seen in appendix VIII.

Conclusion of Interest Ratings

In summary it is conspicuous that at all points the judgement of the interest of the users is much higher than the one of non-users. Especially high differences have been noted in the services ‘reference consultation’, ‘second look consultation’, primary diagnoses for ‘frozen sections’ and on a ‘routine basis’, as well as for ‘online education’. In addition, in almost all points the judgement of the meaning of the different services in the next five years was rated higher than the current interest of participants in using services. Especially users expect the request for frozen section examinations and the organization of so called ‘on call’ services to be strongly expanded in the next five years. If all judgements are combined, reference diagnoses, Internet information services, and the meaning of online expert forums were expected to be the most requested, whereas primary diagnoses on a routine basis or in emergency situations were judged as less important in their future meaning.

18.3 Differences in the Rating of Various Factors of Success

18.3.1 Overview of Critical Factors of Success

Participants were asked to judge various factors by referring to its influence on the success of telepathology introduction. The question to users was: "Considering the experience with your system, how do you judge the following criteria for telepathology's success?" The question to non-users was: " How do you judge the following factors for the success of telepathology?" Participants could vary their ratings from +4 = 'very important, huge influence' to zero = 'no influence at all'.

The following schedule shows their judgments, sorted by the mean of the ratings 'all'. These data should give a general idea of the ratings. Yet, the accumulated factors and their variables are discussed in the next chapters in more detail.

	Mean of Judgement of the Different Criteria (divided in participant's group, place of judgement, and mean)	non-user		user		all	
		place	mean	place	mean	place	mean
1	Quality of **monitor** images (resolution, color, contrast)	1	3,90	1	3,81	1	3,87
2	Guarantee of quality sample **preparation** and field selection	3	3,83	3	3,66	2	3,77
3	Accuracy of **micro examination**	2	3,84	8	3,53	3	3,73
4	Accuracy of **macro examination** (correct gross examination)	4	3,82	9	3,51	4	3,71
5	Quality of **image handling** (orientation in image, focusing)	5	3,81	10	3,50	5	3,70
6	Judgement of the influence for the **equipment** used (microscope)	7	3,75	5	3,58	6	3,68
7	Influence of **system stability**, high system availability	8	3,69	11	3,49	7	3,62
8	Influence of the available **network connections** (speed, security)	11	3,63	6	3,56	8	3,60
9	Influence of fast **respond times** and fast image transfer	15	3,48	2	3,71	9	3,56
10	Explicitness of legal **liability regulations**	9	3,68	17	3,27	10	3,53
11	Qualification (**licensure** regulations) of all people	6	3,79	25	3,03	11	3,52
12	Quality of textual **data** (completeness of data)	10	3,68	21	3,16	12	3,50
13	**Simplicity of systems**, clear and logical system structure	14	3,49	4	3,63	13	3,50
14	Influence of the **computer equipment**	12	3,63	18	3,26	14	3,49
15	**Data security** (no loss of data by exchange, misuse protection)	13	3,59	15	3,32	15	3,49
16	Influence of **system flexibility** and efficient support of workflow	17	3,40	13	3,43	16	3,41
17	Standards - compatible data and **image formats**	19	3,36	14	3,37	17	3,36
18	Influence of **system reliability** (strong crashes, total break down)	25	3,20	12	3,45	18	3,29
19	Explicit regulations about data exchange and **data protection**	16	3,45	27	2,89	19	3,25
20	Influence of **access control** (access to system and data)	20	3,32	24	3,03	20	3,22
21	Influence of **user support** (system training, help menus)	18	3,37	28	2,89	21	3,20
22	Development and use of homogeneous **technical standards**	21	3,30	23	3,05	22	3,20
23	**Internal acceptance** of physicians and medical staff (users)	27	3,00	7	3,54	23	3,20
24	Influence of **investment** and subsequent cost	22	3,23	30	2,81	24	3,08
25	Availability of **advisory centers** for system selection	23	3,23	31	2,79	25	3,07
26	**Cost effectiveness** of telepath. services, economic efficiency	26	3,02	32	2,78	26	2,93

Mean of Judgement of the Different Criteria (divided in participant's group, place of judgement, and mean)	non-user		user		all	
	place	mean	place	mean	place	mean
27 **External** system **integration**	24	3,21	36	2,36	27	2,88
28 Influence of health care **politics** and health care laws	29	2,94	33	2,78	28	2,88
29 Improvement of **health care efficiency** (faster diagnoses)	31	2,71	22	3,08	29	2,85
30 Weight of explicit regulations about **reimbursement**	30	2,89	35	2,50	30	2,75
31 **Coordination** of system usage (no waiting time)	36	2,38	16	3,32	31	2,75
32 **Internal** system **integration** (HIS)	28	3,00	37	2,36	32	2,75
33 Influence of **project design** and management by implementation	34	2,41	20	3,24	33	2,75
34 **External acceptance** (insurance companies)	32	2,64	26	2,95	34	2,75
35 **Internal acceptance** of top management (clinic/medical director)	35	2,41	19	3,25	35	2,73
36 Influence of **geographical factors** (health care provider density)	33	2,55	34	2,60	36	2,57
37 Internal **institution politics** (institutions objectives, strategies)	37	2,08	29	2,89	37	2,37
38 Influence of **cultural factors** (historical structures, ethic)	38	1,67	39	1,82	38	1,73
39 Acceptance of **patients**	39	0,93	38	1,91	39	1,30

The ratings are distinguished between users of telepathology, non-users, and all. Each group-block of columns first show the place of the importance rating, and second the rating itself with the mean. More detailed values can be seen in appendix VIII and X.

Schedule 10: Schedule with all means of the judgement of different factors of success.

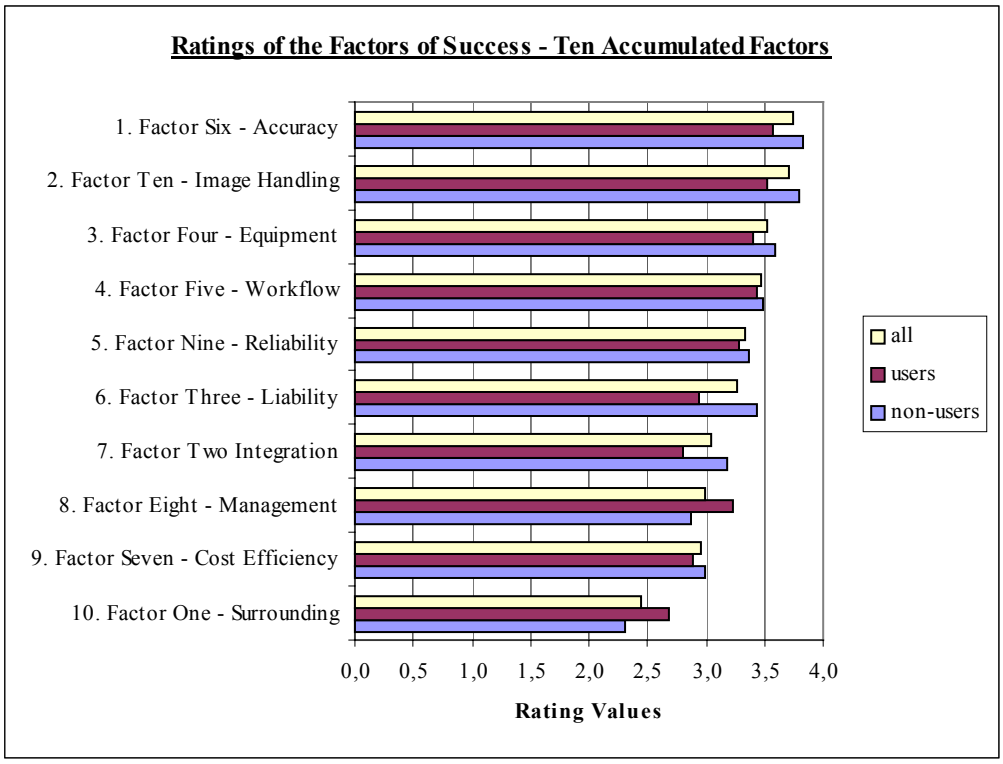
18.3.2 Users Compared to Non-Users – Accumulated Factors of Success

Since the single ratings of the various variables are very complex, the variable39 were accumulated from 39 aspects to 10 factors by the PCA factor analysis (see chapter 17).

Short (contraction)	Factor Number and Factor Name	User			Non-user			All			Significance	
		Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
SURR_2	1 Surrounding	10	**2,69**	0,55	10	2,30	0,85	**10**	2,44	0,78	6,56	**0,012**
INTEG_2	2 Integration, standards	9	2,81	0,69	7	**3,18**	0,69	**7**	3,05	0,71	7,38	**0,008**
LEGAL_2	3 Clear legal situation	7	2,95	0,88	5	**3,44**	0,67	**6**	3,26	0,78	11,03	**0,001**
EQUIP_2	4 Equipment quality	4	3,41	0,54	3	**3,59**	0,47	**3**	3,52	0,51	3,35	**0,070**
WORKF_2	5 Workflow efficiency	3	3,43	0,46	4	**3,48**	0,62	**4**	3,47	0,57	0,21	0,649
ACCUR_2	6 Accurate diagnostic	1	3,57	0,76	1	**3,83**	0,41	**1**	3,74	0,57	5,22	**0,024**
EFFIC_2	7 Efficiency	8	2,90	0,88	8	**2,99**	0,84	**9**	2,95	0,85	0,28	0,595
MANA_2	8 Management	6	**3,22**	0,50	9	2,87	0,82	**8**	3,00	0,74	6,17	**0,014**
RELI_2	9 Reliability / data security	5	3,28	0,74	6	**3,37**	0,78	**5**	3,33	0,76	0,36	0,550
IMAG_2	10 Image handling	2	3,52	0,89	2	**3,80**	0,45	**2**	3,70	0,66	4,95	**0,028**

The schedule above shows the factors of success sorted by the PCA factor analysis number. The significant values between users and non-users are illustrated at the last column. Further, the means and standard deviation of the different groups are illustrated, and for each group the overall place (pl.) of the ratings is given in addition. Significance values: 0,001 (***) = highly significant; 0,01 (**) = very significant; 0,05 (*) = simply significant; 0,10 = statistical trend. The F value of the calculation is 1.110.

Schedule 11: Schedule of the summarized judgment of the accumulated factors of success.



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

Figure 27: Graphic about the distribution of the 10-PCA factors of success.

The ratings in the graphic above are sorted by the mean of 'all'. The graphic clearly shows that the factor concerning accumulated accuracy aspects achieved the highest ratings, whereas the criteria pointing at the surrounding of telepathology (politics, acceptance) got the lowest values in the meaning of telepathology's success. Except of the factors 'workflow efficiency', 'cost efficiency', and 'reliability / security', all factors show significant differences between the judgments of users and non-users.

Considering the different factors, the highest ratings were given to criteria referring to 'diagnostic accuracy' and to 'image handling' (common mean of all: 3.74 and 3,70). At these two factors the rating differences of users and non-users are very significant. Both groups also agree that the quality of the equipment has a high influence on telepathology's success. Yet, here the significance value only shows a statistical trend between both groups ($F(1.110)=3,35$, $p<0,07$). At the next two factors – 'workflow efficiency' and 'reliability/security criteria', the ratings of the users and non-users are almost similar. That may be the reason that the significance calculation was negative (workflow: $F(1.110)=0,21$, $p<0,65$; security: $F(1.110)=0,36$, $p<0,55$). Considering the factors 'clear legal situation' (mean users: 2,95 / Place 7, non-users: 3,44 / place 5) and 'system integration' (mean users: 2,81 / place 9, non-users: 3,18 / place 7), the ratings of the non-users are very significant higher than the one of users. The high judgements of non-users may refer to the problem of missing liability regulations and point to the problem that many systems in pathology are currently not integrated with each other. Decision makers seem to be reluctant in investing in further isolated solutions.

The two factors 'surrounding' and 'management' are the only factors where the ratings of the users is higher than the one of non-users. Users may have recognized that a well managed telepathology selection process helps to avoid unnecessary interruptions and guarantees a smooth and fast system introduction. Therefore this aspect is by users on place six (mean: 3,22), whereas by non-users at place 9 (mean: 2,87). Also the influence of surrounding aspects of telepathology (politics and acceptance of various parties) is rated very significantly higher by users (mean of 2,69 compared to non-users 2,30; $F(1.110)=6,56$, $p<0,012$). The differences in these ratings may reflect the experience of users, which seem to have discovered that environmental factors are likely to have an impact on telepathology's success. It confirms the findings of other telemedicine projects, where political factors were also discovered as reason for the failure of a long-term system introduction (please see for example the studies of Williams, 1995; Moore, 1995, p. 3; or Puskin, 1995/(1), p. 63, discussed in chapter 10.1). Yet, both groups set the factor 'surrounding' in its meaning for telepathology's success on the last place.

Considering the average ratings of all these criteria, the highest ratings are at 3,7 (3,6 at users; 3,8 at non-users) and the lowest are at 2,4 (2,7 at users and 2,3 at non-users). Consequently, all regarded criteria have proved to have an impact on telepathology's success.

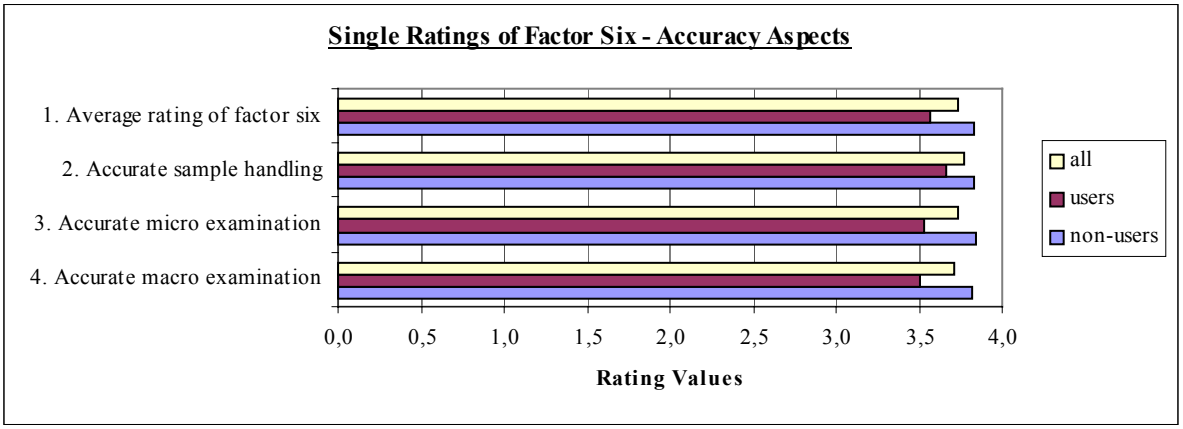
18.3.3 Discussion of the Single Values of Each PCA Factor

18.3.3.1 Factor 'Diagnostic Accuracy'

The following schedules and graphics show the values of the single variables sorted by the range of the 10 factors of the PCA-factor analysis. Again, the results are distinguished in the users' and non-users' single judgements (means) of the different variables:

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 6	1	3,57	0,76	1	3,83	0,41	**1**	3,74	0,57	5,22	**0,024**
4.5.2 Accurate sample preparation	3	3,66	0,77	3	3,83	0,64	**2**	3,77	0,69	1,44	0,233
4.5.3 Accurate micro examination	8	3,53	0,99	2	3,84	0,44	**3**	3,73	0,70	4,99	**0,028**
4.5.1 Accurate macro examination	9	3,51	0,87	4	3,82	0,48	**4**	3,71	0,67	5,55	**0,020**

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd to 4th line).



The number in front of each criterion gives the place of the summarized mean of both groups: a) PCA-factor (10 factors) and b) single variables (39 variables).

Figure 28: Ratings of variables referring to diagnostic accuracy aspects.

The ratings of the criteria describing the diagnostic tele-process got very high values in the judgement of telepathology's critical factors of success (in summary place two, three and four of the 39 criteria).

Sample Handling at Client

In summary the variable 'accurate **sample handling'** (guarantee of high quality sample preparation and precise field selection – for more intensive description see chapter 16.2.3.) was set on place two with an average rating mean of 3,77. The rating difference of users and non-users is statistically not significant ($F(1.110)=1,44$, $p<0,233$).

At least ten non-users made comments about the sample preparation and handling at the client's site. They could not imagine that macroscopy can be delegated to a non-pathologist. In their opinion, a pathologist needs a lot of experience to select the right specimen part for an accurate examination, especially if a tumor is small or distributed. One participant wrote that „r*eliable sample handling is an art, which demands a lot of experience*". Four other non-users explained that for a correct diagnosis the sample is indispensable. „*Each pathologist loves his own preparation*". Many non-users further pointed at the missing sensory examination, like sense of smell or sense of touch in their comments. In their opinion the pathologist needs direct sample access in any case.

In contrast, most users did not highlight 'sample handling' as a major problem. Yet one user emphasized that the client has to be well educated and trained to execute all tasks correctly. Another user remarked that the tele-pathologist can be influenced by the client in his final diagnostic decision. A user of a static system complained that there is sometimes a loss of information due to remote sample handling. A further user meant that images can be misleading, which a telepathologist has to be aware of, especially when using static telepathology systems. Within the accuracy discussion some comments show that pathologists would prefer to use dynamic systems, since they have more control of the examination process and therefore accuracy degrees are almost as high as at direct microscopy. However, considering the comments of static system users, the judgements vary. Some recommend never to use static systems for primary tele-diagnostic, others report from almost unproblematic utilization (comment of static system utilization in Aurich/Germany, experience reported at the project at Sapporo/Japan in chapter 9.1.2.2).

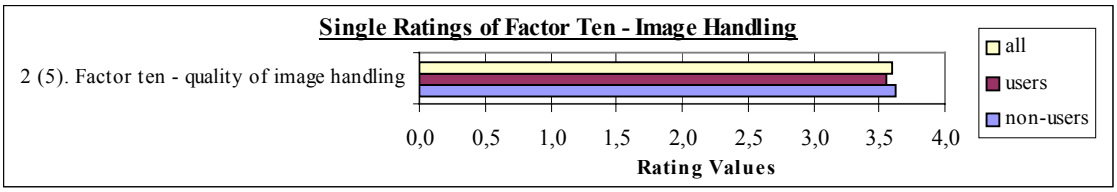
Micro and Macro Examination

The accuracy of the **macro examination** (e.g. correct gross examination, correct cut of sample fields) and the **micro examination** were set on place three and four of the overall ratings. The differences of the users' and non-users' judgments are statistically significant. The high ratings for these two aspects were to expect, since high diagnostic quality is the fundamental basis of pathology. Firstly, because the consequences of a diagnosis are often serious for the patient and secondly because pathologists may fear a destroyed reputation. Therefore most pathologists claim, that the diagnostic results have to be as accurate as if they had been executed directly at the light microscope. (For accuracy results of studies published in journals see appendix VI, please).

18.3.3.2 Image Handling

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 10	2	3,52	0,89	2	3,80	0,45	**2**	3,70	0,66	4,95	**0,028**
4.9.2 Image Handling)	10	3,52	0,89	5	3,80	0,45	**5**	3,70	0,66	4,95	**0,028**

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd line).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

Figure 29: Ratings of variables referring to the handling of images.

Pathologists are used to examine samples quickly on the microscope. Using telepathology systems, the non-users especially claim a similar simple and fast **image handling process** (orientation in the image, focusing, simple objective change) as in the case at a microscope. The average mean of the ratings of the meaning of image handling is 3,81 (place 5 of the overall factor of the success ratings). The users judged this point a little bit lower with a mean of 3,50. This may indicate that if a user recognizes serious advantages, he will accept a less efficient image handling procedure by telepathology. Nevertheless, although the user's rating is lower than the one of non-users, the overall position of this criterion is still on place two.

18.3.3.3 Factor 'Equipment Quality'

Asking the users about the influence of the equipment quality on the success of telepathology introduction their judgement was as follows:

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 4	4	3,41	0,54	3	3,59	0,47	**3**	3,52	0,50	3,35	**0,070**
4.9.2 Image quality (resolution)	1	3,81	0,51	1	3,90	0,35	**1**	3,87	0,42	1,02	0,315
4.7.1 Medical equipment (microscope)	5	3,58	0,54	7	3,58	0,65	**6**	3,58	0,62	0,00	0,964
4.7.3 Network performance	6	3,56	0,55	11	3,63	0,65	**8**	3,60	0,61	0,34	0,560
4.7.2 Computer equipment	18	3,26	0,88	12	3,63	0,67	**14**	3,49	0,78	5,43	**0,022**
4.1.1 Support desk for system selection	31	2,79	1,30	23	3,23	1,14	**25**	3,07	1,22	3,23	**0,075**

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd to 6th line).

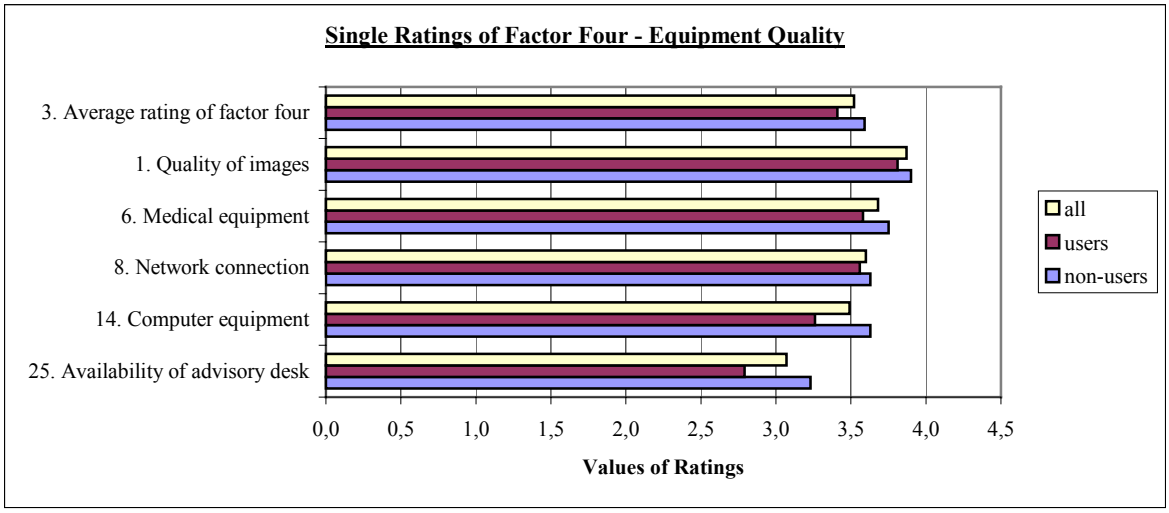


Figure 30: Ratings of variables referring to aspects of selected equipment.

Image Quality

All participants, users as well as non-users, put the quality of **monitor images** (resolution, color, contrast, etc.) on place one of their judgement (user: 3,81; non-user: 3,90). The high ratings again raise the question of excellent image quality contra image size (see chapter accuracy, 16.2.2.4 reduction of image size). One user emphasized that navigational maps have to be available for the scanning process of up to 2,5 cm areas of a section. One non-user doubted in his comment that the currently available image quality is sufficient for primary diagnostic. He argued that digital images are only satisfactory for documentation. Another non-user even doubted that image quality is adequate enough for second opinion consultations. Also some users stated that their system should allow for the reception of live images at a higher resolution for an accurate diagnosis. Yet, this would increase the costs significantly. Fortunately there are also users who reported that image quality is rarely a problem in their experience. Just the limited amount of images at static systems and unsatisfying image quality at low power fields with high magnification were reported by four users as a problem. Besides image quality, one user further highlighted that acoustic communication in a telepathological session is very important, since this way diagnostic certainty will be increased.

Discussion of Equipment Availability and Quality Aspects

The influence of the **medical equipment** used (microscope and camera quality) was rated with 3,68 (place six; users place five, non-users place seven). In comparison, the influence of the used **computer equipment** (e.g. PC performance, monitor size, database) was rated lower, but still in the overall rating on place fourteen (non-users place nine, users place eighteen). Only the judgements of computer equipment show a significant difference between the ratings of both groups ($F(1.110)=5,43$, $p<0,022$). The reason for the lower judgement by the users may be based on the fact that the computer performance improved a lot during the last years. In addition, since the utilization rate of telepathology systems is not very high at the moment, computer capacity does not seem to be a bottle neck. Yet, if many cases have to be processed, image size and computer performance have to be well-suited to each other to avoid shortcomings and long respond times.

Considering the comments, users of telepathology systems mentioned in this study that they are not always satisfied with their available technology. Cameras and video screens are sometimes insufficient. Low quality equipment at the client's site leads to long session time. Therefore one user recommended not to save money on good equipment, because it will not pay off in the long run. Another user urgently claimed electronic printers, audio systems, gross workstations and a dynamic robotic microscope to do telepathology accurately. The decision especially of **static versus dynamic** telepathology led to many comments. Four users of dynamic systems made very positive comments about their satisfaction with the robotic features of their system and the possibility to choose images directly. In this way they keep control of the examination process. In comparison, an user of a static imaging system meant that he just uses his system for capturing reference and educational material. He does not employ his system for primary diagnoses due to the risk of sampling and field selection errors.

That the kind of system used has an impact on physicians' acceptance was also described in the literature. In Sweden, where static systems were tested, only 50% of the surveyed pathologists said they would like to have access to telepathology in their department. These users often reported that static image transfer is too limited. They were not satisfied with

the diagnostic accuracy compared to the conventional light microscope due to problems with resolution and field selection. Dynamic imaging system instead of static systems would be preferred by over 80% of the requested users, but with a hesitation when regarding the high cost of this technology [Olsson, 1995, pp. 238, 240]. That dynamic systems were preferred was confirmed at a dynamic (yet not robotic) telepathology pilot project in Vermont, USA. Thirteen of the fourteen participating pathologists felt the dynamic system should be continued and expanded [Callas, 1996, p. 327].

At the study in Constance, dynamic telepathology systems are also often named as the preferred solution for pathologists. However, similar to the study in Sweden, many users mentioned dynamic systems as too expensive. Therefore, the given examples and the comments of the study should not call up the conclusion that static systems will have a low acceptance in any case. It rather reflects that equipment has to be carefully selected with regard to the specific situation of a user. The final decision should consider the user's needs in relation with efficiency aspects.

Already Available Equipment of Non-Users

Executing the first pre-studies in Constance, some of the non-users argued that they do not have the necessary infrastructure and networks to install telepathology efficiently. Therefore, to discover the currently available equipment non-users were asked in the questionnaire to give information about their current infrastructures.

Equipment		Amount is first given in total, then in per cent					
Personal computers	number	0	1-5	6-10	>10		
	total	3 (6%)	34 (50%)	17 (25%)	14 (19%)		
Workstations	number	0	1-2	3	4	5	8
	total	34 (50%)	14 (21%)	9 (13%)	6 (9%)	3 (4%)	2 (3%)
Cameras	number	0	1	2	3	>3	
	total	39 (55%)	13 (18%)	10 (14%)	5 (7%)	4 (6%)	
PACS	number	0		1			
	total	69	97%	2	3%		
Digitalization	kind	no digitalization	frame grabber (fg)	digital camera (dc)	digital scanner (ds)		
	total	40 (56%)	4 (6%)	3 (4%)	4 (6%)		
	kind	fg + dc	fg + ds	dc + ds	fg + dc + ds		
	total	1 (1%)	7 (10%)	7 (10%)	5 (7%)		
Network access	kind	no external access	modem	ISDN	modem + ISDN	LAN / Uni network	
	total	7 (10%)	14 (20%)	44 (62%)	3 (4%)	3 (4%)	

Schedule 12: Available equipment at participating non-users.

Asking about the amount of personal computers at their department, 4% (3 non-users) answered that they do not have any PCs. 50% of the non-users have one to five PCs, 25% have six to ten PCs, and 21% have even more than ten PCs (highest is 65 PCs) at their department. 50% of the non-users do not have any workstation. 21% have one or two workstations in use, 13% have three workstations, 9 % have four workstations, and 7% have five to eight workstations at their department. 51% of all non-users do not have a video camera. 18% have one camera, 14% two cameras, 7% three cameras, and 6% have even more than three cameras in use. Only two non-users (3%) use PACS (Picture Archiving and Communication System). 56% answered at the question about image digitalization that they are not able to capture digital image slides. 6% use a frame grabber, 4%

a digital camera, and 6% a digital scanner. 18% have a frame grabber and a digital camera and/or scanner. 10% employ a digital scanner together with a digital camera at their department. Asking for the possibility to access external networks, 10% answered that they do not have any network access. 20% use a modem, 62% have ISDN connections, and 4% have both, modem and ISDN. 4% use the network of their university to get access to external services.

In summary it is very positive that more than 90% of all non-users employ PCs or workstations and do have access to external networks and services. Already 45% of the non-users have image capturing features and video cameras available. Unfortunately, only 3% use image management applications like PACS[110].

Meaning of Criteria Referring to the Network Employed

The influence of **good network connections** (speed, security, stability) was rated with a mean of 3,6 and with this on place eight of the overall judgements (non users place eleven with a mean of 3,63, users place six with a mean of 3,56). The ratings of users and non-users show no significant difference. The characteristics of network types and there specific advantages and disadvantages in the context of telepathology were already described in chapter 11.1.4. To name some important criteria for network quality, these are for example capacity rates and speed, availability, cost, or reliability. Which network will be chosen is heavily influenced by the situation of the users and the kind of system employed.

At the opinion poll in Constance, several users made comments concerning network attitudes. Two user claimed that systems should allow more flexibility in the selection of networks. They want to be able to switch the kind of connection used (Internet / network-to-network and point-to-point utilization) and to utilize different network capacities. Another user complained that his system does not allow a sudden change between online and offline during a tele-session. And similar to many other studies mentioned in the literature, also in this study several users of dynamic, but also of static systems found fault with the speed of their employed networks (more detailed aspect of speed are analyzed in chapters: 11.1.4.8, 13.6.2.2, and 16.2.2.8).

To discover the networks, which are employed by participating telepathology users, they were asked about the kind of physical medium they are using to connect their computer with their telepathology partner. The situation looks like follows:

Network connection	Which kind of physical medium do you use to connect your computer with your client / consultant?						
	analog telephone modem	**ISDN**	**local network (LAN)**	**analog + ISDN**	**ISDN + LAN**	**analog + LAN**	**no comment**
client	2	19	10	1	3	1	4
consultant	2	16	11	1	6	0	4

Schedule 13: Utilized networks by clients and consultants.

Only two users used analog telephone modems on both sides. One user in Germany is executing telepathology by analog telephone as well as by ISDN at the consultant's and cli-

[110] Please remember that all non-users are located in Germany. In other countries the situation may be completely different.

ent's side. At a further project in Germany some of the clients are connected by telephone and some by LAN. Yet, most of the users are employing ISDN or get access to the networks by their LAN. That the kind of network used is important for the success of telepathology is confirmed by the high ratings of network importance (see chapter 18.3.3.3). Since networks are the backbone of telepathology interactions, in any case they should be able to guarantee a satisfying data exchange in speed as well as in price.

Support of System Selection

The problem of system selection was described in chapters 11.4 and 18.3.3.3. For physicians it is often not easy to judge the quality of equipment and the consequences which a certain system selection has, since they do not have the required know-how about technological developments. Not rarely they are lacking in accurate information about innovations, in order to know what to expect from a system. Therefore it is difficult for them to choose the most appropriate system for their specific needs. They need assistance. Assistance not only for solving technical problems but especially for support in the selection of systems and for the implementation process.

Asking participants how important they judge the availability of independent **advisory centers**, which support them in choosing the equipment for their specific needs, they rated it in average with a mean of 3,07. Especially non-users, who do not have a system yet, would appreciate support in the selection of the most appropriate system for their specific situation (users' mean 2,79 / place 31; non-users' mean: 3,23 / place 23). The difference of the non-users' and users' ratings show a significant trend ($F(1.110)=3,23$, $p<0,075$).

Several health care organizations started to establish vendor independent offices, which give qualified advise in the purchase of systems to interested parties. For example a Telemedicine Subgroup of the 'Information Infrastructure Task Force's Committee on Applications and Technology' established a directory of federal grant programs, which is available from the 'National Telecommunications and Information Administration' and electronically from the 'National Institute of Standards and Technology'. NASA also developed a tracking document that identifies legislative and regulatory telemedicine initiatives, federal grant programs, and a description of some projects. Further the 'Rural Information Center Health Service' (RICHS), which is staffed by information specialists, provides several up-to-date services for information on current federal and state rural programs in the USA. This service can be reached by either calling a toll-free number or electronically through the Internet [Puskin, 1995/(2), p. 128]. The European Community also introduced several projects for system selection support. FEST for example offers tools which help to identify and to address various factors of influence for particular telemedical service types. Other support institutions, which have already been described, are EHTO or HEALTHPLAN (chapter 5.3).

Concerning the 'system selection' process, again it is to emphasize that users should be early involved in system designs and system selection processes. This way the expectations of users can be met and with this their acceptance will be increases. The need of user's involvement was also highlighted by two telepathology users of this study as a factor of telepathology's success.

18.3.3.4 Factor 'Workflow Efficiency'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 5	3	3,43	0,46	4	3,48	0,62	**4**	3,47	0,57	0,21	0,65
4.11.2 System stability	11	3,49	0,76	8	3,69	0,58	**7**	3,62	0,65	2,22	0,14
4.11.1 Respond times	**2**	3,74	0,51	15	3,48	0,78	**9**	3,56	0,70	2,70	0,10
4.11.4 Simple/user-friendly interface	**4**	3,63	0,62	14	3,49	0,80	**13**	3,54	0,74	0,79	0,38
4.11.5 System flexibility	13	3,43	0,75	17	3,40	0,93	**16**	3,41	0,87	0,03	0,87
4.11.3 User support and training	28	2,89	0,98	18	3,37	0,96	**21**	3,20	0,99	5,76	0,18

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd to 4th line).
The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

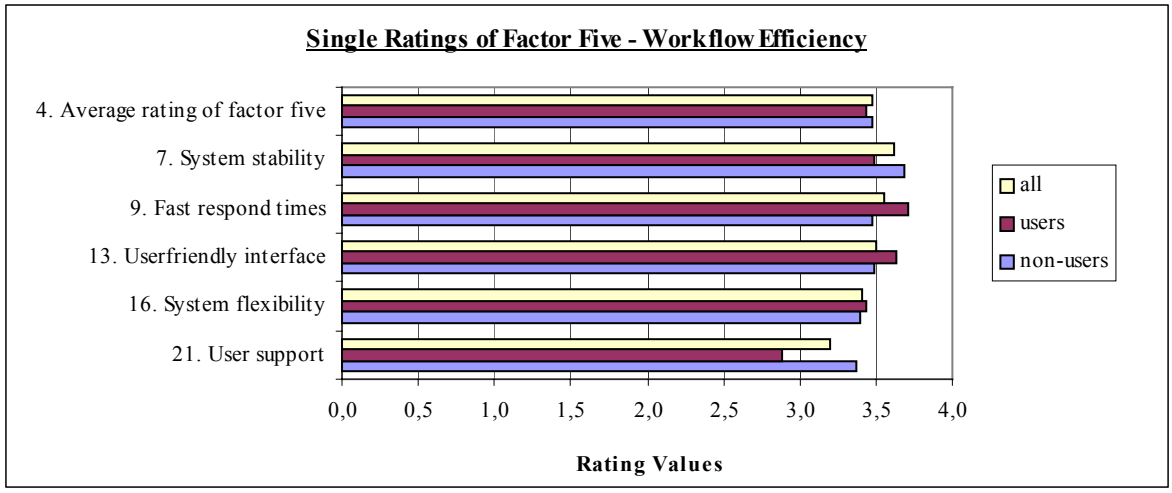


Figure 31: Ratings of variables referring to workflow efficiency aspects at system utilization.

Fast Respond Times

Participants set great store on **fast respond time** (mean: 3,56). Users especially judge the meaning of the **respond times** and fast image transfers as very high. They set it on place two and rated it in average with a mean of 3,71. Yet, the difference is statistically not significant. The high ratings of the aspect 'respond time' correspondents with the criterion 'easy image handling'. It emphasize the importance of network capacity of dynamic systems, where the speed of the image transfer has an influence on the examination process. Fast image exchange is necessary to guarantees a manipulation of images almost as quickly as it could be done at the direct microscope. Considering the current situation, some telepathologists with dynamic systems complained that they only retrieve a certain amount of images due to low network capacities. This is raising the risk of an inaccurate diagnosis (please, see chapter 16.2.2.8).

System Stability

The highest rating (mean: 3,62) in the context of security was given to the aspect of '**system stability**' (short interruption, high system availability - best 24-hours/day). Fortunately, most participating user reported that system interruptions are rare. The few interruptions which occurred were caused by unforeseen system lock-ups, improper system handling by untrained staff, but mostly by network instabilities.

Simplicity and Usefulness

In recent literature physicians reported that some initial interfaces were frustrating tools, since they demand a lot of time, but do not lead to satisfying results [Grace, 1995]. Some users also mention that systems are far to complicated. It is likely that physicians are reluctant to use systems for example, if they have to know exactly how the system recognizes the input data, if they have to type codes correctly, or if they have to dial many numbers like phone number, IP number, logon or password. The problem of such systems is that their designs are driven by technology instead of the needs of practitioners [Mariner, 1995]. Systems have to be user-friendly from the practitioner's perspective. Physicians demand that systems should be as easy to use as a telephone, or in the jargon of telemedicine experts, they must be 'transparent' to the practitioner and operable with relatively little training [Puskin, 1995/(2), p. 127; Weinstein, 1995, p. 225]. To give an example, the first telepathology system used in Vermont was to overloaded and inflexible. Pathologists at all sites expressed frustration with the complexity of use and the technical difficulties. Also other research studies proved that **reliability** of technology and **simplicity** of systems are essential for increasing future usage by consultants and remote clients [Ricci, 1997, pp. 200-204].

> *"So you just push one button. Anything harder than that, and the docs won't use it .... the older physicians want somebody to be there with them to operate the system. The young ones, though, they want to push all the buttons just to see what happens." [Moore, 1995].*

This is also a result of this study. Ten users explained in their comments that user-friendly systems and simplicity of usage have to get absolute priority. „**Keep it as simple as possible**" [comment of an user]. Some of them complained that systems are often not sufficiently pathology oriented. Image handling and archiving is sometimes not flexible enough. They demand multistep working for image management and remote microscope manipulation. One user claimed that systems should be programmed object oriented and that web-technology should be employed to guarantee flexibility and open communication.

Considering the ratings of users and non-users, the **simplicity of systems** and the meaning of logical system structures was rated with an average mean of 3,54. The influence of **system flexibility** and of the system's ability to support the pathological workflow was judged with a mean of 3,41. Both aspects got quite similar values by users and non-users and show no significant difference. In summary user-friendly and flexible interfaces were placed in their importance behind accuracy aspects, equipment quality, system stability, and the necessity of clear legal regulations. Yet, the rating of 3,5/3,4 still emphasize a high meaning of these aspects for telepathology's acceptance.

Training and Assistance

Close related to simplicity of system usage is the factor user training.

> *„Support, training and user involvement are necessary for good systems and acceptance." [Appleby, 1995]*

This was confirmed at telepathology projects in Japan and Vermont (USA). The proportion of hospital pathologists accepting the system was low at the beginning. It was discovered that for appropriate use of the system pathologists have to receive a thorough training and support to become familiar with the system [Allaert, 1999; Callas, 1996, p. 325]. In Sweden pathologists got the possibility to try out several systems. Good instructions and user friendly conditions were seen as major factors to improve acceptance [Olsson, 1995, p. 240]. Especially physicians, who have limited experience and comfort with computers may be slow at using tele-applications at the beginning and perhaps start to be frustrated.

As soon as they get more training this problem can be avoided [Mullick, 1996, p. 191; Mariner, 1995; Perednia, 1995/(3); comment of one responding user]. Also at this study some participants emphasized the need of good user training and education. Users also need advises about the utilization of all available tools. In this way they are able to employ all features efficiently. In addition, one user of this study recommended that a start-/beginner's version should be available for training.

Another important component of a successful telemedicine projects is the provision of on-going **technical assistance**, especially to users without technical expertise. Not rarely the only source for technical assistance are vendors. Such a situation is not acceptable and beneficial for a positive acceptance. Realizing that ongoing technical support is critical to sustain telemedicine systems, a local qualified person needs to be available to address minor technical problems at each rural site [Puskin, 1995/(1), p. 63; Puskin, 1995/(2), p. 127].

Support and communication between clients and experts may enhance acceptance, too. At the telepathology project in Milwaukee, once a month the telepathologists travel to the remote hospital in order to discuss concerns and needs of clinicians users directly. These face-to-face meetings proved to be essential to foster mutual trust and confidence between pathologists and surgeons [Dunn, 1996/(1), p. 469]. The same was experienced at a project in Hong Kong. Periodical meetings and seminars were provided, which helped to promote telemedicine among health-care professionals [Sheng, 1997, p. 71]. For more detailed discussion see chapter 11.2.1, please.

At this study the influence of **user support** (system training, help menus, 24-hour-support-hotline) on telepathology success was in summary rated with a mean of 3,20 (place 21). The ratings of users and non-users show no significant difference. In summary the judg-ments emphasize that in the first place all users as well as non-users expect simple, self-explanatory systems (non-users 3,49 / place 10, users 3,03 / place 4), and just on the second place they demand good training and support.

Comments on Process Efficiency

Another important factor for the acceptance of telepathology systems is that they are de-signed to be easily **integrated** into existing medical **workflow**. Since the time table of pathologists is often overloaded, they do not want to interrupt their work routines. There-fore humans and systems have to be well coordinated to avoid unproductive **waiting times**. In general a system is considered as helpful when it enables a physician to save time or at least to improve services. In other words, telepathology networks will only be successful if pathologists find them beneficial. Therefore **users** should be **involved** in the design of systems right from the beginning. User input is imperative if systems are to garner user acceptance [Callas, 1996, p. 319; Puskin, 1995/(1), p. 127; Kaiser, 1994; comment of three users at the questionnaires].

Referring to process efficiency in this study, one user complained that with his static system it takes too much time to select appropriate images. Two other participants, both using a dynamic system, argued that the efficiency of the tele-examination is not satisfying since the tele-procedure takes much more time compared to the conventional method. In Norway the system is located at another office, which takes additional time out of a busy schedule. Another user remarked that to learn how to handle the system should not take too much time. For him the effort of learning has to be compensated by improved process efficiency. Another user pointed at the fact that the client has to be well educated, since he

has to assist the pathologist accurately. Yet, this will demand additional teaching effort and time. In summary, several participants remarked that cost (personal and time) are critical for telepathology success. As long as fast and cheap shipping routes are available, further two non-users explicitly doubted the need for telepathology[111].

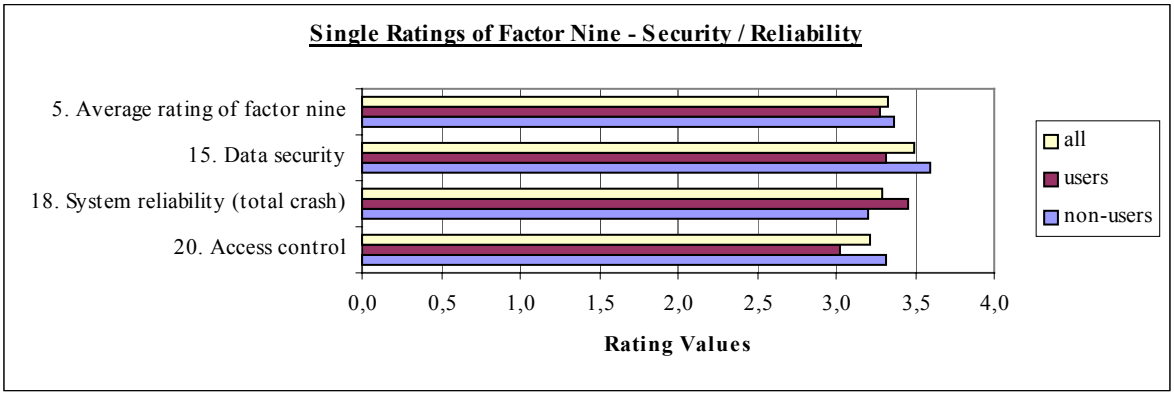
Nevertheless, many users as well as non-users considered telepathology systems as good tools to get fast second opinion advises and diagnoses. One users remarked that he finds it very positive to get a diagnosis on frozen sections, which was previously not possible at his location. Two other user highlighted the faster availability of diagnostic results with telepathology. This way turnaround time is decreased and treatment process improved.

Asking participants to give information about the examination process, static users answered that in average they need five to ten images per case, and a session lasts between 10 to 30 minutes. The users of dynamic systems remarked that the time needed per case is between 5 to 40 minutes. In general the time needed per case is lower at static systems than at dynamic-robotic ones[112]. This may reflect the problem of network bandwidth and consequently slow image selection. Further information about the average time and amount of images needed per case is given in appendix VI.

18.3.3.5 Factor 'Reliability/Security'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 9	5	3,28	0,74	6	3,37	0,78	**5**	3,33	0,76	0,36	0,55
4.10.3 Data security	15	3,32	1,07	13	3,59	0,75	**15**	3,49	0,89	2,07	0,15
4.10.1 System reliability (crash)	12	3,46	0,76	25	3,20	1,01	**18**	3,29	0,94	1,83	0,78
4.10.2 Access control	24	3,03	1,00	20	3,32	1,02	**20**	3,22	1,03	1,98	0,16

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd to 4th line).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

Figure 32: Ratings of variables referring to security and reliability criteria.

111 The non-user opinion poll was restricted to Germany, where the amount of pathologists is rather high and where travel distances are short.

112 "Please, give the average time needed per case and amount of images transferred".
Many users did not answer this question, perhaps because the time and amount of images vary a lot dependent on the case.
The answers are as follows (first number is the amount of users, second the value)
Static systems - amount of images per case: 6 x 5-10 images; 1 x 20 images
Static systems - time per case: 2 x 10min; 3 x 15min; 2 x 20min; 2 x15 to 30 min.
Dynamic systems - time per case: 3 x 5 min; 2 x 10 min; 5 x 15 min; 3 x 20 min; 2 x 25 min; 5 x 30 min; 2 x 20 to 40 min.

Considering technological reliability and security aspects, the ratings of users and non-users show no significant differences. In summary this factor of the PCA was set on place 5 with an average mean of '3,33'.

System Reliability

In the context of reliability, participants were asked to distinguish between system stability (short interruptions) and system reliability (strong crashes and total break downs, where the system is not usable at all). The PCA calculated system stability to factor five 'workflow', whereas 'system reliability' was added to factor nine 'security'. System stability had an overall rating mean of 3,62 (place 7), whereas system reliability got an overall mean of 3,29 (place eighteen). These values could indicate the urgent need of system stability within a pathological session, especially at frozen section tele-examinations. Users gave system reliability a higher importance (3,45 / place 12), than non-users did (3,20 / place 25). Yet, this difference is statistically not significant. The reason for the different judgement may be based on the fact that several users already rely on telepathology. Especially if examinations have to be executed across huge distances and if there isn't a pathologist at the client's site, it is difficult to switch quickly to the common way of examination. Therefore such users are dependent on a working system. In contrast, non-users may recognize telepathology as an additional way of practicing pathology and as a way to get fast second opinion advises. Therefore they may have rated this point lower. Nevertheless, with an average judgement of 3,29 system reliability has to be taken seriously and in any case emergency alternatives have to be available.

Data Security

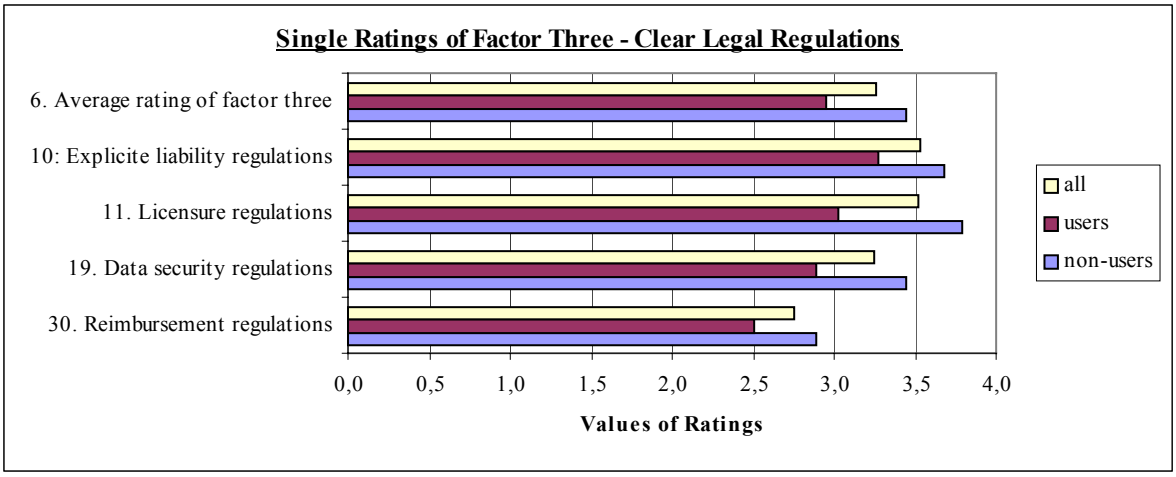
Patients' data is very sensitive. Physicians are aware that insecure data exchange could destroy the confidence between a doctor and his patient. Even pathologists, who already use telepathology systems mentioned in this study that uncertainty of data security is a negative aspect of telepathology. Many physicians believe that the critical concerns of security and confidentiality of patients' data, transmitted on an open network such as the Internet, is currently not guaranteed with the available technology. Therefore most physicians only use the Internet for information gathering or research [Hatcher, 1998/(1), p. 376; Agbamu, 1997, p. 1440]. Until the security problems are solved to an acceptable level, the utilization of telepathology applications via Internet are regarded with skepticism by many physicians. One experienced institution with Internet telepathology services is the AFIP, since it is frequently accessed via Internet. In their respond at this study it was also emphasized that more secure servers for data transmission are desirable. In addition, physicians need information about the security aspects of cyptographical coding, electronic signature or health care professional cards (see chapter 12.3).

Data security (no loss of data during the exchange process, protection from data misuse) was rated higher than system reliability (overall mean: 3,49). Whereas **access control** (access to system and data) was rated in its meaning lower with 3,22. In summary the ratings show that pathologists are serious about the protection of patient data. It also reflects that participants seem to believe that they are able to control the internal access to data. Yet concerning the external data exchange in open networks, they are skeptical about data security.

18.3.3.6 Factor 'Legal Clarity'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 3	7	2,95	0,88	5	3,44	0,67	**6**	3,26	0,78	11,06	**0,001**
4.4.1 Liability regulations	17	3,27	0,92	9	3,68	1,39	**10**	3,53	0,85	5,59	**0,020**
4.4.2 Licensure regulations	25	3,03	1,25	6	3,79	1,40	**11**	3,52	0,93	19,01	**0,000**
4.4.4 Data protection regulations	27	2,89	1,13	16	2,89	0,53	**19**	3,25	1,04	7,01	**0,009**
4.4.3 Reimbursement regulations	35	2,50	1,30	30	3,45	0,78	**30**	2,75	1,32	2,04	0,156

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd to 5th line).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

Figure 33: Ratings of variables referring to legal aspects.

Considering the graphic above, non-users rated the overall absence of legal clarity highly significant higher than users did ($F(1.110)=11,06$, $p<0,001$). In average the PCA-factor three got a mean of 3,26.

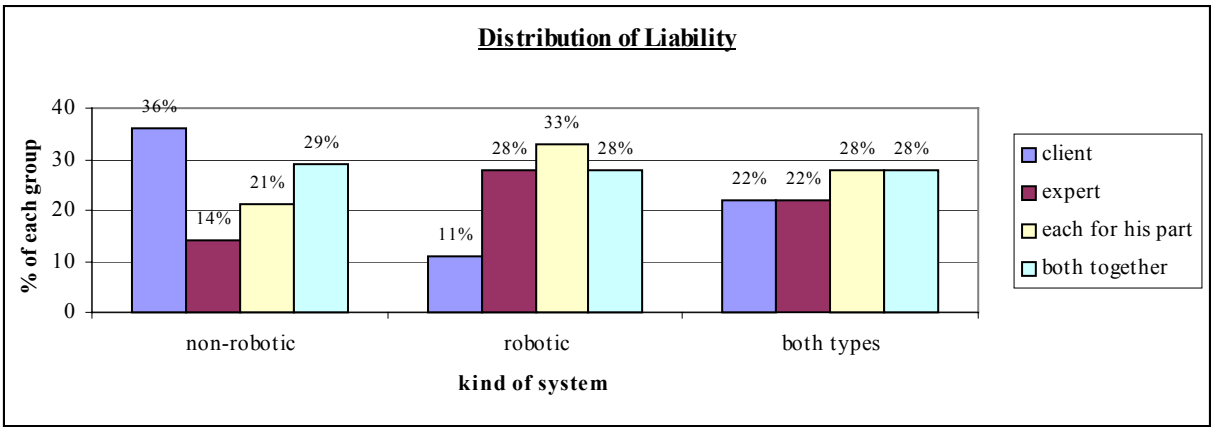
Liability Regulations

With a mean of 3,53 the explicitness of **legal liability regulations** was set on place ten of the importance judgement of all factors (non-users place nine, users place seventeen). The very significant lower judgement of users surprises a little bit. They rated accuracy factors, equipment quality and system stability higher than the liability risk, although compensations for diagnostic errors are very high for physicians. It is even more surprising, since when rating the disadvantages referring to telepathology the problem of 'uncertain legal questions' got the highest rating. This indicates either that users have often solved this problem by special contracts or insurance arrangements, or underlines their personal pioneer character, which make them taking the enhanced risk. In contrast, some non-users mentioned in their comment that they are only willing to use telepathology if liability is settled. The German responding users and non-users especially saw it as legally difficulty if a nonpathologist (surgeon, medical technician) is executing pathological tasks. Legal uncertainty was also mentioned by two Italian participants as a reason for low telepathology acceptance. Non-user often believe that telepathology is not allowed at all at the current jurisdiction. These comments emphasis that the jurisdiction has to be adapted to new technological possibilities like telepathology.

Current Liability Handling

Liability	How do you solve legal liability?								
	client is responsible		expert is responsible		client and expert, each for his part		both together		no comment
static system	4		1		2		2		4
dynamic non-robotic	1	36%	1	14%	1	21%	2	29%	0
dynamic robotic syst.	2 (11%)		5 (28%)		6 (33%)		5 (25%)		4*
all systems	7 (22%)		7 (22%)		9 (28%)		9 (28%)		8

One user is using his system only for research purposes, and at another user liability is covered under the US Federal Veterans Affairs Policy.



Each group counts up to 100%.

Figure 34: Schedule and graphic about liability solutions.

Asking users about their current liability handling, 22% of them answered that only the client is legally responsible, and further 22% replied that only the consultant carries the risk. In 28% of the cases the client and the expert are liable, each for his part, and in further 28% the client and the expert are together liable. Comparing the liability distribution by system type, it is conspicuous that at non-robotic systems the responsibility is rather on the client's side (in 36% only the client is responsible, and in 50% he is partly liable), whereas at robotic systems the expert is more often carrying the liability (in 28% only the expert is liable, in 61% he is partly liable).

In summary the results show that one cannot make a clear statement about the legal responsibility in telepathology. It seems that liability is dependent on the specific arrangements between the client and the telepathologist's or on the jurisdiction of the respective country or region. That makes it obvious that as soon as telepathology services start crossing borders, the problem of clear legal statements will ever increase. Consequently international regulations would be from high value. In any case, before telepathology processes are executed the liability situation should be clearly defined – either by law or by contract.

Licensure Regulations

An aspect which is closely related to liability is the question of **qualification** of all people involved in the telepathology process (**licensure regulations**). This point is rated with a mean of 3,52 (place eleven, non-users 3,79 / place six, users 3,03 / place 25). Again, the rating of the users is highly significant lower compared to non-users ($F(1.110)=19,01$, $p<0,000$). This may be caused by the reason that telepathology participants often know each other personally and therefore can rely on the qualification of their partner. In contrast, non-users may fear that they lose control of the diagnostic quality.

Client's Profession

Since a special point of weakness is the delegation of tasks to the client, participating users were asked about the qualification of their clients. The results are as follows:

Liability	Please give the profession of the participating client.				
	pathologist	**surgeon**	**surgeon and medical technic.**	**med. technician**	**no comment**
non-robotic	14 (93%)	0	1 (7%)	0	2
dynamic robotic syst.	9 (43%)	8 (38%)	3 (14%)	1 (5%)	2
all systems	23 (64%)	8 (22%)	4 (11%)	1 (3%)	4

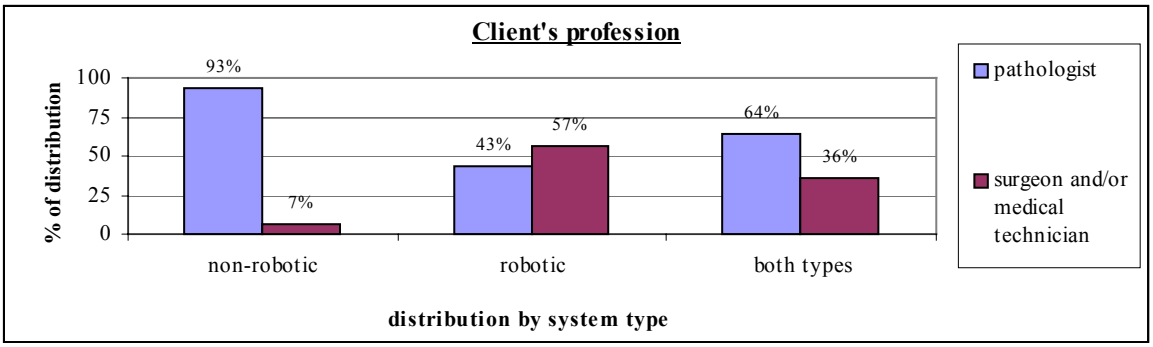


Figure 35: Schedule and graphic about client's profession.

64% (23 users) answered that a pathologist is available at the client's side to execute a proper macro- and micro-examination. In the remaining 36% (13 users) a non-pathologist is handling the system. Of these, 22% (8 users) replied that a surgeon is doing the tasks at the client's side, and 11% (4 users) responded that the surgeon is doing the tasks together with a medical technician. Just in one case only a medical technician is executing all task at the client's side. Four users did not answer the question. In summary, at most non-robotic systems the client is an educated pathologist, whereas 57% of the dynamic-robotic systems are handled by surgeons or medical technicians.

Data Protection

The availability of explicit regulations of data exchange and **data protection** was rated with a mean of 3,25 (place 19). Non-users rated this point significantly higher than users did ($F(1.110)=7,01$, $p<0,009$; users' mean: 2,89; non-users' mean: 3,45). That in summary this point is rated lower than the other legal aspects may be based on the fact that pathologists (especially private doctor's offices) often collaborate with external hospitals or other physicians and therefore have already solved the question of permitted data exchange. Nevertheless, participants are aware that with telepathology the extent of data exchange and the amount of involved people increases, especially if consultations across borders take place. Therefore attention has to be paid to data privacy protection in the context of telepathology interactions. International regulations should be set up (for more information, please see chapter 15.7).

Reimbursement Regulations

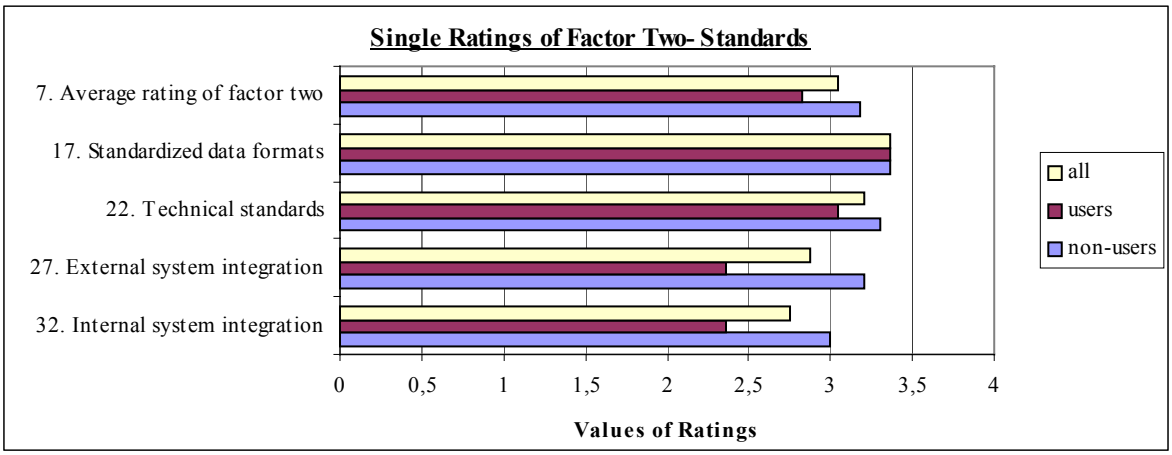
Very surprisingly the rating of the availability of clear **reimbursement** regulations (per contract or law) was only rated with a mean of 2,75 by participants (place 30, non-users

2,89 / place 34, users 2,50 / place 35), although the 'uncertainty of reimbursement' was set on place two of the overall judgement of disadvantages. The reason for this difference may refer to the fact that pathologists are often employed at an institution, where their attention is more focused on the accuracy of diagnoses than on reimbursement. Another reason could be that pathologists may expect that either the question of reimbursement will be solved soon, as this is already the case at several countries, or that reimbursement could be regulated by contracts. Comparing the ratings of users and non-users, there is no significant difference in the judgement of both groups ($F(1.119)=2,04$, $p<0,156$).

18.3.3.7 Factor 'Standardization'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 2	9	2,81	0,69	7	3,18	0,69	**7**	3,05	0,71	7,38	**0,008**
4.8.2 Compatible data + image formats	14	3,37	0,87	19	3,36	0,77	**17**	3,36	0,81	0,00	0,963
4.8.1 Technical standards	23	3,05	0,93	21	3,30	0,78	**22**	3,20	0,84	1,92	0,169
4.8.4 External system integration	36	2,36	1,11	24	3,21	0,91	**27**	2,88	1,08	15,98	**0,000**
4.8.3 Internal system integration (HIS)	37	2,36	1,03	28	3,00	1,05	**32**	2,75	1,09	8,25	**0,005**

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd to 5th line).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

Figure 36: Ratings of variables referring to standardization and integration criteria.

Many users and non-users, who answered the questionnaire recognized standardization of systems and data as an important criterion for telepathology. They expect that standardized systems enable a fast and unproblematic data and image exchange. They would like 'open systems' that all pathologists can access and which are interoperable with other administrative, pathological, and medical systems and resources. Different sources should be integrated in the patient's database, based on international standards. The meaning of unified compatible medical records was already described in detail in chapters 4.3.7 and 14.2.1. To enhance compatibility, one user recommended that telepathology systems should be built up mainly on 'off-the-shelf' components. Another user emphasized that systems have to be open for further developments, adaptable to future needs and based on the current high technological standards. Besides these technical standards, two non-users and two users further claimed that diagnoses and processes have to become standardized to guarantee a smooth communication with other pathologists.

Considering the results of the study, participants judged the meaning of '**standardized data and image formats**' with a mean of 3,36, the influence of '**technical standards**' on the success of telepathology with a mean of 3,20. The ratings of these two aspects differ not a lot between users and non-users and therefore show no statistical significant value

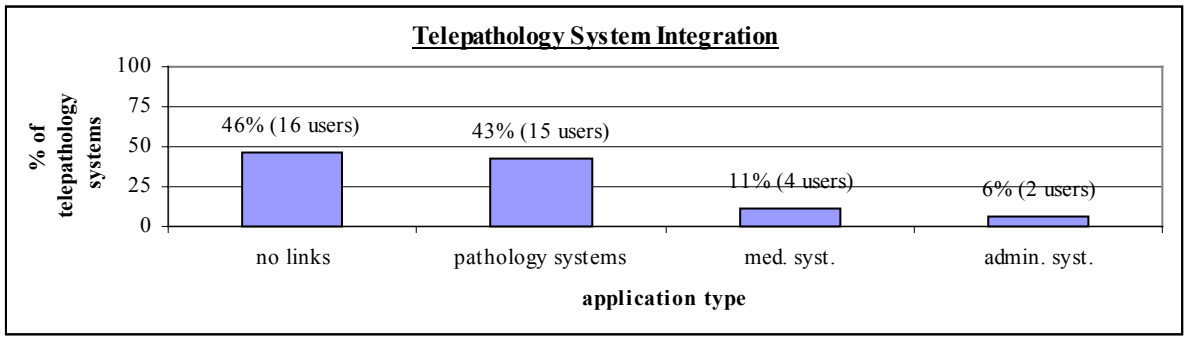
between both groups. Yet, regarding the ratings of the aspects '**external system integration**' (automatic data impute of external data in your system) and '**internal system integration**' (links to internal administrative and medical systems) the values of users and non-users show significant differences. The external integration was judged with a mean of 2,36 at users and with a mean of 3,21 at non-users ($F(1.110)=15,98$, $p<0,000$). The internal integration was rated with a mean on 2,36 at users and with a mean of 3,00 at non-users ($F(1.110)=8,25$, $p<0,005$). These judgements show, that especially non-users claim that telepathology systems should be integrated into already existing information system applications and that investing in isolated solutions should be avoided. The high ratings of users of the first two aspects in comparison to the last two variables reflect that participants are aware that if compatible data formats and technical standards are available, internal and external system integration is considerable simplified.

Influence of Integration and Standard Aspects

To investigate the current situation of users, they were asked concerning the compatibility of their telepathology systems with other internal systems. The results are as follows:

Internal system integration	To which systems is your telepathology system directly linked? Links are available to:						
	no links	**pathology systems**	**medical systems**	**administra - tive systems**	**pathology + medical**	**pathology + administr.**	**no comment**
Telepathology systems	16 (46%)	13 (37%)	3 (8%)	1 (3%)	1 (3%)	1 (3%)	5

The percentages are based on 35 answering users



Med.syst. = other medical applications; admin.syst. = other administrative systems; at the graphic the categories 'pathology and med. system' as well as 'pathology and admin. syst. are added each to its type; the percentages are based on the 35 answering users.

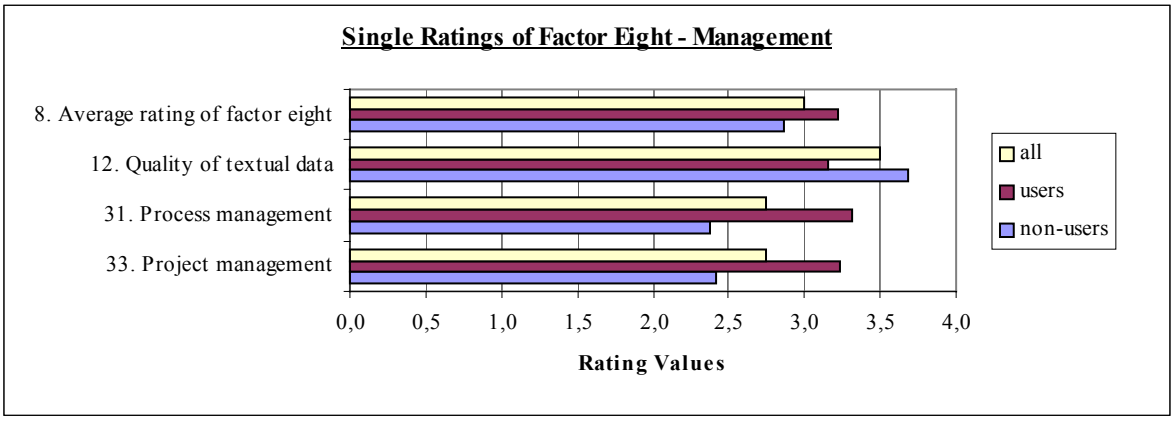
Figure 37: Schedule and graphic about users' situation of system integration.

Regarding the current situation of users, 43% of the used telepathology systems are integrated with other internal pathology systems, 11% have links to other internal medical systems, and 6% are integrated into the internal administrative system. These results show that most telepathology systems are isolated solutions (46%). Yet, integration may not matter a lot as long as utilization rates are low. But as soon as telepathology systems become routine tools, a homogeneous data exchange and overall system integration is very important to avoid redundant data input and data storage. There was no user, whose telepathology system is integrated with all internal information systems. In summary one can say, although users as well as non-users recognize a need for integrated system solutions, the reality still shows a frustrating situation. Not just that telepathology systems are often isolated within the institution's information system environment, but even the communication between different types of telepathology systems is often not possible. To avoid that money is wasted due to isolated, incompatible solutions, effort should be put into standardized solutions and data formats (see chapter standardization 14).

18.3.3.8 Factor 'Management'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 8	6	3,22	0,50	9	2,87	0,82	**8**	2,99	0,74	6,17	**0,014**
4.9.1 Quality of case data	21	3,16	0,94	10	3,68	0,63	**12**	3,50	0,79	10,77	**0,001**
4.3.2 Real-time coordination	16	3,32	0,99	36	3,45	0,93	**31**	2,75	1,34	12,81	**0,001**
4.3.1 Project management	20	3,24	0,88	34	2,89	1,31	**33**	2,75	1,28	10,59	**0,002**

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd to 4th line).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

Figure 38: Ratings of variables referring to management aspects.

Quality of Patient's Data

A criterion, which affects the aspects of management, integration, as well as diagnostic accuracy is the **quality of patient's data** (completeness of data, sufficient data about patient and case). In general it is from advantage, if case data are available in advance. They have to be completely and correctly. Further it is desirable that data is standardized, for it to be directly downloaded into the patient record without additional effort. That sufficient case and patient data have a further influence on diagnostic accuracy has been reported in chapter 16.2.4. The non-users have put this point on place nine (mean: 3,68), whereas the users only put it on place 21 (mean: 3,16). The difference between the judgments of both groups is highly significant ($F(1.110)=10,77$, $p<0,001$). The lower values in the ratings of users may be caused by the fact that most telepathology systems have a patient record, where essential data are requested from the client. In this way telepathology guarantees a high degree of data completeness (see chapter 16.2.4). The availability of these integrated forms (medical records) may also explain the factor loading result (see chapter 17.1.3). The PCA analyzed this criterion to factor eight 'management', but with a negative sign. That is that if telepathology sessions are organized carefully, the availability of correct patient case data is taken for granted.

Management Criteria

To make telepathology successful some participants of this study emphasized the necessity of a careful management. They suggested a **step-by-step introduction** based on a concept, which is focused on the overall integration of health care systems and medical records. Goals have to be defined very focused for not losing control of them, as one participant experienced at his project. It should be carefully analyzed which services are currently lacking and defined how the new technology could change this situation. In this way it can be guaranteed that implementation is based on the services needed instead of the

technology being used. Goals should be based on the departments strategy and technological situation of participants, instead of just propagating illusory advantages and blinding patients to win competitive advantages, is a criticism of one non-user. Before a final decision is made one user recommended to execute **feasibility studies** and to setting up **demand analyses** to match the equipment with service demands. Another user remarked that it is useful to define a competent person, who is in charge of telepathology. This user also claimed that the whole implementation process of telepathology has to be done carefully with a satisfying user support. Good technical support has to be available during as well as after the introduction. Two users remarked that systems should only be introduced, if they proved to be user friendly and advantageous. That is why potential users should participate early in the planning and selection process and be part of the project management team.

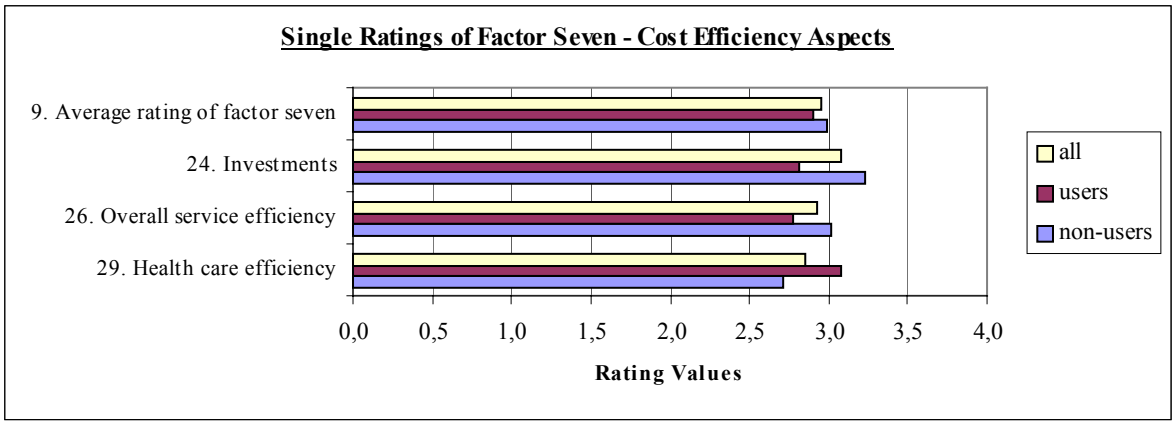
An additional problem of telepathology is the coordination of synchronous telepathology sessions. Four users of telepathology and several non users of this study supposed a problem in the coordination of telepathology interactions. As a result, unproductive waiting time could cause frustration and thus reduce telepathology's acceptance. Further, since at telepathology sessions at least two persons are involved, it has to be clearly specified a) who is responsible for organizational questions, and b) who will be responsible for which task at which time (e.g. documents and data have to be available in time to guarantee an efficient workflow process) [Klutke, 1997, p. 76; Prasse, 1995, p. 262; interview Oberholzer at the field-study in Basel in 1999].

Considering the judgements of management factors, the differences are highly significant between users and non-users. Users judged the influence of good **processes management** (coordination of system usage, no waiting times, clear time tables for dynamic telepathology sessions) with a mean of 3,32 (place 16), and the influence of a well **structured project design** and management at the system implementation with 3,24 (place 20). In contrast, non-users judged the influence of a well coordinated system usage with 2,38 (place 30), and the effect of a good project design with a mean of 2,41 (place 36). The much higher rating of users could be caused by the fact that users already made the experience that telepathology introduction has to be competently planed to win the acceptance of participants and to avoid the waste of resources. They further seem to have recognized that uncoordinated real-time sessions cause frustration. Due low utilization rates the problem of waiting times may not occur currently on a large scale. Yet, as soon as real-time sessions are executed on a regularly basis unproductive workflow could lead to a rejection of telepathology utilization.

18.3.3.9 Factor 'Cost Efficiency'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 7	8	2,90	0,88	8	2,99	0,84	**9**	2,95	0,85	0,28	0,595
4.6.1 Investment costs	30	2,81	1,10	22	3,23	0,94	**24**	3,08	1,02	4,09	0,046
4.6.2 Cost effectiveness of services	32	2,78	1,06	26	3,02	1,19	**26**	2,93	1,15	0,98	0,324
4.6.3 Health care efficiency	22	3,08	1,11	31	2,71	1,29	**29**	2,85	1,24	2,04	0,156

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2^{nd} to 4^{th} line).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

Figure 39: Ratings of variables referring to the cost efficiency of telepathology

Considering how participants judge the influence of different efficiency criteria on the success of telepathology, the criterion **investment costs** got the highest rating with a mean of 3,08. The non-users rated this aspect significantly higher (mean of 3,23) than users did (mean of 2,81). The variable '**cost effectiveness of services'** also got a higher rating by the non-users (mean of 3,02) compared to the users (mean of 2,78), but this difference is statistically not significant. Another criterion, which also has an impact on monetary efficiency is the availability of clear reimbursement regulations (overall mean: 2,75). The influence of this aspect was also rated higher by non-users (mean of 2,89) than by users (mean: 2,50). Yet this aspect was added to factor three 'legal clarity' by the PCA. Finally, the improvement of the overall '**health care efficiency**' (faster diagnoses, shorter treatment procedures) was rated higher by users (3,08) than by non-users (2,71). This difference is also statistically not significant. The higher ratings of the users could be caused by their situation. Many current users are keen on telepathology introduction for teleconsultations to overcome distances and to avoid long transportation times. For them the structural improvements seem to have a high value.

Comparing these ratings with the judgement of disadvantages or the statements about colleagues reasons for telepathology's rejection, participants set investment costs and uncertain reimbursement on place two and three of their advantage judgements. Controversially, at the rating of the factor of influence for telepathology's success efficiency aspects just appear at place 24, 26 and 29. These results indicate that participants recognize system costs and efficiency aspects as a barrier of telepathology introduction, but that in general they expect telepathology to be successful if it proves to be a vital tool in pathology. In summary, with ratings of approximate a mean of three the influence of monetary aspects also have to be taken seriously in the context of telepathology's success.

Discussion of Investment and Operational Costs

Two non-users of this study complained that the financial requirements are not on hand for telepathology introduction. This was also criticized by three users, who especially missed the support for capital expenditures and the reimbursement of services. One user in Sweden further complained that only three workstations are in use, mainly due to cost factors. Another user and one non-user meant that telepathology is far too expensive for blanket coverage.

That investment costs are vital is confirmed by several other comments. At least six users of static systems mentioned the low price for equipment as very positive. Yet, although static systems are much cheaper than dynamic ones, three users of static systems still described the high expenses for telepathology examinations and the investment cost as a problem. Considering dynamic systems, four users of dynamic systems said that the high price for their systems was a problem. Also two non-users expressed that they would like to use a dynamic system, but they are not able to spend the high amount of money. A user of a dynamic system in Germany, who already stopped using his system, said that it is for him very difficult to find the right mixture of good equipment and reasonable price for his needs.

Another user remarked that colleagues are often too focused at expensive brand-name products, instead of choosing more inexpensive but also satisfying solutions. Yet, for a pathologist it is very difficult to select the most efficient system for his purpose and therefore he/she may prefer to rely on well known suppliers. One user desired that high resolution digital scanning has to become a cost-effective alternative to glass slide examinations, otherwise in his opinion telepathology only will be used as a hobby. Finally one user claimed that systems have to be modular to guarantee efficiency in the context of user needs. He further recommended to use freely available modules like NetMeeting or File Maker to keep development costs of systems low.

All these comments show, that investment costs are problematic and that often compromises have to be made.

Situation of Users Referring to Cost Criteria

Investment Costs

Users were asked to give the approximately investment costs of their telepathology equipment, distinguished by client's and consultant's side. Unfortunately many users were not informed about the overall investment costs of their systems. Not rarely systems were self-programmed or developed by research departments where the costs were not recorded exactly. Other users got the chance to participate at a sponsored pilot project of a telepathology system vendor and therefore they did not have to think about costs. The investment costs were sponsored or carried by different parties and therefore the overall costs are not available.

Finally approximately 50% of the participating users gave information about investment costs. The costs for static systems vary at the client's side between US-$ 2.000 up to US-$ 45.000, and at the consultant's side between US-$ 1.000 up to US-$ 45.000. The lowest price occurred at a system in Italy, whereas the most expensive system was employed in Japan. Considering the robotic systems, the costs range at the client's side from US-$ 40.000 (Switzerland and Italy) up to US-$ 90.000 (Germany, UK), and at the consultant's side from US-$ 4.000 (Austria, Germany) to US-$ 25.000 (Norway, Italy). One user (UK) even named an amount of US-$ 90.000 as investment cost at the consultant's side. Three users did not distinguish by client's and consultant's investment costs. One system cost US-$ 120.000, one US-$ 150.000, and one was even quoted with US-$ 550.000 (Japan).

The statements of the users indicate that they are often not sure about the exact investment costs. It further reflects that the systems are quite different in price and consequently also in

design and performance. The final investment costs are heavily dependent on the situation of the user. In addition, prices are changing constantly in the computer market. That is why it is difficult to give statements about guiding price values. Nevertheless in chapter 13.4.3.4 three rough examples about system components and prices are given.

Situation of Users Referring to Financing

Users were further asked about the financing of their capital expenditures. Again 35% (14 users) either did not know who paid for their system, or did not want to answer the question. From the remaining users, 70% (18 users) said that their system is financed by state or research subsidies. Only 15% (4 users) meant that their system is paid by the budgets of participants. Three of these systems are static ones, and only one is dynamic-robotic, located at a metropolitan medical center. One user answered that his system is financed by a mixture of research funding and participants money, and another one said that his costs are covered by research money and telepathology revenues. A further user remarked that his system is paid by the IT-department, and a last one said that his institution got the system from a system vendor for free. In summary, most systems of the users had been financed by subsidies.

Situation of Users Referring to Operational Costs

Asking users about the average cost per examination of a tele-case (including network costs, staff salary, etc.), only three users answered this question. One user said that a session costs about US-$ 10. This user is employing a static system, which he mainly is using for second opinion consultations. For the frozen sections, which he is also executing with his system, he did not give the operational expenses. The other two users are working with a dynamic-robotic telepathology systems. One of these two users said that one session demands about US-$ 220 operational costs. He is employing his system for second look and reference consultations, but not for primary diagnostic. The other is using his system for frozen section examinations and for reference diagnostic consultations. In his estimation operational costs are approximately US-$ 700 per session. These amounts indicate that operational expenses do either vary a lot, depending on the kind of service executed and the region of the user, or that users do not exactly know their operating costs and therefore the estimated amounts are so different. Differences could further relate to the included costs. For example, it makes a huge difference, whether depreciation of equipment is included in the calculation or not (for operational costs please see chapter 13.4.3). Further investigations in this area are desirable.

Savings

In this study the most often mentioned advantage of telepathology systems in the context of efficiency was the reduction of consultation travels and by this the time which can be saved. One user added that he appreciates the minimized risk of „being killed on the road“. Another user highlighted the shortening of operation time for the patient and the reduced waiting time of the operation team for the diagnostic result as a positive argument for telepathology. Non of the participants mentioned reduced labor costs at the clients site as an argument of saving resources due to telepathology introduction.

Situation of Users Referring to Revenues

Only five users answered that their telepathology services are reimbursed. Most users are not paid for their telepathology services. One user said that his revenues for second opinion consultations are approximately US-$ 60, and another one gave the amount of US-$ 22. Doing frozen section examinations one user quoted revenues of US-$ 200. A further user who is doing frozen sections as well as second opinion consultations is charging approximately US-$ 50 per session. The price list of the AFIP is added in appendix IV. In summary, the revenues of telepathology services is currently frustrating, since there is mostly no payment. Hopefully this situation will change soon.

Capacity Utilization at Existing Systems

An additional problem of revenues are the low capacity utilization rates, which do not allow an efficient amortization of the investment costs.

The capacity utilization of telepathology systems is often low. Most telepathology systems are utilized in a limited or experimental situation (partly for economical reasons). For example, at a study with a static imaging system in Sweden, although more than 50% of the users answered that they would like to have access to telepathology in their department, telepathology was not used as frequently as might initially be thought. Many physicians used the method less than once per week [Olsson, 1995, p. 240]. Another example are two Caribbean colleagues (in Guadeloupe), who are theoretically best placed for the use of telepathology due to their geographical situation. Nevertheless, in fact they have used their telepathology system only 19 times during a 12-month period. At a further project in France a specialized network between 7 French hematocytologists was introduced in 1994, which is only used about 3 to 8 times a month. Also other telepathology projects reported an average utilization rate not higher than 3 to 15 times a year. One reason for this may be the lack of experience. Another one the habit to do examinations in the common, well known way. Many users also object that telepathology is too time-consuming. Poor compatibility between different varieties led to further low utilization.

At the study in Constance this situation was confirmed and the low level of utilization was criticized by several users, too. In summary, the total amount of telepathology examinations compared with the overall examinations of a department was far below one percent (examination numbers of participating users see chapter 19.3.2.4, please).

Conclusion of Participant's Financial Situation

Most of the systems are still financed by research money or state funding. Financing from other sources is rare. It is difficult to get clear data of investment and operational costs out of this study, since users often do not know the clear financial situation. Costs seem to be dependent on the system employed, the services offered and the specific conditions of the users (national structures, health politics, price politics, network infrastructures, etc.). Revenues are rare. Only at some countries, like in Japan, are there regulations concerning telepathology reimbursement. Perhaps that is an additional reason for the overall low capacity rates of telepathology services, which make it difficult to write black numbers in efficiency calculations. In summary almost no system of the participants (exception: AFIP) reached the break-even point in cost-benefit calculations.

18.3.3.10 Factor 'Surrounding'

Individuals and Institutions that may have an Influence on Telepathology's Success

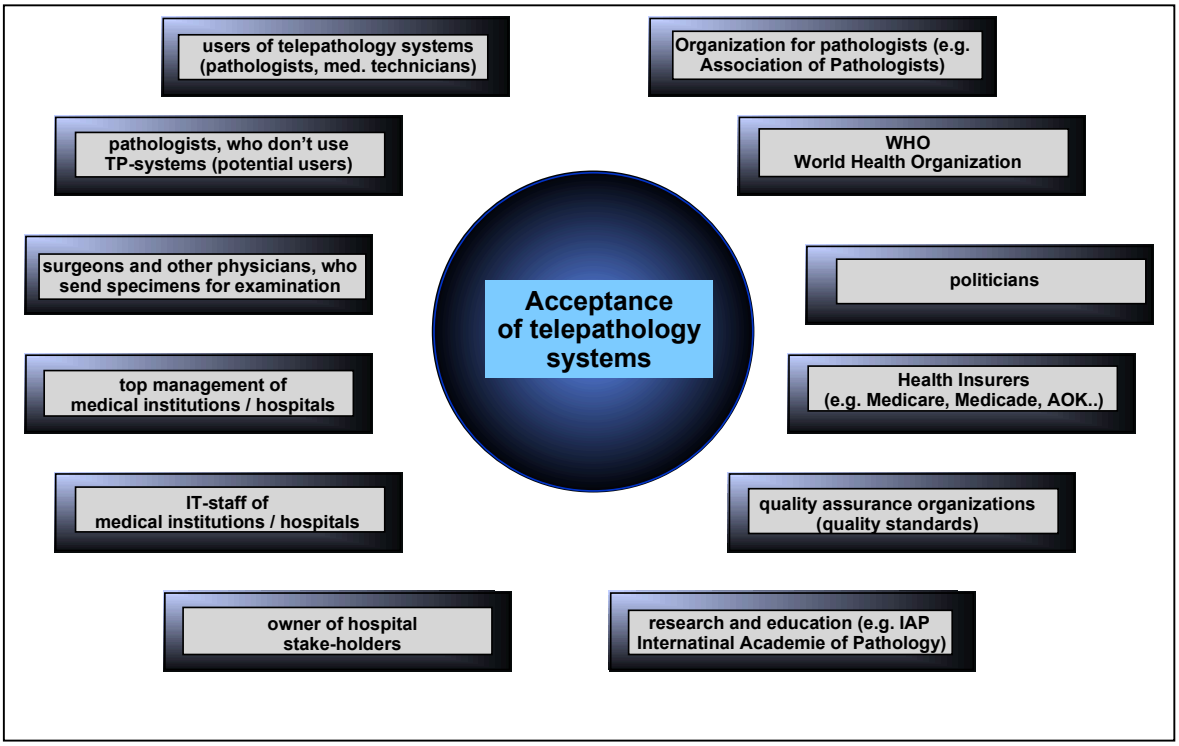


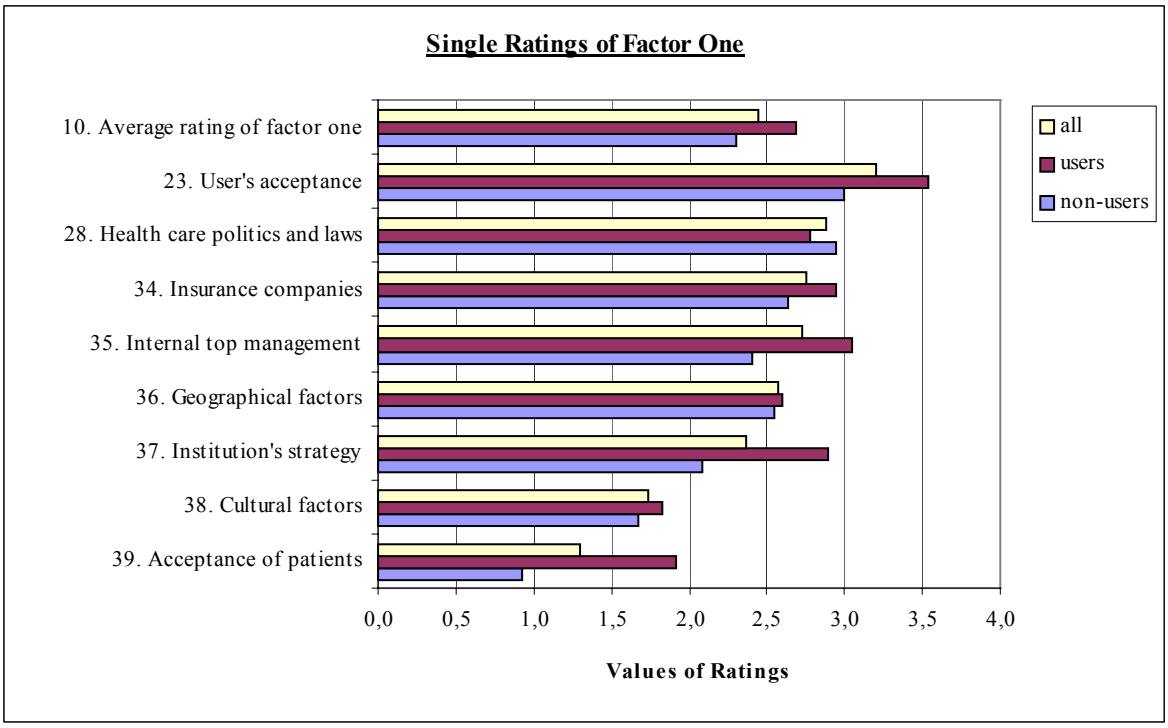
Figure 40: Organizations and human beings with an influence on the success of telepathology.

The figure above shows some of the major players in the health care policy process, who may have an important influence on the acceptance of telepathology systems. On the left side one can see several internal key decision makers with an influence on the introduction of telepathology systems, whereas on the right side external decision making organizations and associations are demonstrated. The attitudes of several parties had already been described (see chapter 10.1).

Judgements of Environmental Aspects

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 1	10	2,69	0,55	10	2,30	0,85	**10**	2,44	0,78	6,56	**0,012**
4.1.4 Internal accept. - users	7	3,54	0,92	27	3,00	1,32	**23**	3,20	1,22	4,77	**0,031**
4.2.1 Health care politics / laws	33	2,78	1,35	29	2,94	1,31	**28**	2,88	1,33	0,38	0,539
4.1.2 External acceptance (HMOs)	26	2,95	1,10	32	2,64	1,34	**34**	2,75	1,26	1,42	0,235
4.1.3 Internal accept.– top management	19	3,25	0,98	35	2,41	0,15	**35**	2,73	1,38	8,95	**0,003**
4.2.3 Geographical factors	34	2,60	1,30	33	2,55	1,41	**36**	2,57	1,37	0,04	0,851
4.2.2 Institutions politics/strategy	29	2,89	1,07	37	2,08	1,46	**37**	2,37	0,14	8,30	**0,005**
4.2.4 Cultural factors	39	1,82	1,27	38	1,67	1,25	**38**	1,73	1,26	0,30	0,583
4.1.5 Acceptance - patients	38	1,91	1,46	39	0,93	1,21	39	1,30	1,39	11,69	**0,001**

The columns ‚pl.' (place) gives the order of ratings a) of the 10 factors (first line), b) of all 39 variables (2nd to 9th line).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users).

Figure 41: Ratings of variables referring to the surrounding of telepathology (e.g. politics)

Users' Acceptance

The success of a new technology is related to the acceptance of the people concerned. Participants rated the meaning of **users' acceptance** the highest (mean of 3,20 / place 23). Considering the two groups of participants, users rated this factor significant higher with a mean of 3,53 and set this point on place seven, whereas non-users rated it lower with 3,00, which puts it on place 27 ($F(1,110)=4.77$, $p<0,031$). This may indicate that users acquired the experience that motivated pathologists are necessary to make telepathology successful.

Acceptance of Political Decision Makers

Three participants of this study argued that the attitude of professional pathological associations has to become positive about telepathology, otherwise it will be difficult to gain success. Other participants stated, that health care politicians also have to consider telepathology as a valuable, reimbursable tool to make it successful. Further one participating user wrote that organizations like the IAP for pathological training and education should be early involved in telepathology conceptions. The positive attitude of the IAP could increase the overall acceptance of telepathology and support a well coordination of training and utilization.

Considering the judgements of participants the influence of political decision makers was rated quite low compared to other aspects, like for example accuracy criteria or equipment quality. The average ratings of the **influence of externals** on telepathology's success (insurance companies, HMOs, health care politicians and provider, etc.) reached a mean of 2,75 (place 34). The users rated this point slightly higher (mean of 2,95 / place 26) than non-users did (mean of 2,64 / place 28). Yet, this difference is statistically not significant. Also the influence of the **internal top management's acceptance** (clinical director, medical director) was rated higher by the users (mean of 3,25 / place 19) compared to the non-

users (mean of 2,41 / place 35). This time the higher rating of the users is statistically highly significant ($F(1.110)=8395$, $p<0,003$). The non-users judged the influence of externals higher than the influence of the internal top management, whereas at the ratings of the users it is vice versa. In summary the results show that the acceptance of users is not sufficient, but that the acceptance of externals and of the internal top management is necessary, too.

Also the influence of political aspects on telepathology's success were investigated in this study. Political aspects were distinguished between the influence of overall **health care politics** and **internal politics** of an institution. The relations between the judgments of both groups are similar to the ratings of external and internal acceptance. The non-users rated the influence of health care politics and laws (mean of 2,94) higher than the influence of internal politics (mean of 2,08). Whereas the users rated the influence of internal politics on telepathology's success higher (mean of 2,89) than the influence of health care politics (mean of 2,78). The difference of the ratings for the aspect 'internal institution's politics' is very significant between both groups ($F(1.110)=8,30$, $p<0,005$), whereas the differences of the judgments of the meaning of health care politics is statistically not significant. Examining especially the influence of internal politics, the experience of already introduced telepathology systems showed that telepathology's success is higher if it is a part of the institution's politics. This is also confirmed by the reasons users named for telepathology introduction at this study (chapter 18.1). 60% of the users mentioned as reason for telepathology introduction that it was a strategic decision. Their institution wishes to cooperate with other partners by telepathology to improve the competitive situation. Considering the overall ratings of all criteria referring to the PCA-factor 'surrounding', participants have set political aspects in the context of telepathology's success on a quite low position. However, interviews with telepathology project leaders showed that especially politics can become a pitfall for telepathology (see comments of Williams and Moore at chapter 10.1.6). Further research is desirable.

Influence of Patient's Acceptance on Telepathology's Success

Interviews with patients showed that patients are skeptical about telemedicine systems since they fear a lack of privacy [Williams, 1995]. They further fear that the relationship with their physician could become impersonal and anonymous [Lumsdon, 1992]. However, experience with existing systems demonstrated that patients' acceptance of this technology is not a problem, if the patient becomes conscious about the advantage of it [Puskin, 1995/(2), p. 127; Wyman, 1994; Bergman, 1993/(2)].

At this study the criterion '**acceptance of patients'** got the lowest rating of all factors (average mean of 1,30 / place 39). The non-users rated this factor highly significant lower with a mean of 0,93 than users determined it (mean of 1,91). That the influence of patient's acceptance was estimated quite low in comparison to other criteria may be caused by the fact that pathologists do not come in direct contact with the patient. That is why the acceptance of the patient does not have such a high impact as it is the case at other medical disciplines. Experiences at existing projects proved that patients recognize the advantages of telepathology services and that acceptance of patients is for the most part not a problem. Nevertheless, if telepathology is employed, the telepathologist is recommended to ask for written permission from the patient that his diagnosis will be executed using telepathology to create a clear, confident, and liable situation. Users may be more aware of this situation and therefore have rated the influence of patient's acceptance with a mean of 1,91.

Cultural Factors

Both groups saw in cultural factors (e.g. historical structures, pathological ethics) the least important aspect for telepathology's success, together with the meaning of the criterion 'patient acceptance'. **Cultural factors** were rated by the users with a mean of 1,82 (place 39) and by the non-users with a mean of 1,67 (place 38). The low rating of cultural factors could be based on the fact that pathologists are anyway facing a situation of permanent changes and therefore they do not recognize cultural factors as a major barrier for telepathology introduction.

Influence of Geographical Factors

If a physician is geographically isolated, his interest in telemedicine support and his acceptance may be higher than the one of a physician, who is located at a congested area. The same could be assumed, if he is employed at a hospital, which won't survive without a closer cooperation with other health care providers. Four non-users and one user pointed exactly at these criteria. Two of them stated that in Germany there are so many pathologists in place that telepathology is not necessary. However these pathologists recognized the need for telepathology for military usage and for zones with huge distances or difficult conditions like islands or locations in the mountains.

At the study in Constance, the influence of **geographical factors** was rated with a mean of 2,57 (place 36). This low position is surprising again, especially since telepathology is often introduced at remote locations. Regarding the situation of users, currently many primary diagnoses are executed for clients, who are located in remote regions. One explanation could be that participants recognize telepathology systems not just as a tool to overcome distances, but also as a technology which helps to improve the quality of pathological services (e.g. improved education, better communication). Therefore geographical aspects may have gotten a secondary meaning.

To judge the meaning of distance, participating telepathology users were asked at which distance they regard telepathology to be more efficient than specimen transportation. They should give their judgements in kilometers and in minutes. The answers were as follows:

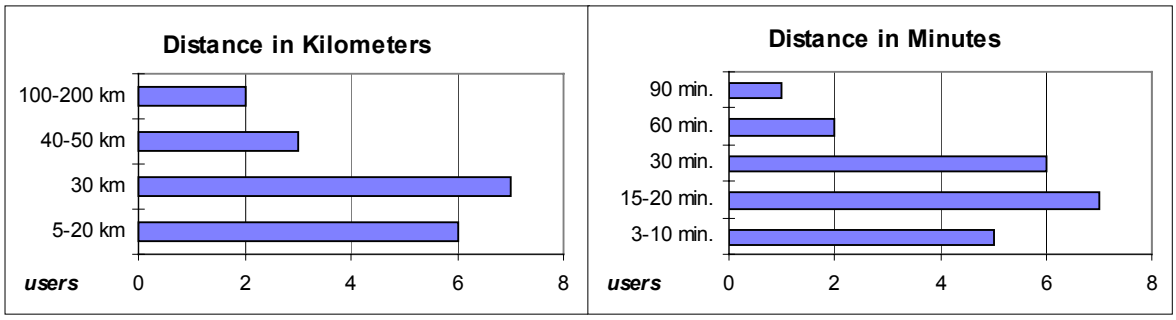


Figure 42: Distances where telepathology is seen as suitable.

Considering the estimated kilometers where telepathology will become suitable, one user stated 5 km, two 10 km, three 20 km, seven 30 km, one 40 km, two 50 km, one 100 km, and another one even 200 km. Judging the minutes, two users ment 3 minutes, three 10 minutes, four 15 minutes, three 20 minutes, six 30 minutes, two 60 minutes, one 90 minutes, and one even 4 hours. That these estimations are so different may be based on the different situation of users. If a user is located at a densely populated region, transport

times and distances are short, whereas a user at a thinly populated region, surrounded by mountains covered with snow in winter time (e.g. Montana/USA) or by an ocean (Tenerife) may come to a completely different judgement. Many users (38%) did not give an answer to the question about telepathology's utilization referring to distances. It could be that these users either think that distances are a secondary factor of telepathology introduction, or they simply leave this aspect to feasibility studies. In summary, most users estimate telepathology to be more efficient than specimen transport at a distance between 20 to 30 kilometers, and at a time between 20 to 30 minutes.

18.3.3.11 Summary of the Ratings of Critical Factors of Success

Considering the overall rating of the critical factors of success, the highest values were given to factors related to diagnostic accuracy (image quality, sample preparation, accuracy of macro- and micro-examination). Further high ratings in the judgement of telepathology's success were given to factors like quality of equipment, user-friendly interfaces, system stability and legal aspects. Behind these factors participants judged the influence of security aspects, the necessity of data and image standardization, and satisfying user support in the selection of appropriate systems, as well as in system usage (training, online help-desks) also very high with a rating between 3,0-3,5 at the scale from zero to +4. The influence of efficiency criteria (investment costs, amortization) and of management aspects (project management, telepathology session coordination) were rated lower in comparison to the other factors. And last but not least, political, geographical and cultural aspects were set on the end with the lowest judgements for the influence of telepathology success. In summary, many factors got a rating of three or higher. This indicates that most of the considered factors have to be taken seriously when introducing telepathology systems.

18.4 Users Compared to Non-Users – Advantages and Disadvantages

To discover the meaning of various advantages and disadvantages for participants, they were asked to judge several aspects of telepathology on a scale from zero (no dis-/advantage) to +4 (high dis-/advantage). The hypothesis behind these ratings was that if the expected advantages for potential users of telepathology systems are high, it is to assume they are keen on using them. In opposite, if disadvantages are higher than the advantages, users may refuse to utilize telepathology. The results of the judgements are demonstrated as follows.

18.4.1 Judgement of all Advantages – Summarized Overview

> *„The real value of telemedicine and medical informatics, however, is their ability to raise patient care to a new height, a level which is beyond the current health care provider's capability to achieve unassisted." [Clemmer, 1995, p. 47]*

The following graphic shows participants' judgements, sorted by the mean of the ratings 'all'. These data should give a general idea of the advantage ratings. Yet, the single advantages are discussed at the sub-chapter, where the accumulated factors of advantages and disadvantages are considered.

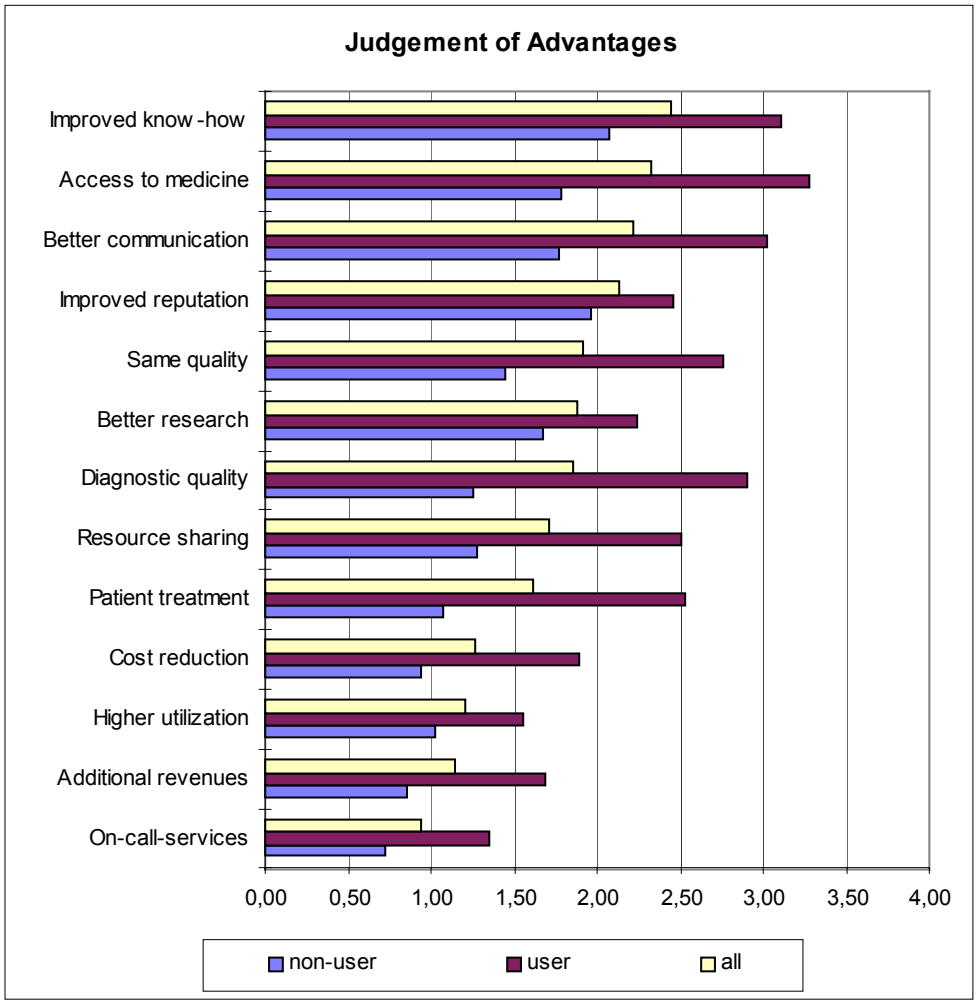


Figure 43: Analysis of the advantages of telepathology systems.

18.4.2 Judgement of all Disadvantages – Summarized Overview

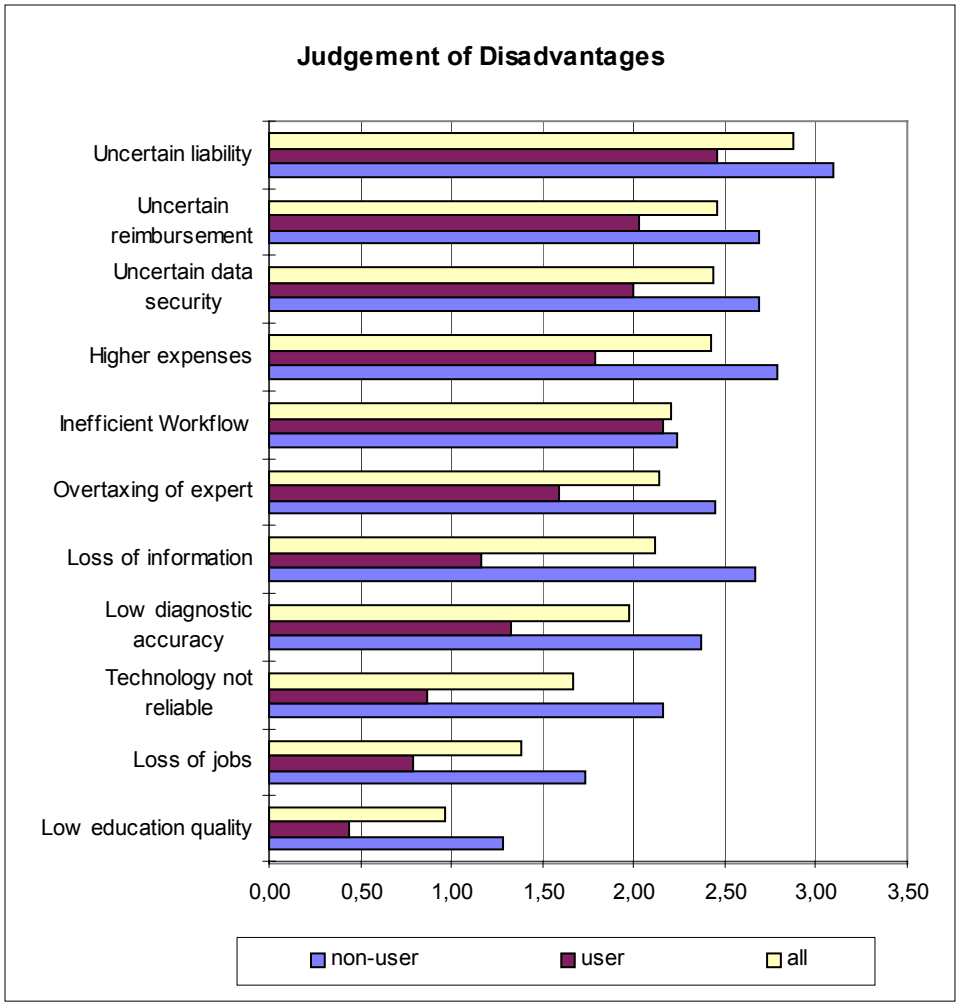


Figure 44: Analysis of the disadvantages of telepathology systems.

18.4.3 Users Compared to Non-Users – Accumulated Dis-/Advantages

A PCA-factor analysis was executed to analyze relations within the single ratings of the various advantages and disadvantages and to reduce the high amount of criteria. Finally the 24 variables were accumulated to the following 6 factors:

Short (contraction)	Factor Number and Factor Name	User			Non-user			All			Significance	
		Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
QUAL_3	**A3** High quality medicine	1	2,89	0,81	4	1,84	1,01	**2**	2,21	1,07	31,58	**0,000**
EFFIC_3	**A2** More efficiency	2	2,24	0,69	5	1,25	0,91	**5**	1,60	0,97	35,81	**0,000**
ONCAL_3	**A5** Background services	5	1,35	0,99	6	0,72	0,99	**6**	0,94	1,04	9,54	**0,003**
UNCER_3	**D4** Uncertain situation	3	2,20	1,07	1	2,81	1,09	**1**	2,59	1,12	8,07	**0,005**
WORKF_3	**D6** Workflow inefficiency	4	1,90	1,14	2	2,33	1,16	**3**	2,17	1,16	3,50	**0,064**
FEAR_3	**D1** Fears	6	1,09	0,85	3	2,13	0,93	**4**	1,76	1,03	33,87	**0,000**

The schedule above shows the dis-/advantages sorted by the PCA factor analysis number (D= disadvantages; A= advantages; e.g. **D**1= PCA-factor 1, **d**isadvantages; **A**2=PCA-factor 2, **a**dvantages). The significant values between users and non-users are illustrated at the last column. Further, the means and standard deviation of the different groups are illustrated, and for each group the overall place (pl.) of the ratings are given in addition. A table with the detailed values of the statistical analysis can be seen in appendix X. The F value of the calculation is 1.110. The number in front of each criteria gives the range of a factor sorted by the mean of ‚all'. It is not distinguished by dis-/advantages.

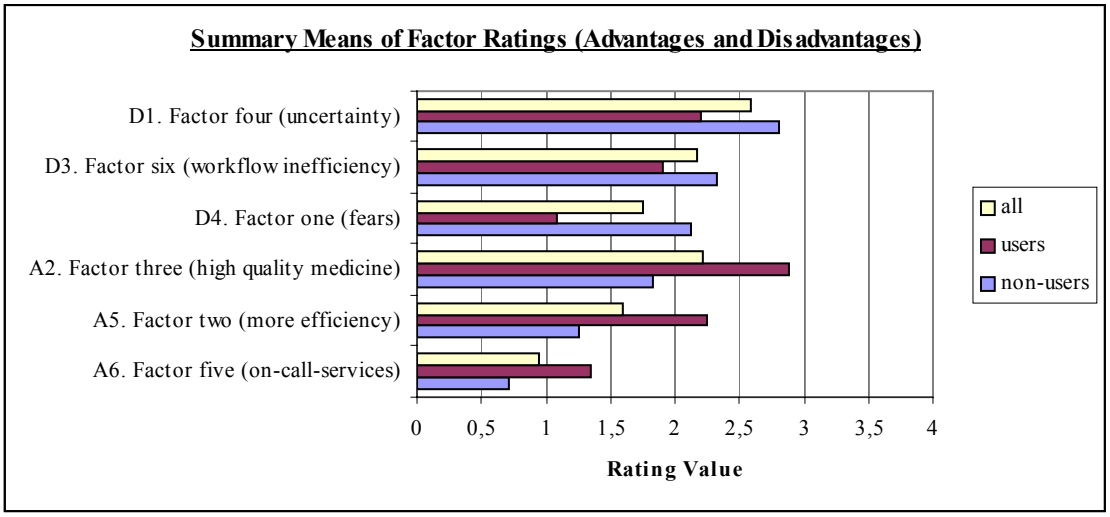


Figure 45: Schedule and graphic of the 6 accumulated dis-/advantage factors of the PCA.

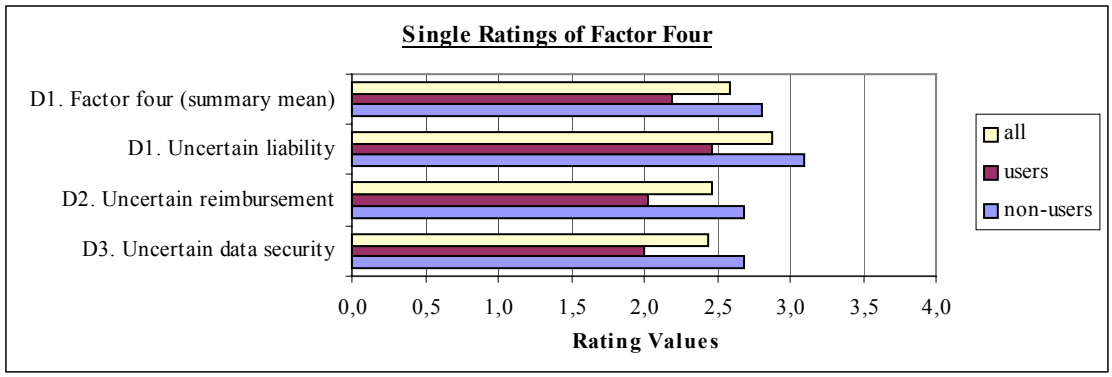
The schedule above shows clearly, that the ratings of users and non-users vary a lot. The users judged the advantages much higher than non-users did, whereas disadvantages are rated much higher by non-users. The highest ratings of advantages were given to the factor 'improved quality of medicine' by users (mean of 2,89) as well as by non-users (mean of 1,84). The lowest values of advantages was given to the availability of 'background services' (mean of users: 1,35 and of non-users: 0,72). The highest ratings of disadvantages were caused by criteria referring to the uncertain situation of telepathology. Users had a mean of 2,20 and non-users 2,81. The lowest values of disadvantages can be found for the factor 'fears' at both groups (mean of users: 1,09 and of non-users: 2,13). The differences between users and non-users are significant at all factors.

18.4.4 Discussion of Single Values

18.4.4.1 Discussion of the Factor 'Uncertainty'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 4	3	2,20	1,07	1	2,81	1,09	**1**	2,59	1,12	8,07	**0,005**
D5.3.7 Uncertain legal situation	1	2,46	1,29	1	3,09	1,28	**1**	2,87	1,32	5,57	**0,020**
D5.3.9 Uncertain reimbursement	3	2,03	1,40	3	2,69	1,45	**2**	2,46	1,47	4,88	**0,029**
D5.3.8 Uncertain data security	4	2,00	1,41	4	2,69	1,35	**3**	2,44	1,41	5,81	**0,018**

The columns ‚pl.' (place) gives the order of ratings a) of the 6 factors (first line), b) of all disadvantages (2nd to 4th line). F(1.110).
For the whole summary schedule see appendix X, p.11, please.



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users). D=Disadvantage.

Figure 46: Ratings of variables referring to the disadvantage of related to uncertainty.

Uncertainty of Legal Situation

The legal situation of telepathological consultations is dominated by uncertainty. Uncertainty about license questions, uncertainty about liability, and uncertainty over whether telepathology consultations are in agreement with pathological professionally. A situation indeed, which is not positive for the success of telepathology system utilization. Therefore it is no surprise that legal uncertainty got the highest valence in the judgement of telepathology disadvantages (in average a mean of 2,87, by non-users even 3,09).

Uncertainty of Reimbursement

Most of the telepathology services are currently not reimbursed. As long as there is no reimbursement, most pathologists prefer to stay away from high investments. This is confirmed by the rating of disadvantages. Uncertainty of reimbursement was the second meaningful disadvantage and therefore rated very high (in average 2,46). Considering the two groups, non-user set this disadvantage on place four (2,69) and users on place three (2,03).

Uncertainty of Data Security and Data Protection

Many pathologists named data security as a major problem in telepathology. First of all they do not know which kind and amount of data they are permitted to exchange with other colleagues. And they know that patient data is sensitive and therefore, there is fear about data being lost in open networks or even stolen by not authorized individuals. Data security and protection was rated with an average mean of 2,44 (place 3, mean of users: 2,00 and of non-users: 2,69). The difference between both groups is very significant ($F(1.110)=5,81$, $p<0,018$).

18.4.4.2 Discussion of the Disadvantage Factor 'Workflow Inefficiency

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 6	4	1,90	1,14	2	2,33	1,16	**3**	2,17	1,16	3,50	**0,064**
D5.3.4 Inefficient work routine	2	2,16	1,37	8	2,24	1,41	**5**	2,21	1,39	0,07	0,79
D5.3.3 Overtaxing of expert	6	1,59	1,40	6	2,45	1,40	**6**	2,14	1,46	8,52	**0,004**

The columns ‚pl.' (place) gives the order of ratings a) of the 6 factors (first line), b) of all D=disadvantage (2nd to 3rd line). F(1.110).
For the whole summary schedule see appendix X, p.11, please.

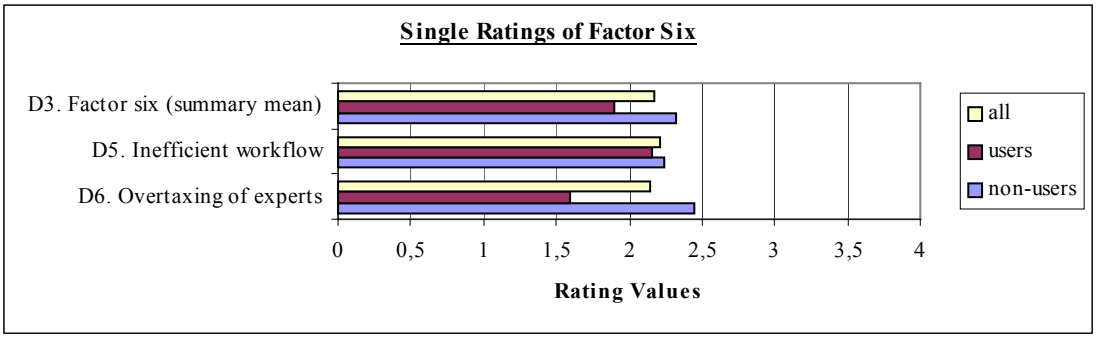


Figure 47: Ratings of variables referring to the disadvantage related to 'workflow inefficiency.

Inefficient Work Routine - Long Waiting Times

It has already been mentioned that several pathologists doubted that telepathology services can be coordinated. They expect long unproductive waiting times, especially if real time systems are used, by which client and consultant have to be available at the same time. At the research project in Vermont, USA, the time commitment required to ensure interactive consult coordination already proved to be a problem [Callas, 1996, p. 326]. At the study in Constance the disadvantage of telepathology coordination was rated in average with a mean of 2,21 and set on place five. Users rated this criterion with a mean of 2,16 and set it in summary on place two of all disadvantages, whereas non-users rated it with a mean of 2,24 and set it on place eight. That indicates that users recognize or even experienced the problem of session coordination as a bigger one than non-users did – at least when regarding the ranges, since the values do not show a significant difference. How current users overcome the problem of unproductive waiting time should be investigated in further studies.

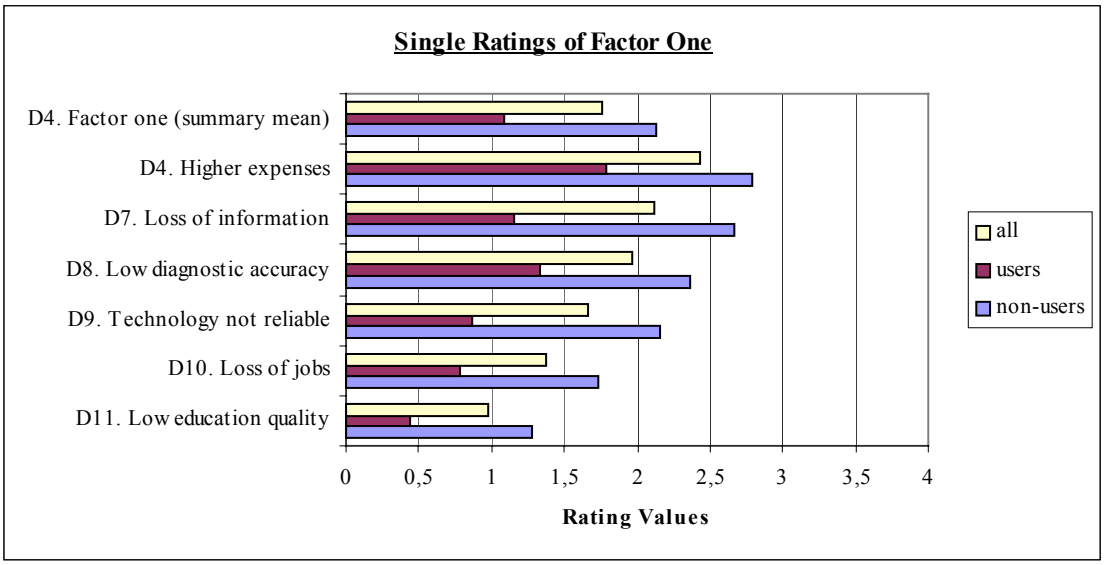
Overtaxing of Pathological Experts

More often specialists express their fear to be over-used due to too easy accessibility. In using traditional mail transportation, general pathologists just placed a request with their local colleagues for a 'second look'. With telepathology access they may prefer to access a distant top-specialist directly, although their case is not too complicated. One non-user therefore remarked that he fears he will be bothered with banal cases by surgeons and other colleagues due to the simple tele-accessibility. Similar comments were made by two more users. The overall value of this disadvantage was rated with 2,14 at this study and with this set on place six. Non-users rated this aspect highly significant higher ($F(1.110)=8,52$, $p<0,004$) with a mean of 2,45 than users did (mean of 1,59).

18.4.4.3 Discussion of the Disadvantage Factor 'Fears'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 1	6	1,09	0,85	3	2,13	0,93	**4**	1,76	1,03	33,88	**0,000**
D5.3.1 Higher expenses	5	1,79	1,40	2	2,79	1,25	**4**	2,43	1,39	14,10	**0,000**
D5.3.11 Loss of information	8	1,16	1,25	5	2,67	1,40	**7**	2,12	1,53	29,63	**0,000**
D5.3.2 Less diagnostic accuracy	7	1,33	1,29	7	2,37	1,23	**8**	1,97	1,35	16,42	**0,000**
D5.3.10 Technology not reliable	9	0,87	1,26	9	2,16	1,37	**9**	1,67	1,47	22,05	**0,000**
D5.3.5 Loss of jobs	10	0,79	1,20	10	1,73	1,37	**10**	1,38	1,39	12,31	**0,001**
D5.3.6 Reduced education quality	11	0,44	1,01	11	1,28	1,45	**11**	0,97	1,37	10,27	**0,002**

The columns ‚pl.' (place) gives the order of ratings a) of the 6 factors (first line), b) of all disadvantages (2nd to 7th line). F(1.110).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users). D=Disadvantage.

Figure 48: Ratings of variables referring to the disadvantages related to fears.

A very important factor for user acceptance is to overcome the fear, which telemedicine applications may cause. Several telemedicine programs have set up systems only to find that physicians will not use it because they recognize it as a threat. Considering the single ratings, all fears got significantly higher ratings by non-users when compared to users. This indicates that a lot of prejudices are in existence. Adequate information and communication between users and non-users would be desirable.

Unnecessary High Investments

In the last years prices for computer equipment dropped and the quality and performance improved tremendously. Nevertheless, telepathology systems cost money and decision makers will only invest in such systems, if they recognize advantages in efficiency or in the improvement of quality. Since telepathology services are often not reimbursed, there is no money available for the amortization of investment costs. Perhaps that is a reason that static systems are wider distributed than dynamic systems are. They are not as flexible as dynamic systems are, but they are much cheaper and still a good tool to exchange case data. In summary participants set the disadvantage of high investments on place four and rated it with a mean of 2,43.

Loss of Information and Communication due to Divided Procedures

Another fear of telepathology is that it will diminish the communication between the surgeon and the pathologist according to one non-user. Previously a pathologist examined the whole pathological processes by himself. Now with telepathology systems this process is divided into tasks, which are partly executed by the client. With the common method the pathologist had the chance to talk directly with the surgeon. Employing telepathology he has to use the telephone or the computer. Many pathologists fear that this may lead to a loss of information and with this decrease diagnostic accuracy. In contrast, the fear of reduced communication and lost information was disproved in the comment of five users of this study. One user even explained in his comment that telepathology helped to improve the internal communication between pathologists and other medical staff. In Berlin for example, telepathology improved the integration and communication between five hospitals, which cooperate with each other but are located in different locations. Another user also emphasized the good cooperation with surgeons and the improved, fast information exchange between pathologists, no matter where they are located. Other two user highlighted the usage of telepathology for education in his comment. Telepathology enables them to explain and discuss practical problems with students and colleagues.

Interestingly the seven users who judged the loss of information as a high disadvantage were mostly users of dynamic systems (two with +4, three with +3). This negative judgement really surprises, because most dynamic telepathology systems are going along with intensive acoustic communication and the telepathologist is under control of all processes. The only reason for their negative judgement could be assumed in equipment weakness and in low transmission speed, which make it difficult to follow the scanning process. Non-users set this disadvantage on place five with a rating of 2,67. This value could be caused by the fear to lose control of the pathological process. A concern, which especially was often named when referring to the physical macro-examination of specimens.

Comparing the ratings of the disadvantage with the values of the advantage, the values are as follows. Loss of information was rated by the users with a mean of 1,16 and by the non-users with a mean of 2,67. The advantage of improved communication by telepathology was rated with a mean of 3,03 by users and with a mean of 1,77 by non-users. Both differences are highly significant. One can clearly see, that users do not see a huge risk in telepathology to reduce information, but expect that communication will improve a lot. In contrast, the fear of non-users is higher than their expectation of improved communication.

Fear of Decreased Accuracy of Diagnoses

Many non-users mentioned the fear that diagnostic accuracy is not guaranteed by telepathology. Some pathologists even think that the quality of pathological diagnoses will decrease, especially if a less educated person is active at the remote side. They pointed to the problem of telepathology that the expert has to do the macro examination without direct tasting and feeling of the specimen. And they emphasized the fact that it is not acceptable that the specimen handling is done by a medical technician at the client's side. One non-user also remarked, that reduced accuracy will destroy the reputation of pathologists and therefore should be avoided. With an overall rating of 1,97 the fear of decreased accuracy of diagnoses was set on place seven by users as well as by non-users.

Considering the situation of a tele-examination, the diagnostic interpretation is still performed by a competent pathologist at the receiving station. In addition the remote hospital

gets the added value effect that the expertise of the entire highly qualified pathology staff at the consultant's side is available for a more accurate diagnosis [Almagro, 1998, p. 1162]. Therefore with telepathology expertise and accuracy are more likely to be even increased. Pathologists need information to overcome unjustified fears.

Fear of Unreliable Technology

Pathologists are mostly not used to interact in a computer environment. They believe that the traditional pathological process by direct light microscope can't be replaced by telepathology systems. They fear losing the confidence of patients due to unexpected technological errors. They complain that the pathological job is far to trustful that its reputation can be risked [Ulsenheimer, 1999, p. 200]. At the research study in Vermont, USA, technical problems, equipment downtime, and problems with pathologist's ability to regulate the system were recognized as unexpected difficulties during telepathological sessions [Callas, 1996, p. 326]. Such results show that technological reliability and system interruptions have to be taken seriously.

At the ratings of the factors of success 'system stability' was set on place seven of the 39 criteria with a mean of 3,62, and 'system reliability' on place 18 with an average mean of 3,29. Considering the ratings of disadvantages, nineteen participants rated technological unreliability as a huge disadvantage of telepathology. The overall rating was 1,67. Where non-users rated this disadvantage with 2,16, users only judged it with 0,87. When asking participants to give the reason why colleagues are against telepathology 'technology is not reliable' was named by 31% of all participants. These results show that non-users are far more skeptical than users are.

Fortunately when asking users about the approximately system interruptions per session, these were rated by far less than one time per session or described with 'rarely'. 50% explained that there were no system interruptions at all. Most system interruptions occurred due to network instabilities. Program errors like 'slow system' or 'unexpected system lockups' were mentioned as another matter of interruption. One user expressed that clients are often not trained enough in system usage. As an effect, their unprofessional system handling caused occasional problems. Another user said that he had problems with the maintenance of his system. The number of involved people is small (one client, one expert, one computer specialist, who is also responsible for many other systems). One time the system was locked for several days, but the computer expert did not find the time to travel the 300 km to the client's location. Fortunately the utilization rate is very low by this user. Nevertheless it shows how seriously the organization of telepathology system maintenance has to be taken. In summary, the low error rates at existing systems prove that the currently available technology is already reliable. These experiences may help to overcome the mistrust of non-users.

Fear of Losing Jobs

Physicians may fear that computers will replace humans.

> *"Using dynamic-robotic telepathology, the role of the pathologist at the remote transmitting site may be diminished or eliminated." [Almagro, 1996]*

> *„An off-site pathologist using dynamic-robotic telepathology can substitute for an on-site pathologist as a service provider." [Dunn, 1997/[1], p. 11]*

The experience of the Iron Mountain project showed that indeed, the work situation of pathologists may change. Small hospitals perhaps may not employ a full time pathologist any more but handle pathologic examinations through a telepathology system. However regarding the situation of small hospitals, in most of the cases there anyway was no pathologist full time employed, but served by an external pathologist. This caused unproductive travel time, which could be avoided with telepathology. One non-user of this study further remarked that jobs may be replaced and intensified, since images could be used for rough analysis or a kind of automated pre-diagnostic. Yet currently electronic image analysis is only used for diagnostic improvement, but not for replacing employees.

Considering the ratings of participants, from the list of all given disadvantages, the fear of losing jobs was rated quite low (1,38, place 10). User rated this disadvantage with a mean of 0,79 and non-users with 1,73. Regarding the characteristics of non-users, 52% are employed at university hospitals or medical centers, 24 % at small hospitals, and 24% are working at independent pathological institutions. The high rating for lost jobs (+4/+3) came by 21% of the university pathologists, 9% of small hospitals, and 70% of private institutions. If the characteristic of the non-users is set in relation with the judgement of lost jobs, 70% of the negative judgement came from 25% of the non-users, who are employed at private institutions. Information is needed for this type of pathologists to diminish this fear.

Another fear which goes along with the fear of losing jobs is the fear of lost patients, revenues, and autonomy. Physicians may fear the impact of change on the health care system combined with the fear of lost income [Williams, 1995; Engelmann, 1997/(1), pp. 26 ff.]. They think that specialty centers would employ telemedicine systems to steal patients. Neither do they regard telepathology as a tool to enhance the partnership between the specialized centers, rural clinics, or other linked communities, nor they consider telepathology as a technology, which enables rural providers to stay in touch with other professionals and to improve the pathological know-how. Puskin therefore warns that top-down projects are unlikely to be successful in the long-term if they are developed by specialty medical centers without significant input and acceptance from the rural communities [Puskin, 1995/(1), p. 65; Puskin, 1995/(2), p. 127].

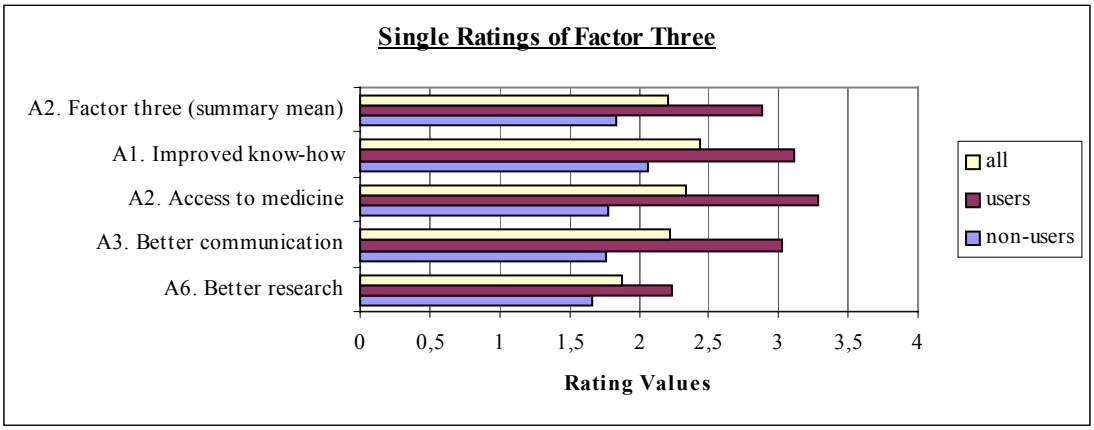
Fear of Reduced Educational Quality

One argument for telemedicine applications is improved access to educational features. This advantages was rated very high. However some pathologists may also fear that direct education will be replaced by online education, which may not be able to offer the same quality as direct individual training. Fortunately only 12 participants rated this risk as very high, whereas 60 participants did not recognize any risk that educational quality could be reduced by online services. The average mean of the criterion ‘reduced education quality’ was 0,97.

18.4.4.4 Discussion of the Advantage Factor 'High Medicine Standard'

Factor Number and Factor Name	User			Non-user			All			Signification	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 3	1	2,89	0,81	4	1,84	1,01	**2**	2,21	1,07	31,58	**0,000**
A5.1.8 Improved know-how standard	2	3,11	1,09	1	2,07	1,35	**1**	2,44	1,36	15,47	**0,000**
A5.1.7 Improved access to medicine	1	3,28	0,93	3	1,78	1,30	**2**	2,33	1,39	39,14	**0,000**
A5.1.5 Better communication	3	3,03	1,05	4	1,77	1,23	**3**	2,22	1,31	29,00	**0,000**
A5.1.6 Improved research	9	2,24	1,33	5	1,67	1,27	**6**	1,88	1,32	4,65	**0,033**

The columns ‚pl.' (place) gives the order of ratings a) of the 6 factors (first line), b) of all 13 advantages (2nd to 5th line). F(1.110).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users). A=Advantage.

Figure 49: Ratings of variables referring to the advantage 'high medicine standard'.

Improved Know-How Standards

The biggest advantage has been seen in the **easy access to high quality online education**, which may lead to the improvement of know-how standards (mean of 2,44). The non-user judgement was 2,07 and the users' judgement 3,11. The difference is highly significant ($F(1.110)=15,47$, $p<0,000$). These judgements show that participants recognize the advantage to get access to current know-how and literature. Know-how standards will also be improved by continuing high quality online education sessions and by the access to discussion circles and forums. In addition, online services provide a better utilization of staff expertise across separate, regional and remote facilities. Students can participate at online case demonstrations and ask questions. Professionals get an enhanced opportunity for training classes and are able to discuss cases online with other experts [Stieglitz, 1998, p. 23]. In this way they can increase their knowledge and enhanced compliance with diagnoses and treatment processes. That online information access is important was confirmed at a study in Vermont, USA. The possibility of formal and informal education was judged as the second most important advantage of telepathology (the most important was turnaround time) [Callas, 1996, p. 326]. Besides the improvement of know-how standards, pathologists may also recognize that computers and telepathology systems are vital tools to overcome the limitations of human memory capacity within an information overloaded medical profession, which often even the most gifted physician is not able to retain. The high ratings of participants (place one and two) indicate that participants are aware about all these improvements in education and information access.

Improved Access to Medicine

That telepathology systems will '**improve the access to high quality medicine and reduce doctor's isolation**' was seen as the second most important advantage (mean of

2,33). Telepathology systems provide access to high quality medical resources of large clinical centers. They offer the possibility of specialty supervision to previously insufficient served areas. The same quality of diagnosis know-how is available, independent of location, and this for 24-hours a day. In this way the isolation of doctors will be reduced [Puskin, 1995/(1), p. 60; Moore, 1995, Perednia, 1995/(3); Grigsby, 1993]. With telepathology applications small remote hospitals even can be linked to specialized medical centers for daily surgical pathology service support [Almagro, 1998, p. 1162]. Vice versa, the independence of the expert's location may increase the specialization of pathologists, since they are able to transfer their know-how all over the world.

Improved Communication

The advantage of '**better communication** between treating physicians' was rated with a mean of 2,22 in average. Telemedicine applications will improve the communication between physicians (family physician, referring physician, consulting specialists, and patients) since they enable to provide the synergy derived from a health care team [Moore, 1995]. It can already be recognized that telepathology enhances decision making through heretofore unavailable collaborative activities. It does not just improve the communication between physicians and pathologists and increase pathologists' availability, but it also improves the communication between pathologists. At a research study with interviews in Vermont, USA, three of four referring pathologist strongly agreed that telepathology systems will improve communication between physicians. Interactive video consultations were judged as far more valuable than mail or phone consults [Callas, 1996, pp. 325, 326].

Not just the direct communication between physicians will improve, but also the exchange of patient data. As soon as data and images are available in digital format, one can quickly retrieve them from electronical archives and databases for sending them to the consulting specialist immediately. In this way firstly less paper is necessary, secondly data do not have to be typed again, and thirdly the creation of result reports demands less effort [Swoboda, 1997, p. 37]. In addition, digital images can be modified in size, contrast or brightness.

That participants are keen on a better communication with other physicians is not just recognizable by the high ratings here, but also at other questions. Approximately 60% of the users named the wish of cooperation as a reason for telepathology introduction. Asking participants about their attitude to cooperate with other institutions, non-users rated it in average with a mean of 3,20 and users even with 3,70 (see chapter 19.2.3).

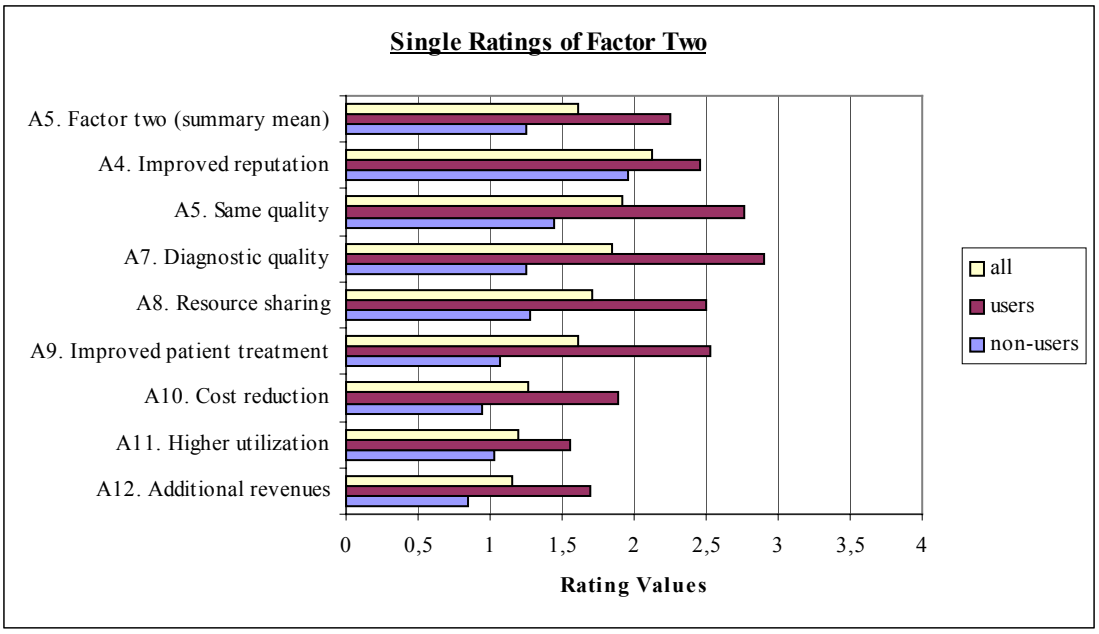
Improvement of Research Findings

Case data of telepathology systems are stored in a electronical database. In this way data and images can be used for scientific research analyses and for educational purposes. Two users highlighted the possibility to improve research findings due to the technical possibilities and data analysis. The findings will lead to an advancement in diagnostic in their opinion. In average the **'improvement of research findings'** was rated with a mean of 1,88. The users judged this advantage significantly higher than non-users did. Interestingly, the standard deviation of the users' ratings is quite high and there are several users, who do not recognize improved research activities due to telepathology introduction. One factor which may support this argumentation is data protection. However, if patient data are anonymous, there is no risk for the patients that their data are misused. The other possibility for the negative judgement of some users could be related to the fact that users are so involved in their own telepathological activities that they put the idea of research aside.

18.4.4.5 Discussion of Factor: 'More Efficiency and Improved Treatment Process'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 2	6	2,24	0,69	3	1,25	0,91	**4**	1,60	0,97	35,81	**0,000**
A5.2.5 Improved reputation	8	2,46	1,06	2	1,96	1,43	**4**	2,13	1,33	3,46	**0,065**
A5.1.3 Same quality of medicine	5	2,76	1,10	6	1,45	1,16	**5**	1,91	1,30	30,10	**0,000**
A5.1.1 Improved diagnostic quality	4	2,90	1,28	8	1,25	1,55	**7**	1,85	1,660	32,40	**0,000**
A5.2.1 Efficient processes (resources)	7	2,50	1,07	7	1,28	1,29	**8**	1,71	1,35	22,29	**0,000**
A5.1.2 Improved pat. treatment	6	2,53	1,16	9	1,07	1,28	**9**	1,61	1,42	34,56	**0,000**
A5.2.2 Cost reduction, savings	10	1,89	1,45	11	0,94	1,21	**10**	1,27	1,37	12,02	**0,001**
A5.2.4 High utilization	12	1,56	1,29	10	1,03	1,33	**11**	1,20	1,34	3,48	**0,065**
A5.2.3 Additional revenues	11	1,69	1,22	12	0,85	1,08	**12**	1,15	1,20	12,61	**0,001**

The columns ‚pl.' (place) gives the order of ratings a) of the 6 factors (first line), b) of all 13 advantages (2nd to 9th line). F(1.110).



The number in front of each criterion gives the place of the overall ratings (mean of all = users and non-users). A=Advantage.

Figure 50: Ratings of variables referring to the advantage 'more efficiency'.

Department's Reputation

Interestingly, participants judged the 'improvement of the department's reputation' as the fourth most important advantage of current telepathology utilization. This indicates that if high technology medicine is offered, pathological services may become more attractive and by this create a competitive advantage. However, there was also a non-user who complained that telepathology users just pretend an improved pathological quality for gaining competitive advantages, but in summary telepathology would be 'pure eyewash' and propaganda. The opinions in this point seem to be quite contrary. Nevertheless, in summary participants ment that the effect of telepathology introduction is very positive for the reputation of institutions. This criterion got a mean of 2,13 and showed a statistical trend in the higher ratings of users (mean of 2,46) compared to non-users (mean of 1,96).

Same Quality of Diagnosis and Treatment

If an user decides to buy and introduce a telepathology or another telemedicine system, he gets immediately access to highly specialized health care resources, no matter where he is located and how big his hospital or doctor's office is [Schmid, 1996/(2), p. 929]. The idea

is that telepathology systems deliver the same quality of care as if a pathologist is at the place. Yet even a better one, since a fast 'second look' examination can be requested when there is any kind of uncertainty. Participants rated the advantage of 'same quality of diagnosis and treatment, independent of location' with a mean of 1,91. Non-users judged this advantage more than one point highly significant lower than users did ($F(1.110)=30,10$, $p<0,000$). Perhaps the reason for this is that many non-users are still skeptical about the quality of telepathology diagnoses, especially if the client is not qualified in pathology. Nevertheless, of the thirteen given advantages, the possibility to get the same diagnosis quality independent of the location of the patient, was seen as the fifth greatest advantage of telepathology systems.

Improved Quality of Diagnoses

Telepathology helps to reduce the risk for pathological generalists to take responsibility for diagnosis and treatment errors due to uncertainty, since they can easily request other specialists for their **expert opinion** via network. Immediate feedback on a case will be available [Callas, 1996, p. 324]. Users of telepathology systems for second opinion consultations agree that their system offers new possibilities to increase the certainty of difficult diagnoses. The diagnostic quality and accuracy will be improved [Kayser, 1996, p. 476]. Another improvement in diagnostics, which goes along with telepathology introduction is the easy access to external **DNA-analysis** features.

At the study in Constance, several users of telepathology systems declared that diagnostic quality improves with telepathology. One user pointed at the reduction of doctors isolation. Another one mentioned the possibility to have one (or many) consults. Faster diagnostic results and faster, improved patient treatment was also remarked as positive attitude of telepathology by several users in their comment. Two users highlighted the possibility to use telepathology for educational purposes and to improve know-how standards. The improvement of research findings due to the technical possibilities and data analysis approaches was mentioned as a further factor for diagnostic advancement.

Considering the judgements of this study, 29 participants rated the possibility to 'improve the diagnosis quality' by telepathology as huge (+4), whereas 38 participants did not recognize telepathology as a tool to improve diagnostic results. The high amount of negative judgements is basically due to the rating of non-users. 35 non-users graded this point with zero and in total this advantage was assessed highly significant 1,65 points lower by non-users (mean of 1,25) than by users (mean of 2,90; $F(1.110)=32,10$, $p<0,000$).

Comparing this advantage with the values of the criterion 'less diagnostic accuracy', non-users rated this disadvantage highly significant one point higher with a mean of 2,37 than users did (mean of 1,33, $F(1.110)=16,42$, $p<0,000$). Perhaps the reason for this is that many non-users are still skeptical about the quality of telepathology diagnoses and assume that telepathology will never be as accurate as the conventional method. Especially the fact that the telepathologist is not able to feel and to smell the specimen was mentioned by many non-users as an unacceptable disadvantage of telepathology examinations. The qualification of the client was also emphasized when considering diagnostic quality: 'the blind man cannot guide the blind man' (comment of a non-user). If images are not of an adequate quality (content and resolution), the risk of an incorrect diagnosis increases. Considering accuracy rates (see appendix VI), indeed the accuracy rate of conventional glass slide examinations is slightly higher than the one of telepathology. Nevertheless, the current employment of telepathology proves, and the positive responses of many users reflects that there are various situations

where a fast and accurate diagnosis can be executed by telepathology. Second opinion results are available within minutes, this, a study in Heidelberg concerning frozen sections showed, was of high value and very appreciated [Kayser, 1995/(1), p. 59].

More Efficient Procedures and Structures

Telemedicine applications can be employed to improve the utilization of medical resources, particularly for scarce education and for specialty medicine resources. First of all it offers faster diagnoses, more rapid reporting to referring physicians and more efficiency in personal work procedures. Second it provides a method for moving resources around to where they are needed most, and through this support a better continuity and coordination of care [Moore, 1995; Olsson, 1995, p. 238; Perednia, 1995/(3)]. In this way existing medical know-how and equipment can be used more efficiently. Capacity utilization of expensive equipment can be increased. Expensive equipment does not have to be bought but can be accessed by online connections (e.g. DNA-analysis programs).

Telepathology also can help to take better advantage of **staff resources** and decrease unproductive working hours. It is obvious that the waiting time of the operation team for a diagnostic result is diminished by telepathology, since physical sample transportation disappears. The time for unproductive background presence of high qualified staff could also be diminished, since such services could be optimized by telepathology on-call services. In addition, efficient permanent or specific back-up services during times of crisis or disaster can be provided by telepathology. Adding central resource management features to telepathology applications could offer information about the on-board personnel' level of medical expertise, their available free capacities, or about the inventory of medical supply on the spot. Such an resource information tool enables the consulting physician to efficiently access the available resources on board for treatment.

Considering the judgement of this advantage, users rated the possibility of resource sharing and increased process efficiency significantly higher with a mean of 2,5, whereas non-users with just a mean of 1,28 ($F(1.110)=22,29$, $p<0,000$). The low judgement of non-users could be related to the high investment costs, which makes efficiency difficult to achieve. In the ratings of disadvantages non-users rated this aspect a significant one point higher than users did (mean of users: 1,79 / place 5 and of non-users: 2,79 / place 2). But it could also be based on the fear that telepathology examinations will cause long unproductive waiting times. Several non-user mentioned this objection in their comment and doubted that processes can be managed efficiently. However, regarding the weighting of disadvantages, unproductive processes were only rated with 2,24 by non-user (place eighth of disadvantage ratings; mean of users 2,16 / place 2). The reason for this contradiction in the judgement could be based on the fact that the direct image examination process lasts longer by telepathology. But as soon as physical transportation time is added, telepathology shows positive results. (Comparison of different process procedures see chapter 13.6.2, please).

Improvement of Patient's Treatment Process

How can telepathology improve the treatment process of patients? First of all due to the **reduction of diagnosis turnaround time**. Instead of the surgeon waiting two to five days until he gets the results through traditional pathology, case images and results are sent quickly over electronical networks. Diagnosis results are available faster and therefore treatment and therapy procedures can start earlier. With the possibility of frozen section telepathological

examinations, only one operation of the patient is necessary, since results are available as fast as if the pathologist is at the place. This reduces the time of uncertainty for the patient and efficient treatment can start at once. At a research study in Vermont, most of the interviewed pathologists named turnaround time as a paramount consideration of telepathology since it drops waiting time from 3 to 5 days down to a few minutes [Callas, 1996, p. 323].

The improvement of the patient's treatment process was rated in average with 1,61. Again, there is a highly significant difference in the judgement of non-users as compared to users of almost 1,7 points ($F(1.110)=34,56$, $p<0,000$). Where this advantage was set at the users on place six (mean: 2,53), it can be found by the non-users at place nine (mean: 1,07). The reason for this low judgement could be seen in the fact that pathologists are responsible for fast and accurate diagnoses, but as for the treatment process, another physician carries the authority.

Cost Reduction and Savings

One of the most mentioned cost advantage is the reduction of **travel efforts**, both monetary and time [Stieglitz, 1998, p. 21[113]]. Travel efforts to educational classes, travel efforts of the specialist to the rural hospital, travel efforts of the patient to the medicinal center to see a specialist. With telematic health care one is able to bridge room and time by transferring data, information and know-how to patients or physicians [Ulsenheimer, 1999; Puskin, 1995/(1), p. 66]. Besides travel cost, the patient will be less psychically stressed, if the distance to his family is not very large.

Costs are further diminished due to the reduction of **second surgical interventions,** reduction of **anesthesia intervals** for the patient, or the reduction of costs by more efficient use of **operating theaters** [Schmid, 1996/(2), p. 929; Schmid, 1996/(1), p. 479]. Because diagnosis and treatment processes are faster, the hospital stay of patients will be reduced and with this cost, too.

Small remote hospitals would **not need to hire on-site pathologists**, thereby converting the pathologist's salaries into cost savings. Telemedicine services allow for the provision of services in rural hospitals with less overhead costs due to the lack of specialized equipment and lower personnel costs. Intensive care facilities can be used more efficiently. Patient data is available in advance, which allows for the estimation of necessity for intensive care. Emergency cases are easier to coordinate. The patient can stay at the local hospital and the specialty support comes via Internet (e.g. frozen section examination). **Administrative time and cost** will also be reduced (e.g. data is only typed once) [Stewart, 1994, p. 37]. Expensive **duplication** of services, technologies and specialists can be avoided [Stieglitz, 1998, p. 21; Lischka, 1996[114]].

All these examples show that there are many possibilities of cost reductions and savings by using telepathology. Yet, this advantage was only judged in average with a mean of 1,27. Users rated this aspect with a mean of 1,89 and non-users even highly significant lower with a mean of 0,94 ($F(1.110)=12,02$, $p<0,001$). The reason for this may be based on the high investment costs, which were set at the disadvantages at place two by the non-users (2,79) and on place five at users (mean of 1,79).

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113 For example, at the Eastern Bavarian project approximately US-$ 30.000 helicopter transportation costs were saved.

114 http://www.kp.dlr.de:„Telemedizin - Stand und Ausblick“

Telepathology Guarantees the Survival of Pathology Departments - Capacity Rates

Telepathology applications offer the possibility of increasing the number of case examinations. As already has been described, telepathology applications can help to improve the quality of pathological services. As a consequence, the reputation of the tele-equipped department will improve. If such a high level medicine department becomes known, confidence of physicians will increase and doctors may choose this specialized centers for their pathological case examinations [Stieglitz, 1998, pp. 19 ff.]. Again the AFIP is a good example, since it created a new market for its telepathology services. Yet, to offer telepathology equipment and high know-how standards is expensive. Therefore high capacity numbers and reimbursement are desirable to guarantee a fast amortization of the costs.

Interestingly participants judged this advantage quite low (mean of 1,20). Again, there is a statistical trend in the lower ratings of non-users (mean of 1,03) compared to users (mean of 1,56, $F(1.110)=3,48$, $p<0,065$). The reason for the low ratings for this advantage could be based on the fact that highly qualified experts, who work at a medical center, are already so busy that the survival of their department is never questioned. A second reason could be seen in the low utilization rate of telepathology systems. Since acceptance is low, non-users especially do not recognize, in telepathology, a possibility to increase partnerships and examination rates.

Additional Revenues

Perednia already discovered that telemedicine systems are a way of bringing international health care dollars to the United States [Perednia, 1995/(3)]. Indeed, since telemedicine applications are high quality tools, specialty services can be offered all over the world. One example for this is the AFIP. In addition, since all data are electronically available, the billing process can be speeded up and the cash-flow is faster [Matthies, 1997, p. 31].

However, as long as telepathological services are not reimbursed, the low judgement (average mean of 1,15) is understandable. At present, the introduction of telepathology seem to cause additional expenses but is poor in gaining additional revenues. The non-users rated the possibility to increase revenues by telepathology highly significant lower (mean of 0,85) than users did (mean of 1,69). Yet considering the ranges, both groups set it at the end of the ratings of advantages (place 11 and 12 of 13 criteria).

18.4.4.6 Discussion of the Advantage Factor 'On-Call Services'

Factor Number and Factor Name	User			Non-user			All			Significance	
	Pl.	Mean	St.D.	Pl	Mean	St.D.	Pl	Mean	St.D.	F	p
Value of Factor 5	5	1,35	0,99	6	0,72	0,99	6	0,94	1,04	9,54	**0,003**
A5.1.4 Efficient on-call services	13	1,35	0,99	13	0,72	0,99	13	0,94	1,04	9,54	**0,003**

The columns ‚pl.' (place) gives the order of ratings a) of the 6 factors (first line), b) of all 13 advantages (2nd to 9th line). F(1.110).
The ratings of 'on call services' are at the PCA-analysis on place 6 of 6 factors and at the single ratings on place 13 of 13.

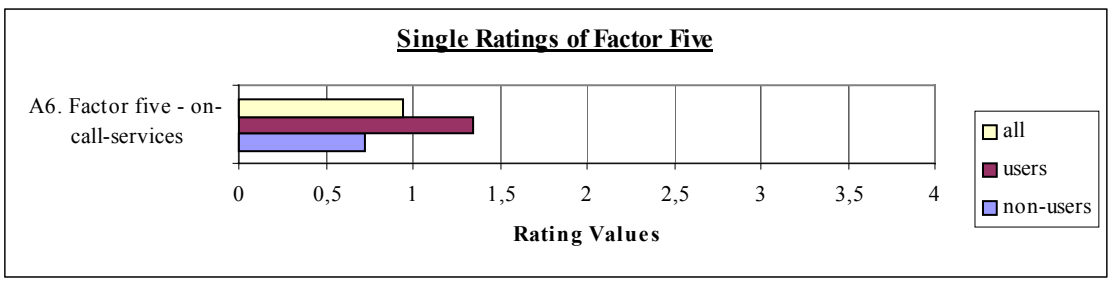


Figure 51: Ratings of the advantages of having access to on-call services.

Efficient On-Call-Services

Telepathology systems allows for a twenty-four hour high quality service support structure. Even if there is an emergency case in the middle of the night, the surgeon and a medical technician is able to operate their telepathology system to get the diagnostic result from the online telepathology consultant. With telepathology systems a continuous quality of diagnoses can be offered, independent of holiday periods or other times where staff is rare.

The idea of increased efficiency due to on call service support was just rated with a mean of 0,94. Again, the users rated this advantage significantly higher (mean of 1,35) than non-users did (mean of 0,72, $F(1.110)=9,54$, $p<0,003$). At both groups on call services got the lowest ratings in the judgement of advantages. The reason could be based on the fact that at current pathological processes the participants know each other. Talking with pathologists, this contact is very important for them. At the telepathology conference in Aurich in July 2000, one speaker even stated that pathologists insist on their personal contact with surgeons and other physicians. In his opinion it is difficult to change old structures and habits towards a technology driven communication. That is why it has to be investigated, whether on call services could be organized efficiently and how its acceptance could be improved.

18.4.4.7 Rating of Service Interest in Relation to Advantage Ratings

			Current interest in		Future interest in	
			services to improve diagnostic	services to improved know-how	services to improve diagnostic	services to improved know-how
Correlation: Advantages with Interest in Telepathology Services						
EFFIC3	More efficiency	Correlation by Pearson	,658	,422	,651	,451
		Significance (2-sides)	**,000**	**,000**	**,000**	**,000**
QUAL3	High quality medicine	Correlation by Pearson	,531	,690	,455	,629
		Significance (2-sides)	**,000**	**,000**	**,000**	**,000**
ONCAL3	Efficient on-call services	Correlation by Pearson	,421	,285	,411	,237
		Significance (2-sides)	**,000**	**,002**	**,000**	**,012**
Correlation: Disadvantages with Interest in Telepathology Services						
FEAR3	Fears	Correlation by Pearson	-,457	-,407	-,425	-,285
		Significance (2-sides)	**,000**	**,000**	**,000**	**,002**
UNCER3	Uncertain situation	Correlation by Pearson	-,362	-,115	-,381	-,078
		Significance (2-sides)	**,000**	**,227**	**,000**	**,411**
WORKF3	Workflow inefficiency	Correlation by Pearson	-,259	-,109	-,229	-,054
		Significance (2-sides)	**,006**	**,252**	**,015**	**,572**

Schedule 14: Ratings of service interest in relation to advantage ratings.

The values of the significance analysis clearly prove that there is a correlation between the ratings of advantages and disadvantages and the interest in telepathology services. That is that the more advantages and the less disadvantages a participant expects from telepathology, the higher his interest is.

18.4.5 Summary of Advantage and Disadvantage Judgements

The overall judgements show clearly that non-users rated all advantages lower than users did. The non-users judged the given advantages between 0,72 and 2,07, which is not very high, whereas the users' judgements were between 1,35 and 3,28. In summary, efficiency aspects were put behind quality factors. These judgements could be based on the low utilization rate of telepathology systems and with this on the inefficiency of breakeven calculations. Considering the single ratings of advantages of telepathology online education, improved access to high quality medicine, and the improvement of physician's communication got the highest ratings, whereas the improvement of efficiency due to on-call services, the possibility to gain additional revenues and to increase utilization rates by telepathology got a secondary rating.

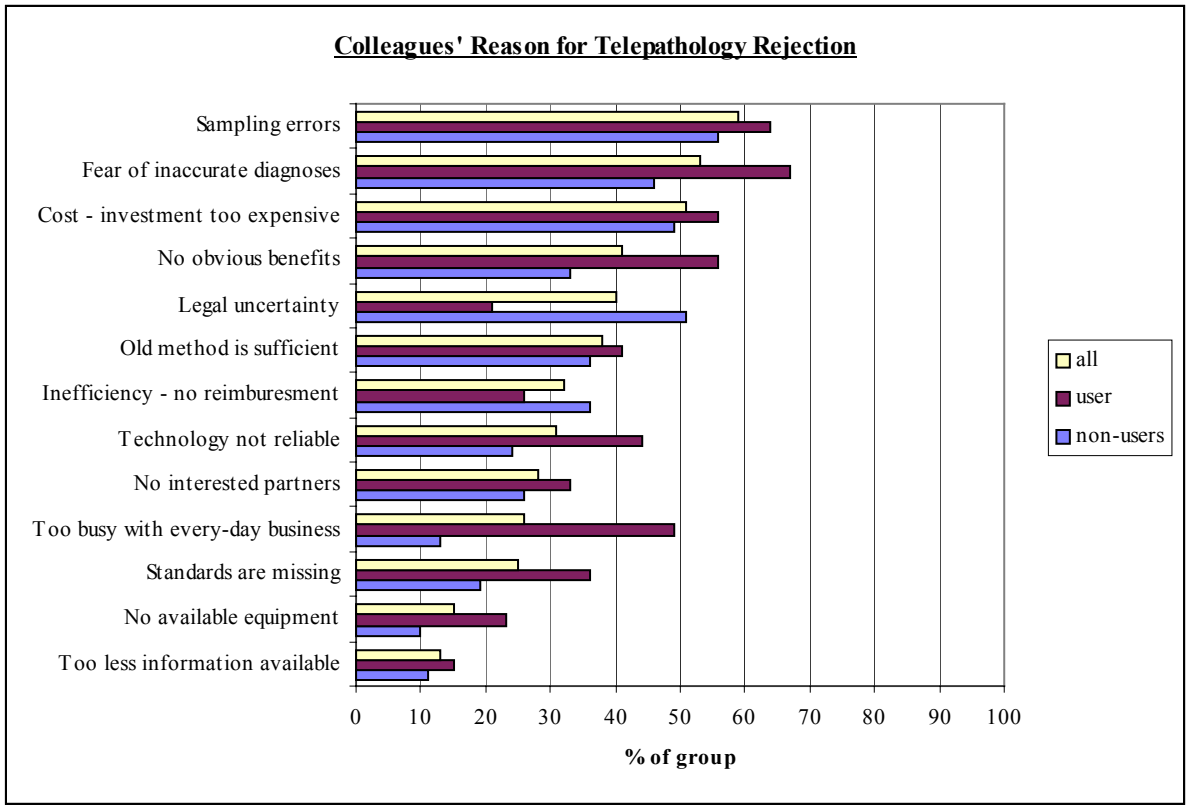
At the judgements of disadvantages the values of non-users range from 1,28 to 3,09, whereas the ratings of the users were between 0,44 and 2,46. Non-users judged disadvantages significantly higher than the users did. Uncertain legal situation, missing reimbursement regulations, unsatisfying data security and the high investment costs got the highest ratings, whereas the fear of lost jobs or the fear of unreliable systems were judged much lower. The higher ratings of non-users emphasizes that there is still great reluctance and fear by the non-users to come in touch with telepathology. As it is often the case, failures of new technologies get around faster and leave deeper impressions than successes do. There is also a high statistical correlation between the judgement of dis-/advantages and the interest in telepathology services. That is that as more positive advantages were rated, as higher the interest in telepathology services was, or vice versa as higher disadvantages were expected, as lower the interest in telepathology services was. Information is necessary to overcome wrong prejudices. Doing so, the scepticism of non-users has to be taken seriously. Regarding the ratings of users, the higher values of advantages and the lower ones of disadvantages compared to non-users could be based on the fact that users are keen in using their system and therefore are less critically. This could be the reason that they judged telepathology more positively than non-user did. Considering the standard deviation values, these are often high. This indicates that the rating of disadvantages is dependent on the specific situation and type of system a user is working with.

18.5 Situation and Acceptance of Colleague Pathologists

All users and non-users were asked to answer the question: „when discussing with colleagues, who do not use telepathology yet, what are the arguments against it?“ Several possibilities were offered, which could have been marked with yes/no. The idea was, not just to discover the individual reasons for participant's reluctance to telepathology, but to get more extended judgements. In the following graphic the ratings of different factors in percentages, distinguished by users, non-users, and the total of both can be seen.

Areas of Acceptance		Users			N-User			All			Significance	
Num.	Criterion of Judgement	pl.	tot.	%	pl.	tot.	%	pl.	tot.	%	$\chi^2(1)$	p
6.2.4	Errors in sample handling (e.g. field selection)	2	25	64,1	1	39	55,7	1	64	58,7	0,73	0,394
6.2.3	Fear of examination errors / inaccurate diagnoses	1	26	66,7	4	32	45,7	2	58	53,2	4,42	0,035*
6.2.1	Cost (investment is too expensive)	3	22	56,4	3	34	48,6	3	56	51,4	0,62	0,432
6.2.7	Colleagues cannot recognize any benefits	4	22	56,4	7	23	32,9	4	45	41,3	5,73	0,017**
6.2.5	Legal uncertainty	12	8	20,5	2	36	51,4	5	44	40,4	9,94	0,002***
6.2.8	Traditional method of examination is sufficient.	7	16	41,0	5	25	35,7	6	41	37,6	0,30	0,583
6.2.2	Inefficiency of service (reimbursem., utilization)	10	10	25,6	6	25	35,7	7	35	32,1	1,17	0,280
6.2.13	Technology isn't reliable	6	17	43,6	9	17	24,3	8	34	31,2	4,35	0,037*
6.2.6	No interested partners for telepathology	9	13	33,3	8	18	25,7	9	31	28,4	0,71	0,398
6.2.10	Too involved in every-day-business	5	19	48,7	11	9	12,9	10	28	25,7	16,8	0,000***
6.2.12	Standards are missing, incompatibility	8	14	35,9	10	13	18,6	11	27	24,8	4,03	0,044*
6.2.11	Colleagues don't have the equipment	11	9	23,1	13	7	10,0	12	16	14,7	3,42	0,064
6.2.9	Too less information (about advantages, technol.)	13	6	15,4	12	8	11,4	13	14	12,8	0,35	0,554

Num.=number at questionnaire; Pl.=place of ratings; tot.=total of group; 3 participants did not answer the question.
The total gives the amount of participants, who saw in the given aspect a reason for colleagues' rejection of telepathology introduction.



The x-axis gives the amount of participants (in %), who saw in the given aspect (y-axis) a matter for colleagues' rejection of telepathology.

Figure 52: Judgement of colleagues' rejection.

Fear of Inaccurate Diagnoses

The most mentioned argument against telepathology was the '**fear of reduced diagnostic accuracy**' (53%) due to factors like inadequate sample preparation and field selection at the remote site (59%) or other factors like for example insufficient images. Over 64% of the users and approximately 50% of the non-users mentioned this aspect as the main reason of colleagues rejection of telepathology. That more users saw in 'inaccurate diagnoses' an argument against telepathology is significant (chi^{2}[115](16.1)=4,42, p<0,035).

Cost Factors

51% estimated that the **investment costs** are a barrier for many colleagues to introduce telepathology systems in their department. Since already available equipment could reduce the overall investment costs of telepathology applications, or vice versa costs will be high if there are no infrastructures available, participants were asked about the current situation of their colleagues. Only 15% of the participants stated that their colleagues reject telepathology because they do not have any necessary equipment and infrastructures and that they are therefore scared about huge investment costs. The problem is, that investment costs are especially a barrier if a pathological institution is small (one to two pathologists) and the budgets are therefore low. It could be assumed that if pathologists have the money available and if diagnoses can be executed accurately, they would be willing to employ telepathology systems.

A factor closely related to investment costs is the overall efficiency of telepathology services. **Inefficiency** was seen as a factor for telepathology's rejection by 32% of the participants (non-users 36%; users 26%). Telepathology services are often not reimbursed. If a pathologist is employed at a university hospital (as many participating users are), in general money for research activities is available so that the lack of reimbursement may not have a huge impact as this is the case at users, working in a small institution where cost efficiency is essential.

Reasonableness

Many pathologists remain still doubtful about the real usefulness of telepathology, which is still too expensive in their opinion. They prefer to stay in a 'wait-and-see' mode and not to purchase an expensive tool as long as the real usefulness and practicality for them is not proved [Martin, 1996, pp. 458, 461; Azumi, 1996, p. 452]. Therefore affordable, easy to use, and at the user's needs oriented systems are necessary to improve acceptance.

In this study, eight non-users also doubted the overall usefulness of telepathology in their comments. One states that the initial euphoria will soon yield to a disillusionment. Another one wrote that telepathology is only used to propagate competitive advantages. These participants stated that the expected advantages in relation to quality and efficiency improvement are highly dubious. A further non-user argued that telepathology is a simple 'show effect'. And last but not least, one of the non-user even called telepathology as a computer game for playful pathologists. Such skeptical pathologists want to see facts about

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[115] Chi-Square by Pearson.

the usefulness of telepathology. They need exact information about the advantages and disadvantages of telepathology for their specific situation.

Effort of Changed Structures

Telemedicine is more than just doing what one was used to do in pathology but just with a new technology. The success of the whole telemedicine ultimately depends on the intention to use such a system and to cooperate with other pathologists.

> *"Telemedicine is not just an instrument that you buy to see a patient. And the impact of telemedicine is more than just doing what we used to do in healthcare with a new technology. Telemedicine is a complex system of technology and human factors. It has the potential for profound sociological change." [Preston in Moore, 1995]*

> *„To adopting telemedicine is not conscious or deliberate, but is more related to the effort required to change habits that are ingrained as a result of years of practice." [Grigsby, 1995/(1), p. 25]*

That is why telemedicine applications are often seen as a threat to physician's business-as-usual, and systems are denied before they can prove advantages. Also at this study two users clearly emphasized that telepathology will create new workflow, which could cause confusion and additional efforts. One non-user remarked that before one thinks about closer cooperation and structural changes, telepathology has first of all to prove its advantages. However, many participants (users as well as non-users) agree that there will be a trend towards more specialization due to telepathology. Knowing, that in general human beings are reluctant concerning changes, it has to be emphasized again that pathologists need information about advantages to become positive about telepathology.

Considering the ratings for colleagues' rejection of telepathology, the argument that colleagues **do not recognize any benefit** was seen as a barrier by 41% of the participants. The ratings of the users were very significant higher (56%) than the ones of the non-users (33%; $Chi^2(16.1)=5{,}73$, $p<0{,}02$). One reason that colleagues do not see any benefit could be caused by the attitude of thinking the **old method is sufficient.** This was seen as criterion for telepathology's refusal by 38% of the participants.

That there are '**no interested partners**' available was seen as a matter of colleagues resistance by 23%. However, as the situation with Internet services changed dramatically during the last decade, it is also possible that the interest for telepathology services will increase and that structures will change towards more pathological partnerships. 25% of all participants expressed that colleagues are so involved in their '**every-day-business**' that there is no time to worry about telepathology. Regarding the single judgements, only 13% of the non-users, but 49% of the users rated the problem of work-overload as a reason for the rejection of telepathology. This difference is highly significant ($Chi^2(10.0)=16.8$, $p<0{,}000$). It could indicate that non-users would be willing to spend time out of their busy schedule, if it is worth for them. Further investigations are desirable.

Legal Uncertainty

Besides accuracy, **legal uncertainty** was named as the fifth most important factor of pathologists reluctance against telepathology (40%). Especially the non-users rated this argument significantly higher (51%) than users did (21%, $Chi^2(15.7)=9,94$, $p<0,002$). This confirms the results of the ratings at the judgements of the factors of success. It seems that especially non-users are very sensitive about the uncertain legal situation of telepathology. For them it is a serious barrier in the utilization of diagnostic telepathology services.

Reliability of Technology

That '**technology is not reliable**' was marked by 31% of all participants. They stated that colleagues prefer to wait until telepathology is tested. In this way they want to avoid wrong investments, unnecessary time consumption and wasted money. Users saw in this factor a significant higher reason for telepathology's rejection (44%) than non-users did (24%, $Chi2(12.1)=4,35$, $p<0,037$).

Lack of Standardization

25% of the participants stated that colleagues will not introduce telepathology as long as there is a '**lack of standardization**'. Again, as long as there are no standards available, there is the risk that systems are not compatible. Hence, if systems are not compatible, the idea of far-reaching integration will not work and money would be invested in isolated solutions.

Lack of Information

That pathologists are not informed enough about the possibilities that telepathology offers, about the functionality of the systems, and about the market situation was seen as a problem by 13% of the participants. Yet considering the various ratings at this study, the lack of information is likely to have even a higher meaning in colleagues acceptance of telepathology. There seem to be many prejudices and fears against telepathology, which could be diminished with the dissemination of truthful information.

18.6 Summary of All Judgements of Users and Non-Users

18.6.1 Quality in Pathology

Diagnostic Accuracy

Summary of Diagnostic Accuracy Criteria		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Colleagues' judgement (13*)	Sampling errors	2	56%	1	64%	1	59%	-
"	Errors in examination accuracy	1	46%	4	67%	2	53%	*
Advantages (13*)	Improved access to high level medicine	3	1,78	1	3,28	2	2,33	***
"	Improved diagnostic quality	8	1,25	4	2,90	7	1,85	***
Disadvantages (11*)	Diagnostic accuracy not guaranteed	7	2,37	7	1,33	8	1,97	***
	Loss of information due to task sharing	5	2,67	8	1,16	7	2,12	***
Factors of success (39*)	Diagnostic accuracy	1	3,83	1	3,57	1	3,74	*

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues' judgements the ratings of participants are given in % (yes).

Schedule 15: Overviews of all ratings concerning diagnostic accuracy.

Diagnostic Accuracy was seen as on of the most important factors for telepathology's success. First of all in the ratings for the factors of success this criterion was set in first place in its meaning concerning telepathology's success by all participants with an average mean of 3,74[116]. Non-users rated the influence of diagnostic accuracy significantly higher (3,83) than users did (mean of 3,57). Also the reasons for colleagues rejection of the introduction telepathology accuracy criteria occurs in first place. Interestingly, at the judgement of disadvantages the criterion 'reduced diagnostic accuracy' was set on 7th place (of 11 possibilities) by both groups. The low rating of this disadvantage indicates that participants believe that the accuracy aspect can be solved, but still they emphasize it as the most important factor of telepathology's success.

Improved Quality of Pathological Services

Summary of Criteria Referring to Pathological Services		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Colleagues' judgement (13*)	Colleagues cannot see any advantage	7	33%	4	56%	4	41%	**
"	Traditional method is sufficient	5	36%	7	41%	41	38%	-
"	To involved in every-day business	11	13%	5	49%	10	26%	***
Advantages (13*)	Improved online education, forums	1	2,07	2	3,11	1	2,44	***
"	Better communication of physicians	4	1,77	3	3,03	3	2,22	***
"	Improved research findings	5	1,67	9	2,24	6	1,88	*
Disadvantages (11*)	Reduced education quality	11	1,28	11	0,44	11	0,97	***

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues' judgements the ratings of participants are given in % (yes).

Schedule 16: Overviews of all ratings concerning the quality of pathological services.

Telepathology has been recognized as a medium to improve education and with this know-how standards in pathology. It further helps to improve the communication between treating physicians and improves research findings. Yet the results show, that users rated this advantages significantly higher than non-users did. It is necessary that non-users are informed about the advantages of telepathology that they are willing to overcome their attitude that the old method is sufficient. If non-users judge telepathology as a valuable tool, they are likely to invest time and money in employing it.

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[116] Rating scale: +4 very important for telepathology's success; zero = no meaning for telepathology's success.

18.6.2 Interface Quality and Workflow Efficiency

Summary of Criteria Referring to Interface and Workflow		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Advantages (13*)	Better communication between physicians	4	1,77	3	3,03	3	2,22	***
“	Improved patient treatment process	9	1,07	6	2,53	9	1,61	***
Disadvantages (11*)	Inefficient waiting times	8	2,24	2	2,16	5	2,21	-
“	Overtaxing of expert with simple cases	6	2,45	6	1,59	6	2,14	***
PCA-factor of success (10)	Image handling	2	3,80	2	3,52	2	3,70	**
“	Workflow efficiency	4	3,48	3	3,43	4	3,47	-
Factors of success (39*)“	Influence of respond time	15	3,48	2	3,74	9	3,56	-
“	Simple user-friendly interfaces	14	3,49	4	3,63	13	3,54	-
“	User support and training	18	3,37	28	2,89	21	3,20	-
“	Influence of real time session coordination	36	3,45	16	3,32	31	2,75	***

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues’ judgements the ratings of participants are given in % (yes).

Schedule 17: Overviews of all ratings concerning interface and workflow quality.

The PCA factor ‘workflow efficiency’ was set in the overall judgements of the factors of success on place 4 (mean of 3,47). It summarizes criteria like user-friendly interfaces, training and users’ support, as well as respond time or system flexibility. Special importance was given to smooth and flexible image handling features (place 2 of the PCA factors with a mean of 3,70). Non-users especially would appreciate features, which enable them to manipulate images almost like sitting in front of a microscope (focusing, objective change). Besides system quality, participants, especially users, hope that the overall communication and cooperation with other physicians will improve with telepathology (mean of 2,22). Also the treatment process of patients is expected to be improved, since turnaround time will be diminished. Resulting reports and documentation will be simplified, too. In contrast, participants fear unproductive waiting times due to coordination difficulties at real time sessions. Further pathological experts fear to be bothered with simple cases since telepathology allows an easy access to their departments.

18.6.3 Equipment Quality

Summary of Equipment Quality Criteria		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Colleagues’ judgement (13*)	Fear of incorrect diagnoses	4	46%	1	67%	2	53%	*
“	Investment is too expensive	3	49%	3	56%	4	51%	**
“	Technology is not reliable	9	24%	6	44%	8	31%	*
Disadvantages (11*)	High investments	2	2,79	5	1,79	4	2,43	***
“	Accuracy of diagnosis is not guaranteed	7	2,37	7	1,33	8	1,97	***
“	Technology is not reliable	9	2,16	9	0,87	9	1,67	***
PCA-factor of success (10)	Equipment quality	3	3,59	4	3,41	3	3,52	-
Factors of success (39*)“	Image quality (resolution)	1	3,90	1	3,81	1	3,87	-
	Medical equipment quality	7	3,58	5	3,58	6	3,58	-
“	Network performance	11	3,63	6	3,56	8	3,60	-
“	Computer equipment	12	3,63	18	3,26	14	3,49	**
“	Support desk for system selection	23	3,23	31	2,79	25	3,07	-

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues’ judgements the ratings of participants are given in % (yes).

Schedule18: Overviews of all ratings concerning equipment quality.

Users as well as non-users claimed that the employed equipment has to be of high quality. The criteria ‘quality of the images’ was set on the first position of the ratings of the factors of success. Factors which also got a high rating were the quality of the medical equipment and the performance of networks. These two aspects again refer to ‘image quality’, since one needs good microscopes for the selection of images. High bandwidth guarantees a fast image transfer, which is important at real time sessions. Due to improvements in computer

technology and image capturing devices, these two areas are rather unlikely to be a source of trouble at telepathology systems. Nevertheless, that the quality of IT-equipment is important is reflected by the mean of 3,63 by non-users and the mean of 3,26 by users. Regarding the criterion 'high image quality', this is in conflict with the aspect 'investment costs' and 'speed of image transfer'. Investment costs are set on high levels at the ratings of colleagues' rejection of telepathology and at the ratings of disadvantages. In the context of quality, participants' fear that low quality equipment will cause incorrect diagnoses is higher than the fear of unreliable technology.

18.6.4 Reliability of Technology and Security Aspects

Summary of Reliability and Security Criteria		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Colleagues' judgement (13*)	Technology is not reliable	9	24%	6	44%	34	31%	*
Disadvantages (11*)	Uncertain data security	4	2,69	4	2,00	3	2,44	**
	Technology is not reliable	9	2,16	9	0,87	9	1,67	***
PCA-factor of success (10)	Reliability/security aspects	6	3,37	5	3,28	5	3,33	-
Factors of success (39*)	System stability (short interruptions)	8	3,69	11	3,49	7	3,62	-
"	Data security (e.g. secure networks)	13	3,59	15	3,32	15	3,49	-
"	System reliability (system no more usable)	25	3,20	12	3,46	18	3,29	-
"	Access control	20	3,32	24	3,03	20	3,22	-

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues' judgements the ratings of participants are given in % (yes).

Schedule 19: Overviews of all ratings concerning reliability aspects.

At the ratings of the factors of success 'system reliability and security' aspects were set on place 5 of the overall ratings with a mean of 3,33. The ratings of both groups do not show a significant difference in this point. Considering the single ratings, the most important aspects of security is system stability (mean of 3,62, place seven of the overall ratings). At the ratings of disadvantages the fear of unreliable systems occurred on place 9 (of 11 aspects) with an average mean of 1,67. Non-users rated this disadvantage highly significant higher (mean of 2,16) than users did (mean of 0,87). In summary users as well as non-users recognize the fear of unreliable telepathology applications as a barrier of telepathology's introduction, although this aspect is not rated as high as the aspects discussed before. However, since the system currently in use do not show a lot of problems stability and reliability, it seems that it is more a matter of fear than of facts. Nevertheless, these fears have to be taken seriously when in discussions with pathologists.

18.6.5 Legal Uncertainty

Summary of Legal Uncertainty Aspects		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Colleagues' judgement (13*)	Legal uncertainty	2	51%	12	20%	5	40%	***
Disadvantages (11*)	Uncertain legal questions	1	3,09	1	2,46	1	2,87	**
PCA-Factors of success (10*)	Meaning of legal clarity	5	3,44	7	2,95	6	3,26	***
Single factors of success (39)	Liability regulations	9	3,68	17	3,27	10	3,53	**
"	Licensure regulations	6	3,79	25	3,03	11	3,52	***
"	Data protection	16	3,45	27	2,89	19	3,25	**

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues' judgements the ratings of participants are given in % (yes).

Schedule 20: Overviews of all ratings concerning liability aspects.

When rating the factors of success, the influence of legal clarity was rated with a mean of 3,26. Especially the non-users judged the insecure liability situation (mean of 3,68, 51% rated it as a reason for colleagues rejection of telepathology) and the missing clarity of qualification regulations (mean of 3.79) as very critical. At the ratings of disadvantages 'legal uncertainty' was even set on place one of all disadvantage judgements by users as well as by non-users. This indicates, that non-users are very skeptically about the legal situation

of telepathology examinations. As long as there are no legal regulations available this uncertainty will be a huge barrier in the acceptance – and with this in the utilization of telepathology examination services.

18.6.6 Lack of Standardization

Summary of Standardization and Integration Aspects		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Colleagues' judgement (13*)	Standards are missing	10	19%	8	36%	11	25%	*
Advantages (13*)	Access to medicine, reduced isolation	3	1,78	1	3,28	2	2,33	***
"	More efficiency in procedures + structures	7	1,28	7	2,50	8	1,71	***
PCA-Factors of success (10)	Meaning of standards and compatibility	7	3,18	9	2,81	7	3,05	**
Factors of success (39*)"	Meaning of standardized data formats	19	3,36	14	3,37	17	3,36	-
"	Meaning of technical standards	21	3,30	23	3,05	22	3,20	-
"	Meaning of internal syst. integration (HIS)	28	3,00	37	2,36	32	2,75	**
"	Meaning of external syst. integration	24	3,21	36	2,36	27	2,88	***

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues' judgements the ratings of participants are given in % (yes).

Schedule 21: Overviews of all ratings concerning standardization criteria.

At the factors of success the PCA factor standardization was set on place seven with an average mean of 3,05. Non-users rated this factor with a mean of 3,18 very significant higher than users did (mean of 2,81). The difference in the ratings is caused by the judgement of the demand that telepathology systems have to be integrated in the existing environment of users. The users rated this fact lower than non-users did. Nevertheless users also have recognized that missing compatibility of systems is often a reason for colleagues rejection of telepathology introduction (36%). In summary the aspect standardization goes along with the factor 'investment'. If systems and data are not standardized, additional unnecessary integration effort will be caused if pathologists want to access medical resources and if they want to make use of the value added effect of 'resource sharing'. Therefore this criterion has to be taken seriously, although it lies in its meaning behind several other aspects. And last but not least, standardization does not just include data and equipment integration, but also the standardization of medical vocabularies. This aspect was emphasized by several participants in their comment and is discussed in chapter 14.2.

18.6.7 Investment Costs and Efficiency Aspects

Summary of Investment and Efficiency Criteria		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Colleagues' judgement (13*)	Costs / investments too expensive	3	48,6%	3	56,4%	3	51,4%	-
"	Services are inefficient	6	35,7%	10	25,6%	7	32,1%	-
Advantages (13*)	More efficient structures by telepathology	7	1,28	7	2,50	8	1,71	***
	Improved patient treatment process	9	1,07	6	2,53	9	1,61	***
"	Cost reduction, savings by telepathology	11	0,94	10	1,89	10	1,27	***
"	Survival of department (examination rates)	10	1,03	12	1,56	11	1,20	-
	Additional revenues	12	0,85	11	1,69	12	1,15	***
"	Efficient on-call services	13	0,72	13	1,35	13	0,94	***
Disadvantages (11*)	Uncertain reimbursement	3	2,69	3	2,03	2	2,46	**
"	Unnecessary investment	2	2,79	5	1,79	4	2,43	***
PCA-factor of success (10)	PCA factor 'cost efficiency	8	2,99	8	2,90	9	2,95	-
Factors of success (39*)"	Meaning of investment costs	22	3,23	30	2,81	24	3,08	*
"	Meaning of service efficiency	26	3,02	32	2,78	26	2,93	-
"	Improved health care efficiency by telepath.	31	2,71	22	3,08	29	2,85	-
"	Meaning of clear reimbursem. regulations	30	3,68	35	2,50	30	2,75	-

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues' judgements the ratings of participants are given in % (yes).

Schedule 22: Overviews of all ratings concerning investment and efficiency criteria.

At the ratings of the factors of success cost efficiency was set on place 9 of the ten factors. The differences in the ratings of users and non-users was not significant. At the ratings of disadvantages the argument of high investments was highly significant higher rated by non-users (mean of 2,79 / place 2) than by users (mean of 1,79, place 5). Also at the judgements of the reasons of colleagues rejection of telepathology 'high investment costs' were seen as the second most important criterion after accuracy aspects. In average 51% of the participants named it as a factor for colleagues refusal of telepathology. In summary the ratings reflect, that investment costs are especially by non-users seen as a barrier for telepathology's introduction.

Considering the ratings of the PCA factors of success, which refer to the aspect 'cost efficiency', this criterion was rated with a mean of 2,95 in its meaning for telepathology's success. Efficiency of tele-examinations are heavily influenced by reimbursement. 'Uncertain reimbursement was the second highest disadvantage (mean of 2,46), rated significantly higher by non-users (mean of 2,69) than by users (mean of 2,03). At the judgments of advantages 'cost reduction and savings' were rated highly significant higher by the users (mean of 1,89 / place 10) than by the non-users (mean of 0,94). 32% saw in 'inefficiency of services' a reason for colleagues rejection of telepathology. That is that high investment costs seem to create a higher barrier than the overall efficiency of services does. In addition, participants see in investment costs and inefficiency a main disadvantage of telepathology and a huge reason for colleagues rejection of telepathology. Users expect that the efficiency situation will improve due to cost reduction and savings, whereas non-users point at the uncertain reimbursement situation. In summary monetary aspects were rated lower than many other criteria. It seems that efficiency is dependent on the situation of a user.

18.6.8 Politics and Acceptance Criteria

Summary Politics and Acceptance Aspects		non-users		users		all		
Area of question	**Content of question**	**pl.**	**mean**	**pl.**	**mean**	**pl.**	**mean**	**p**
Colleagues' judgement (13*)	No interested partners	8	26%	9	33%	9	28%	-
Disadvantages (11*)	Fear that medical centers will steal examin.	10	1,73	10	0,79	10	1,38	***
Advantages (13*)	Improvement of reputation	2	1,96	8	2,46	4	2,13	-
"	Survival of pathological department	10	1,03	12	1,56	11	1,20	-
PCA-factor of success (10)	Surrounding	10	2,30	10	2,69	10	2,44	**
Factors of success (39*)"	Internal accept. - users	27	3,00	7	3,54	23	3,20	*
"	Health care politics / laws	29	2,94	33	2,78	28	2,88	-
"	External acceptance (HMOs)	32	2,64	26	2,95	34	2,75	-
"	Internal accept.– top management	35	2,41	19	3,25	35	2,73	***
"	Geographical factors	33	2,55	34	2,60	36	2,57	-
"	Institutions politics/strategy	37	2,08	29	2,89	37	2,37	**
"	Cultural factors	38	1,67	39	1,82	38	1,73	-
"	Acceptance - patients	39	0,93	38	1,91	39	1,30	***

Pl.=place/range of rating result; * amount of questions in total.; at the colleagues' judgements the ratings of participants are given in % (yes).

Schedule 23: Overviews of all ratings concerning environmental aspects such as politics and acceptance.

The criteria referring to the surroundings of telepathology got the lowest ratings compared to other aspects. Regarding the acceptance of people and politicians, who are affected by telepathology, users' acceptance was seen as most important. This was especially seen by participating users of the study in Constance, who set users' acceptance on place seven of their overall ratings. The influence of the health care policy and laws was seen as the second most important 'surrounding criterion'. Non-users especially rated it with a high mean

of 2,94. In contrast, users rated the influence of insurance companies higher (mean of 2,95). They also found the internal policies of an institution more important for telepathology's success (mean of 2,89) than the influence of health care laws (mean of 2,78). Users further emphasized that the acceptance of the internal top management also plays a vital role for telepathology's success (place 19, mean of 3,25). The lowest ratings were given to the meaning of patient's acceptance for telepathology's success. Also the influence of cultural factors was rated very low (mean of 1,73), whereas geographical factors got an overall mean of 2,57.

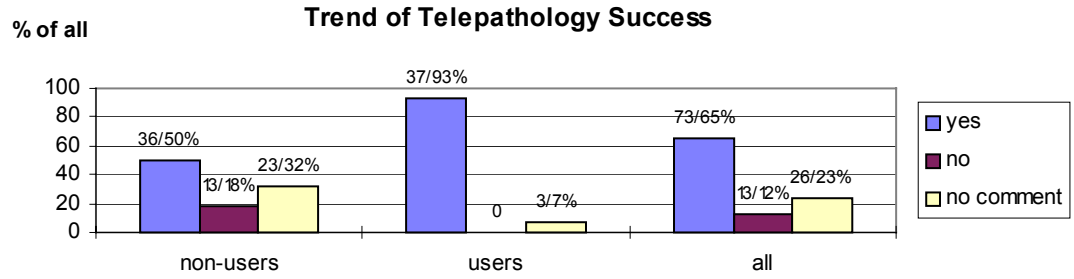
Considering further ratings, which refer to policies and strategies, 28% of the participants stated that their colleagues do not introduce telepathology, because there are no interested partners available. This ratings could either emphasize the reluctance of pathologists to introduce telepathology or point at the current structures of telepathology service distribution. Another reason for the rejection of telepathology could be caused by the fear that examination numbers will decrease, since customers may prefer to access highly specialized medical centers. Yet, this fear got low ratings compared to other disadvantages. Also the possibility to increase examination numbers by telepathology got low ratings. That is that pathologists seem not to expect a change in pathological examination structures, but expect improved quality due to telepathology utilization. With this, the reputation of their department would improve, which was especially seen by non-users as a central advantage (place two of the ratings of telepathology's advantages).

18.6.9 Summary of All Judgements

In summary, judgeing the of various criteria, the highest importance was given to factors related to diagnostic accuracy, to the quality of equipment, user-friendly interfaces, system stability, investment costs and to legal aspects. Also security aspects, standardization, satisfying user support were seen as important factors of influence for telepathology success. Lower importance was seen in efficiency criteria, management aspects, as well as in political, geographical and cultural criteria.

At the ratings of disadvantages the uncertainty in liability, reimbursement and of data security was seen as the highest barrier for telepathology's success. There are also many fears in existence, which refer to the quality in pathology and to the fact of being dependent on technology. Yet participants also recognized the potentials of telepathology to improve the quality and efficiency of pathological services. In summary users rated the advantages higher than the disadvantages of telepathology applications, whereas the non-users ratings are exactly opposite.

18.7 Trend of Telepathology Introduction



Question 6.5 of users' questionnaire (appendix V): "Trends and future developments. Do you think, that telepathology will become established in health care? What trend do you recognize? Where will telepathology end up?"
The first amount of each column is the number of participants in total, the second amount in per cent (e.g. 36/50%).

Figure 53: Trend of telepathology introduction in the future.

Participants were asked whether they think that telepathology will become established in health care. 65% remarked that they believe that telepathology systems will settle down in the future. Considering the single judgements, 50% of the **non-users** meant that telepathology will be accepted, whereas another 18% believe that it will not succeed. In opposite, 100% of the **users** (without the abstention of three users) believe that telepathology will become established as a tool for pathologists in the future.

Participants were further asked about the trend they recognize for telepathology and where they expect telepathology to end up in the future. Seven users meant that telepathology systems will be used as a tool to execute **frozen section services** for hospitals without a pathologist. One user even believes that progressive pathological laboratories will connect to each other internationally and bypass local/regional/national laboratories, which do not want to participate. However, there are also five participants (including one user) who remarked in their comments that telepathology should never be used for **primary diagnostic**, no matter whether it is on a routine basis or restricted to frozen sections. They stressed that a correct sample preparation and a qualified field selection can never be executed by a non-pathologist. In addition, they emphasized that primary diagnoses by telepathology lead to an legally not acceptable risk. Only one user expects the opposite. He assumes that telepathology will be soon introduced as a tool to execute primary diagnoses on a routine basis by many pathologists. Another user even went so far to remark that in his opinion 'virtual slides will replace robotic microscopes'.

Thirty-three participants made comments about telepathology being used for requesting experts' **second opinion**. They believe that the quality of diagnoses will improve due to the advantage to easily ask an external specialist about his opinion. Especially if a case is rare or very complicated or if a pathologist is not very experienced, he can quickly contact an expert of his choice. Seven other participants (including two users) underlined that telepathology systems should only be used for second opinion consultations, and consequently in any case be rejected for primary diagnoses. Four participants remarked that with telepathology the exchange of images and case data will be speeded up, and that final diagnostic reports will be faster available. Moreover, three participants emphasized the trend that the communication between pathologists, and between pathologists and physicians will enhance.

Thirteen other participants stressed in their comment about the future trends that they expect telepathology to improve **education** and **quality assurance**. They meant that telepathology offers the possibility to participate at teleteaching and online education sessions, which would especially be of advantage for young, inexperienced pathologists. Users can easily plug in into expert discussion circles, ask questions or retrieve current information of expert conferences. Eight participants further expect that telepathology systems will improve and change the future quality assurance activities in pathology.

Three users also made comments about the changes in **research**, which telepathology will cause in the future in their opinion. One user believes that telepathology will help to integrate research into routine pathology. Another meant that digital image archives will quickly support research projects. Telepathology will enhance the interdisciplinary data and image collection. In this way much more distinguished analyses are possible and with this research findings can be fundamentally improved, how one user remarked.

But how ever the future usage of telepathology will look like, seven users remarked in their comment that telepathology is a simple tool which almost all pathologists will use in future. They see it as a useful (complementary) tool for the daily diagnostic routine. It will be a 'system in every laboratory besides the microscope or telephone', how one user assumes. Another user meant that within the next ten years the utilization of telepathology will increase like this was the case with e-mail, scanners, or electronical image management systems.

In summary, most participants recognized a value in telepathology services and assumed that systems will be accepted and widely used in future. As in the ratings of interest in telepathology services, also in the comments the most expected utilization of telepathology is seen in qualified second opinion consultations, tele-education and online discussions.

18.8 Strategy of Telepathology Introduction

18.8.1 Current Geographical Distribution of Telepathology Systems

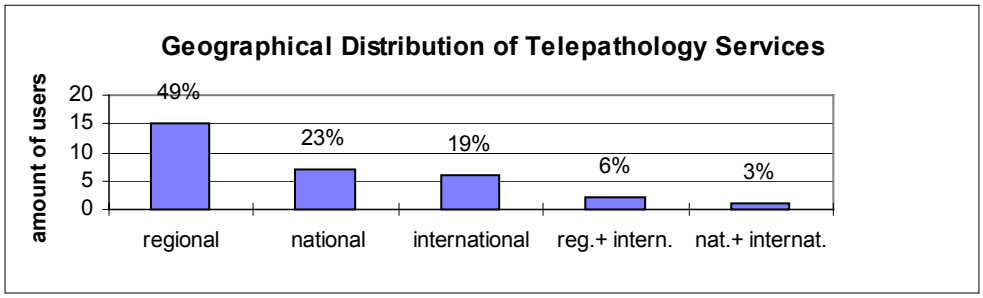


Figure 54: Geographical distribution of telepathology services.

First of all users, who are practicing telepathology as a consultant, were asked about the geographical area to which they provide their telepathology services. 49% replied that they are serving their services only regionally, 23% nationally, and 19% internationally. Two users said that they offer telepathology services regionally and internationally, and one user meant that his telepathology services are offered nationally and internationally. This distribution indicates that in general pathologists are used to work regionally instead of internationally, and that telepathology is rather used to improve current work processes instead of creating new global structures.

18.8.2 Extent of Telepathology Concept Development

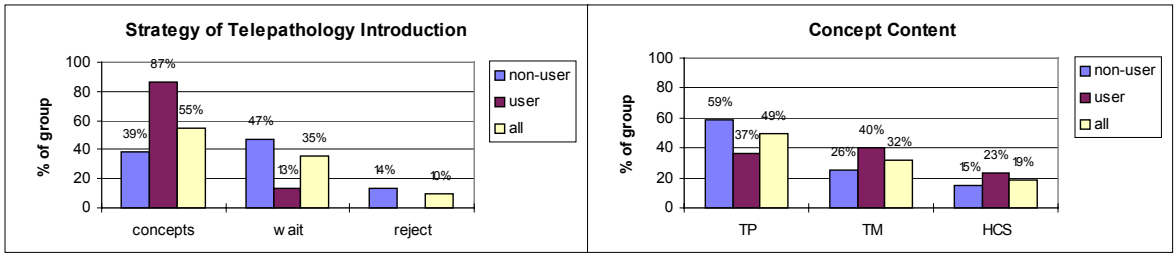
Participants were further asked, which structural telepathology developments they would recommend. They got the options a) '**to reject telepathology**', b) '**to waiting**' until technology is proved and until all unsolved questions are answered, and c) '**to start with the development of concepts**' and to introduce solutions.

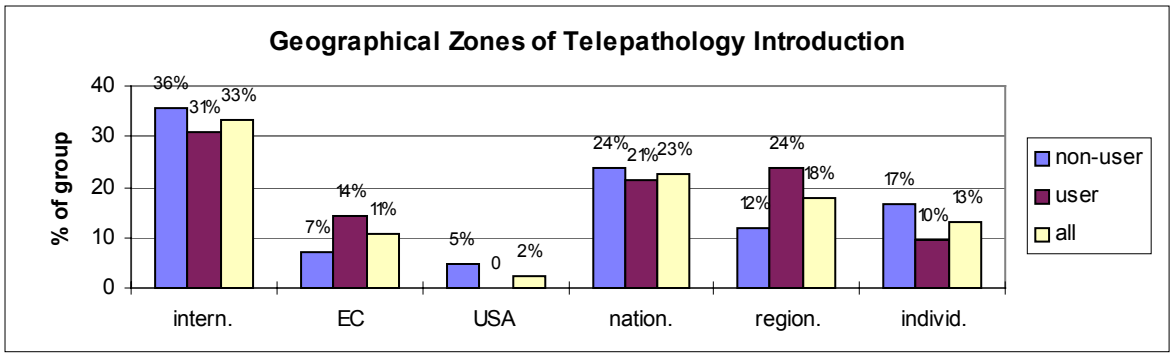
If participants chose to start with concept developments, they were further asked to distinguish them into desired '**geographical zones**'. For this the following options were offered: a) international, b) Europe, c) USA, d) national, e) regional, and f) individual, focused on specific projects.

In addition they were asked to give their desired extent of the **concept content**. For this they got the options: a) concepts should be focused mainly on telepathology, b) concepts should also integrate other telemedical applications, c) concepts should regard the whole health care system' The results are as follows:

Future structure	Which structure of telepathology would you recommend?											
Alternatives:	**reject**	**wait**	**development of concepts and introduction of solutions**									
			total *	**geographical zones**						**concept content**		
				inter-nat.	**Euro -pe**	**USA**	**natio-nal**	**regio-nal**	**indivi -dual**	**only TP**	**only TM**	**whole HCS**
Non-User	10	**34**	28	**15**	3	2	10	5	7	**23**	10	6
User	0	5	**33**	**13**	6	0	9	10	4	11	**12**	7
All	11	39	**60**	**28**	9	2	19	15	11	**34**	22	13

* The total gives the number of participants who marked the option 'to develop concepts'. Yet, although several participants chose the option 'reject' or 'to wait', they recommended their desired concept design, too. Therefore the total ≠ the sum of geographical zones or concepts. TP = telepathology; TM = telemedicine; HCS = Health Care System. The most preferred option of each group is emphasized (fat number).





Pay attention: the overall number of non-users is 72, the number of users 40 -> the percentage of '**all**' is dominated by the non-users' judgements.

Figure 55: Desired structural introduction processes in telepathology.

Considering the results, ten non-users (14%) but no user recommended to reject telepathology. One of the non-user meant that telepathology just is a 'toy' for researchers, but not a

useful method to improve his work. Therefore it should be turned down. Thirty-four of the non-users (47%) and five of the users (13%) were of the opinion that one should wait until telepathology is proved and until unsolved questions are answered. Finally 28 (39%) of the non-users and 32 (87%) of the users are in favor that telepathology concepts should be developed and that solutions should be introduced. The differences in the ratings of both groups are highly significant ($Chi^2(0,71)=25.2$, $p<0,000$)[117].

At the choice of the **geographical zones**, most of the participants (28 / 33%) wanted an international solution. Both groups set international solutions on the highest position. 19 (23%) would have preferred a national, 15 (18%) a regional, and 11 (13%) an individual project oriented solution. That concepts are focused on an European or US solution was selected by eleven participants (13%)[118]. Considering the **concept content**, 34 participants (49%) meant that concepts should be mainly focused on telepathology aspects. 22 (32%) thought that telepathology system designs should include the whole spectrum of telemedicine and effort should also be put into an overall compatibility with telemedical applications. The remaining 13 participants (19%) recommend that telepathology concepts should be designed with consideration of the whole health care delivery system.

In summary, most of the systems are recently used regionally. Asking participants about their attitude of telepathology introduction, most of the non-users prefer a 'wait and see' position, whereas 87% of the users meant that well suited concepts should be developed. These concepts should mainly be focused on telepathology requirements, but still keep the integration with other telemedical applications and with the whole health care delivery system in mind. Most participants are of the opinion that concepts should be designed internationally. Yet, since international developments are often slow, many participants recommended to make progress in national and regional developments, too.

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[117] A variance analysis was executed to investigate the significant differences in the ratings of telepathology service interest, factors of success, and dis-/advantages in relation to the acceptance / recommended introduction strategy. Yet, since the recommended introduction strategies are highly significant in correlation with the characteristics users and non-users, the significant rating differences are almost identically. That is that participants who, recommended to develop strategies (87% of the users), also rated the interest in telepathology services and advantages significantly higher, and disadvantages significantly lower, than the participants did, who recommended to reject telepathology or to wait (61% of the non-users). (For significance values see appendix X, please).

[118] Within these numbers, sixteen participants recommended a mixture:

- one meant a mixture between international, European, and an US-solution,
- one a combination of European, national and regional solution,
- one a solution between Europe and national,
- one a solution between USA and national,
- one a solution between regional and individual,
- five would have liked a combination of national and regional,
- and another five between national and individual.

19 Influence of Participants' Characteristics

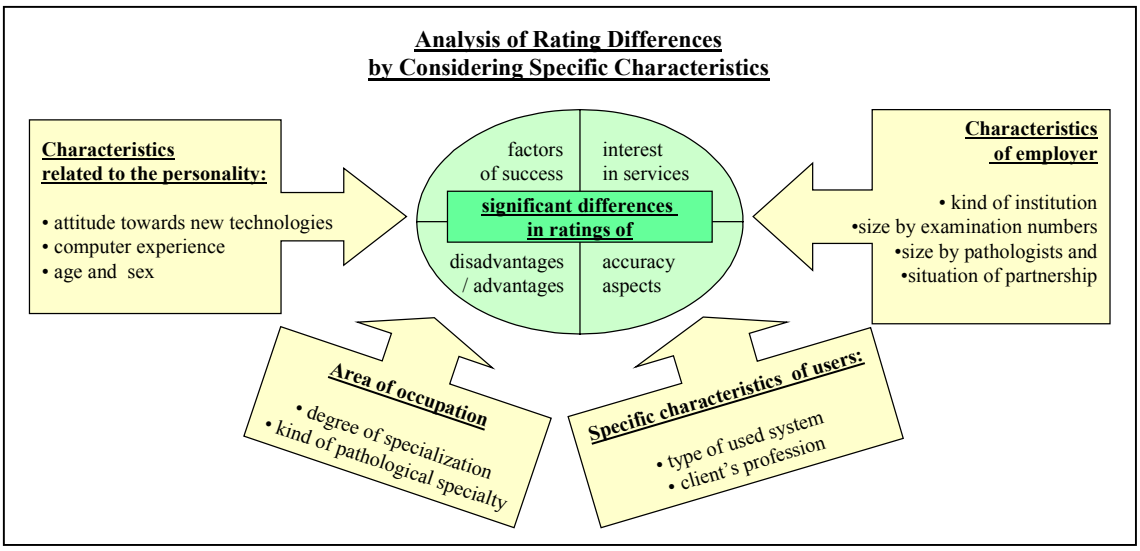


Figure 56: Analysis of specific influence factors on the ratings of participants.

19.1 Characteristics Related to Participants' Personality

19.1.1 Age and Sex

One reason for little acceptance of telepathology applications, which is often named in the literature, is the lack **of computer experience** of attending physicians, often **related to their age**. Some pathologists, especially **older** ones, who have never been comfortable with computers and related technology, and who are relatively uninterested in their usage, may simply decide to avoid contact to telepathology. Many doctors have even an aversion to computers and new network technologies. One reason for this attitude is that pathologists have been trained to work in a human and literature environment instead of a computer/ machine environment [Wyman, 1994]. Since they have less experience with computers they tend to have negative views about technical complexity and the effects of computers on existing referral patterns [Callas, 1996, p. 320].

Younger, technologically inclined physicians may be more likely to try applications like telepathology. Many medical students of today have a lot of computer and video game experience. For many of them computers are a daily tool since they recognize computers as an easy way to communicate and to get information [Clements, 1995; Mullick, 1996, p. 191]. Nevertheless, young medical students are often negative about information technologies, too [Rienhoff, 1998, p. 12]. This attitude is intensified by a vast majority of medical curricula, since they still do not encourage their medical students to take computer classes to learn new computer applications like telepathology [Wyman, 1995].

In contrast, to get student physicians early familiar with computer health care resources, the Case Western University gave students access to a self-triaging computer diagnosing program.

> *„The intent is not to keep people out of the system, but to get them to use it and perceive a benefit from seeking care that does not begin with a $50 entrance fee." [Wyman, 1994]*

Such approaches may help to create a new generation of younger pathologists, who are highly motivated and better adapted in rendering diagnoses from video images [Eide, 1994, p. 888; Weinstein, 1997/(3), p. 5].

Sex and Age of Participants

To investigate the personal characteristics of participants of this study, they were requested about their age and sex. The results show that only 2,7% of the participants are younger than 35 years. Approximately 45% are 35 to 50 years old, but most of the participants (52%) are older than 50 years . Only eleven of the 112 participants are female. This reflects that pathology is still a male dominated discipline.

Age and Sex	Please give your age and sex.									
Group	**Age**						**Sex**			
	< 35 years		**35 to 50 years**		**> 50 years**		**male**		**female**	
	total	**%**	**total**	**%**	**total**	**%**	**total**	**%**	**total**	**%**
Non-User	1	1,4	34	47,2	37	51,4	66	91,7	6	8,3
User	2	5	17	42,5	21	52,5	35	87,5	5	12,5
All	3	2,7	51	45,5	58	51,8	101	90,2	11	9,8

For further significance calculations the groups were summarized in two groups: a) age <=50 and b) age >50.

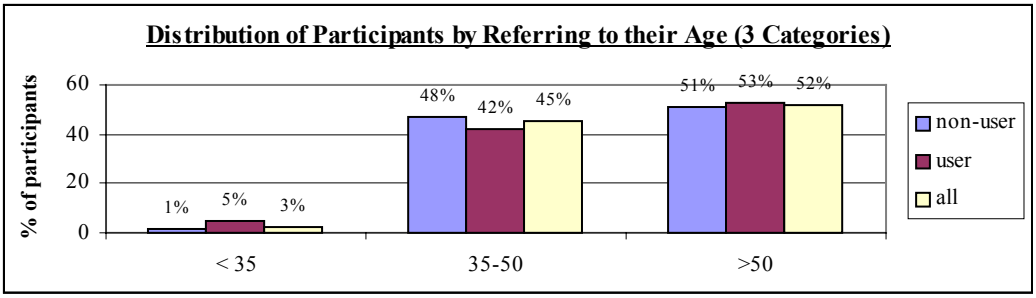


Figure 57: Sex and age of participants.

Considering the figure above, it surprises that the number of young telepathologists is low, since it is contrary to the argumentation before – that is that young physicians are willing to work with computers. Yet, at both groups the amount of young pathologists is small. In summary, the distribution of users' and non-users' age is quite similar and does not show a statistically significant value ($Chi^2(19.2)=0,01$, $p<0,91$). This could refer to the long training period a physician has to carry out till he/she becomes a licensed specialist. The low number of young telepathologists could also point out that a young pathologist does not have as much experience in pathological diseases as an older pathologist has, and therefore he/she prefers to avoid the additional difficulty of uncommon screen examination. In other words, pathological experience could have more impact on telepathology's acceptance than computer experience. Yet, this is mere guesswork. Interestingly the schedule also exhibits that many pathologists who are more than 50 years old, are still in the mood to use telepathology systems. Again, these results are in opposite to the experiences mentioned in recent literature. The findings of this study indicate that if an older pathologist recognizes advantages, he is willing to use telepathology systems.

Significance Analysis of Rating Differences due to the Age of Participants

Analyzing, whether the age of a participant has a significant influence on the rating of the various factors and variables (interest in telepathology services, the judgements of the fac-

tors of success, and of the advantages and disadvantages), the following schedule gives the aspects where significant values were investigated.

Significance Analysis	**<=50**		**>50**		**all**			
Considered the Age of Participant	Mean	St.D.	Mean	St.D	Mean	St.D	F(1,110)	p
Interest in services – 'high know how' (Educa_7)	**2,50**	1,01	2,18	0,96	2,34	0,99	3,04	0,084
I2.5.12 Current interest: in Internet information	**2,92**	1,27	2,34	1,31	2,62	1,32	5,53	0,020
I2.6.12 Future interest: in Internet info., WWW	**3,06**	1,14	2,51	1,41	2,78	1,31	5,20	0,025
I2.6.11 Future interest: in quality assurance	**2,26**	1,46	1,76	1,37	2,00	1,43	3,52	0,063
I2.6.4 Future interest: in second look consult.	**2,80**	1,16	2,17	1,44	2,47	1,34	6,530	0,012
I2.6.5 Future interest: in reference consult.	**2,90**	1,09	2,39	1,30	2,64	1,22	4,893	0,029
Analysis of factors of success	PCA-factors did not show significant differences							
f4.1.4 Influence of the acceptance of physicians	**3,41**	1,04	2,30	1,26	3,20	1,17	3,599	0,060
f4.2.2 Influence of institution's politics	**2,64**	1,29	2,12	1,31	2,37	1,32	4,451	0,037
f4.5.3 Influence of accurate micro-examination	3,56	0,90	**3,88**	0,36	3,73	0,69	6,203	0,014
Analysis of advantages and disadvantages	PCA-factors did not show significant differences							
a5.1.1 Advantage: TP will improve diagnostic quality	1,50	1,60	**2,18**	1,63	1,85	1,64	5,073	0,026
d5.3.6 Disadvantage: TP will reduce education quality	0,70	1,09	**1,22**	1,50	0,97	1,34	4,356	0,039

The significance values of the other factors can be seen in appendix X.

Schedule 24: Significance values referring to the age of participants.

Considering the PCA-factors, there was only one statistical difference. The future interest in 'educational services to improve the know-how' was rated significantly higher by younger pathologists ($F(1,110)=3.04$, $p<0,084$). Considering this factor the difference was caused by the different ratings of the interest in 'quality assurance services' and in 'Internet information access'. Yet, there occur also significant differences in the ratings of the current interest in Internet services, and in the future interest in second look and reference consultations. Again, younger pathologists rated the interest in all these services significantly higher than older ones did. In summary these ratings could indicate that indeed younger pathologist are more positive about telepathology and its future utilization than are older ones.

Considering the ratings of the factors of success, the influence of the 'acceptance of physicians/users' and of the 'institution's policy' for telepathology's success was also significantly higher rated by the younger than by older pathologists. These differences may refer to the fact that older pathologists are often the main decision makers and therefore they recognize internal politics as a lower barrier for telepathology's success.

Yet, at the judgement of the meaning 'diagnostic accuracy criteria' for telepathology's success the older pathologists gave significantly higher ratings. As the next point shows, these older pathologists hope that telepathology will improve diagnostic quality ($F(1,160)=5.07$, $p<0,026$) and therefore they may have emphasized the need of a high diagnostic accuracy. Finally older pathologists also rated the fear of reduced education quality significantly higher than did younger ones. However, since there were now significant differences in the judgements of the interest in online education and discussions, these differences may only reflect the slight reluctance of older pathologists to change their habit of written education towards an electronical one.

To analyze the influence of user's sex in relation to the various ratings does not make sense due to the low number of female pathologists.

19.1.2 Acceptance of Telepathology by Referring to Specific Personal Characteristics

Moore characterizes different types of people, who are involved in telemedicine utilization and whose acceptance of telemedicine is high [Moore, 1995; Williams, 1995].

Leader of projects are described as charismatic entrepreneurs, who are articulate, enthusiastic, energetic, self sacrificing, obsessed with their users, and true believers in their causes. These attitudes, especially their curiosity makes them to pioneers for telepathology introduction. They are inquisitive and confident enough to ask questions, because they believe that they do not know all answers. They demonstrate qualities of life long learning, use many sources of information, are mostly outgoing, and are often information influentials.

Consulting specialists, who provided telemedicine are characterized as being opinion leaders in their fields. They are experienced, provide a high standard of care, are flexible and adaptable. They recognize telepathology as a vital tool to share their know-how with colleagues or to support them in their daily business. They are also altruistic, since theses physicians are rarely reimbursed for their services.

Referring health care practitioners are inquisitive, confident enough to ask questions and are not intimidated by specialists. They humble enough to believe that they do not know all the answers. Similar to project leaders, they believe in lifelong learning, also use many sources of information, and are outgoing. They are often 'information influentials' who conducted telemedicine consultations and who are keen on informing other local colleagues about the outcome of their consultations. Their cooperative attitude makes them highly interested in introducing telepathology systems.

Technical support personnel for telemedicine applications have to be experienced, capable, and flexible, since telemedicine needs vary a lot and are mostly unpredictable. Such persons are not routine driven, but filled with enthusiasm for new technologies like telepathology.

Telepathology reluctant persons do have less experience with computers and are skeptical. They follow an attitude of 'wait and see', instead of a 'try and error' approach. Therefore they want to have facts about the advantages of a new technology as telepathology is, before they spend time and money for its introduction.

19.1.3 Computer Experience

Computer experience was already mentioned as a possible barrier of telepathology when considering the age of pathologists. Yet, fortunately the resistance against computers can be diminished as an example at a telepathology project in Vermont proved. The attitude toward the system was negative at the beginning due to the lack of experience, but improved after users have used the system [Callas, 1996, p. 320]. At another telepathology trial between the Rush-University of Arizona and the St. Luke's Medical Center in Chicago, older, light microscope experienced pathologists were slower in screen image examination compared to the younger pathologists with experience in video and computer technologies. Yet, this difference diminished after a time and did not lead to a major obstacle in the utilization of telepathology for diagnostic purposes [Krupinski, 1993, pp. 77-81, 84].

Distribution of Computer Experience between Users and Non-Users

To discover the computer experience of participants, they were asked to rate their IT know-how as 'no experience', 'average experience' (usage of standard programs), or with 'huge experience' (fundamental know-how like programming languages).

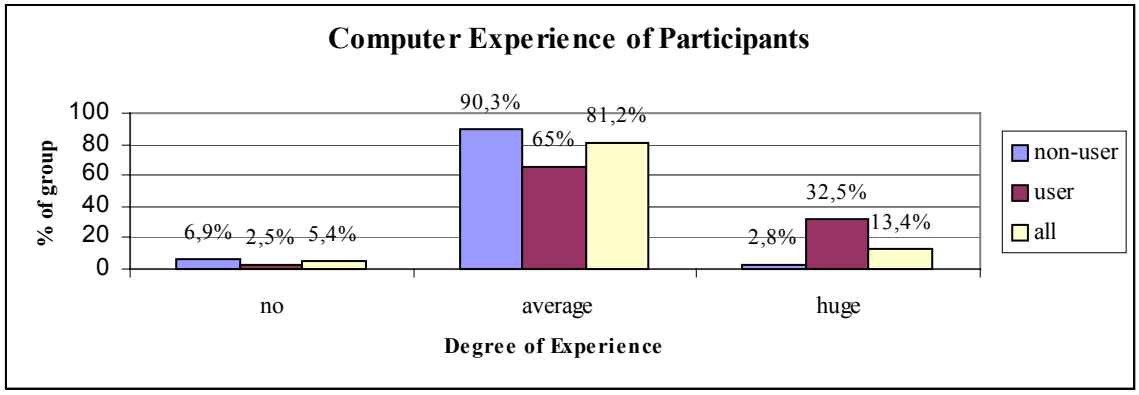


Figure 58: Computer experience of participants.

Only one user answered that he does not have any computer experience. Twenty-six (65%) said that they have average experience, and thirteen (32,5%) judged their computer know-how even as huge. In comparison, of the non-users 6,9% (5) have no experience, 90% (65) average experience and only 2,8% (2) have huge experience. The differences of users and non-users in the distribution are highly significant ($Chi^2(2.14)=19.9$, $p<0,000$). The results reflect that the current users are more experienced and interested in computers. They seem to be more keen in utilizing computers to support their tasks than the average pathologist is. Vice versa, if pathologists decide to become a telepathology user, they automatically will increase their computer know-how, and enlarge their ability in image management and in rendering diagnoses by computer support.

Significance Analysis of Ratings Referring to Participants' Computer Experience

Interest in Telepathology Services Considered by Computer Experience	**Low (n=6)**	**Average (n=91)**	**High (n=15)**	**Significance Multiple Range Test by Scheffe**		
	Mean	Mean	Mean	F	p	Scheffe p
Interest in Services – 'High know how' (Educa_6)	1,05	**2,24**	**2,59**	5,13	0,007	1->2, 1->3
I2.5.12 Internet info., WWW	0,94	**2,71**	**2,71**	5,59	0,005	1->2, 1->3
I2.5.9 Online education	1,05	2,25	**3,00**	4,24	0,017	1->3
I2.5.7 Interdisciplinary cooperation	0,87	2,21	**2,27**	3,29	0,041	1->3
Future Interest in Services – 'High know how' (Edu_7)	1,14	**2,38**	**2,56**	5,19	0,007	1->2, 1->3
I2.6.10 Discussions, forums, etc.	1,50	**2,82**	**2,89**	3,85	0,024	1->2, 1->3
I2.6.9 Online education	0,83	**2,54**	**3,00**	6,84	0,002	1->2, 1->3
I2.6.11 Quality assurance	0,17	**2,13**	**1,93**	5,82	0,004	1->2, 1->3

Scheffe's multiple range analysis was used to investigate significant differences within a group; for example, 1->2 means that the significance is caused by group one and two.

Schedule 25: Schedule of the significance analysis of service interest in relation to computer experience.

Considering the ratings of the current and future interest in several services, the values of the six users with low computer experience were significantly lower at the services, which are given in the schedule above. There are no significant differences between group two (average computer experience) and three (high computer experience) in the ratings of the interest in telepathology services. These findings confirm the results of other research stud-

ies, where low computer experience was recognized as a barrier to utilize telemedical applications.

Ratings of Factors of Success and Advantage- and Disadvantage Ratings Considered by Computer Experience of Participants	**Low (n=6)**	**Average (n=91)**	**High (n=15)**	**Significance Multiple Range Test by Scheffe**		
	Mean	Mean	Mean	F	p	Scheffe p
Accuracy (Accur_2, factor 6 of the 10 PCA factors)	**3,94**	3,79	3,34	4,67	0,011	1->3
4.5.1 Success factor: accurate macro examination	**3,83**	3,80	3,11	8,02	0,001	2->3
Management (Manag_2, factor 8 of 10 PCA factors)	1,92	**3,05**	**3,13**	7,62	0,001	1->2, 1>3
4.3.1 Success factor: project management	1,00	2,83	**2,97**	8,25	0,000	1->2,1->3
4.3.2 Success factor: real-time coordination	1,17	2,79	**3,15**	8,77	0,003	1->2,1->3
Fears (Fear_03 – factor one of six factors)	**2,09**	1,83	1,19	1,70	0,058	no group
D5.3.2 Disadvantage: less diagnostic accuracy	**3,00**	2,05	1,07	6,30	0,003	1->3;2->3
D5.3.6 Disadvantage: reduced education quality	**2,17**	0,98	0,47	3,62	0,030	1->3
High Medical Standards (Qual_3, factor 3 of six)	1,04	**2,23**	**2,58**	4,83	0,010	1->2, 1>3
A5.1.7 Advantage: improved access to medicine	1,22	2,30	**2,93**	3,66	0,029	1->3
A5.1.8 Advantage: improved know-how standard	0,74	2,50	**2,76**	5,99	0,003	1->2,1->3

Scheffe's multiple range analysis was used to investigate significant differences within a group; for example, 1->2 means that the significance is caused by group one and two.

Schedule 26: Schedule of factors of success and dis-/advantages in relation to computer experience.

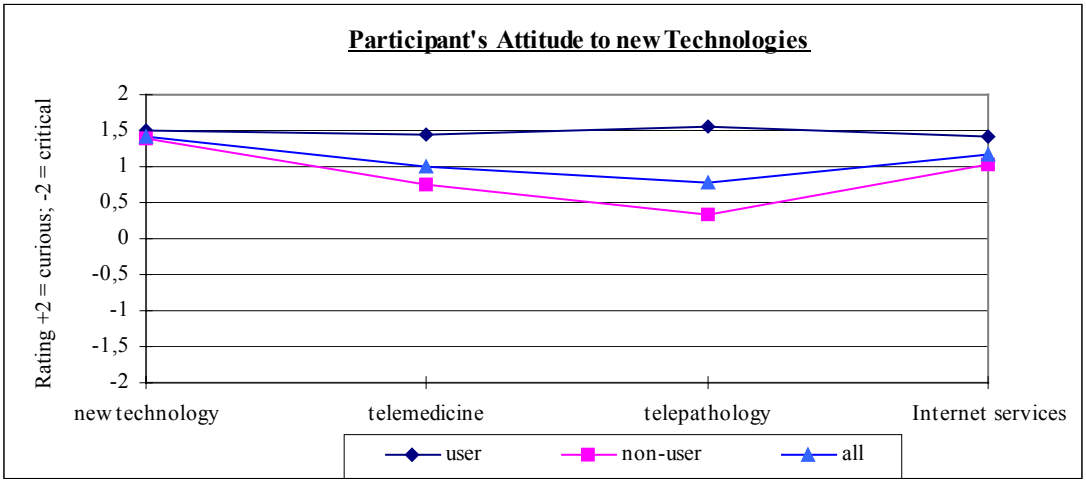
First of all the schedule above proves that there is a relation between the judgement of accuracy factors and computer experience (#4.5.1 and #5.3.2). The lower the computer experience is, the higher the meaning of accurate diagnostic procedures was rated. Special concern was given to the accuracy of macro-examinations. The meaning of management aspects were rated significantly lower by the users with low computer experience than by the other two groups (#4.3.1 and #4.3.2). Perhaps participants, who have already introduced computer systems, made bad experiences when management failed to support a proper introduction process. Finally there was also a significant difference in the ratings of the advantages 'improved access to medicine' and 'improved know-how standards'. These improvements may be the reason that participants with average and high computer experience rated there interested in telepathology services higher. There occur no significant rating differences in the judgements of reasons, which cause diagnostic inaccuracy.

Unfortunately the groups are very different in size. Especially the group with low computer experience, which caused most of the significant differences, was very small (six participants). Further investigation to confirm and specify the findings would be desirable.

19.1.4 Attitude Towards New Technologies

19.1.4.1 Participants Attitude to New Technologies

The following graphic demonstrates the interest of users and non-users in computer supported medical systems.



Question 1.7 of the questionnaire at appendix V: "What is your attitude when faced with new technologies?
The rating was possible from +2 = receptive/curious to -2 = very critical.
Significant differences of users/non-users - summarized PCA-factor: $Chi^2(0,35)=28.97$, $p<0.114$
Signif. differences in the single values: a) new technology: $Chi^2(0,35)=1.80$, $p<0.87$; b) telemedicine: $Chi^2(0,71)=15.82$, $p<$**0.007**; c) telepathology: $Chi^2(0,35)=25.43$, $p<$**0.000**; d) Internet services: $Chi^2(1,78)=12.37$, $p<$**0.030**;

Figure 59: Graphic about participant's attitude to new technologies.

Interestingly, when asking about the attitude to new technologies, users and non-users judged their interest almost similar and very high. But when asking about their opinion concerning telemedicine and telepathology, the non-users rated their interest significantly lower than users did. The interest in Internet services was rated by both groups quite high. Still the difference in the ratings of non-users was significantly lower. In summary, the attitude towards new technologies is higher by the participating users than this is the case with non-users. Yet both groups showed positive values. It is difficult to speculate on the reasons for the lower judgement of non-users especially for telepathology. Whether it is caused by the personality of participants, by prejudices, the lack of information, financial factors, or other reasons has to be further investigated.

For further statistical calculations a factor analysis was executed. The results show that all ratings can be summarized to one factor (see appendix X, page 1). Analyzing the relations of the attitude of participants in new technologies (summarized PCA-factor) and their computer experience, there occurs a statistical correlation. That is that as lower as participants judged their computer experience, as lower they rated their attitude in new technologies, too. The similarity of the ratings is highly significant: $p<0,000$ and shows an average correlation by Pearson of +0.412.

19.1.4.2 Significant Rating Differences in Relation to Technology Attitude

Ratings of the Interest in Various Services

Interest in Telepathology Services Considered by Ratings of the Attitude to Technology N=112 (40 users, 72 non-users)	Current Interest Correlation Analysis			Future Interest Correlation Analysis		
	r	p	mean all	r	p	
Interest in diagnostic services (Diagn_6)	0,467	0,000	1,57	0,329	0,000	1,70
I2.5.1 Primary diagnoses in emergency	0,30	0,001	0,81	0,16	0,088	0,93
I2.5.2 Primary diagnoses – frozen sections	0,37	0,000	1,68	0,29	0,002	1,97
I2.5.3 Primary diagnoses – routine basis	0,35	0,000	0,88	0,18	0,062	1,00
I2.5.4 Second look consultation	0,40	0,000	2,48	0,36	0,000	2,47
I2.5.5 Reference consultations	0,40	0,000	2,71	0,32	0,001	2,76
I2.5.6 On call support – 24hours/day	0,18	0,059	0,94	0,11	0,247	1,16
Interest in services, which improve know how (Educ_6)	0,526	0,000	2,22	0,399	0,000	2,34
I2.5.12 Internet info., WWW	0,47	0,000	2,62	0,34	0,000	2,78
I2.5.10 Discussions, forums, etc.	0,32	0,001	2,70	0,22	0,018	2,76
I2.5.9 Online education	0,45	0,000	2,28	0,38	0,000	2,76
I2.5.7 Interdisciplinary cooperation	0,28	0,002	2,20	0,28	0,003	2,19
I2.5.11 Quality assurance	0,40	0,000	1,96	0,33	0,000	2,00
I2.5.8 Central case archiving	0,39	0,000	1,61	0,23	0,014	1,78

p=significance value between ratings; r=correlation (0,0-0,15=no correl.; 0,15-0,3 low; 0,3-0,60=middle; 0,6-0,9=high correlation).

Schedule 27: Interest ratings of TP services in relation to participants' attitude towards new technologies.

The analysis results show that there is a significant correlation within the ratings at almost all interest judgements. That is that the more positive the attitude towards new technologies is, the higher the interest in telepathology services is. At most variables the correlation values are between 0,3 and 0,4, which is not very high, but still statistically relevant.

Ratings of Factors of Success in Relation to Technology Attitude

Factors of Success Considered by Ratings of the Attitude to Technology N=112 (40 users, 72 non-users)	Significance Correlation Analysis		
	r	p	Mean all
Factor referring to surrounding (Surr_2)	0,362	0,000	2,44
4.1.2 Factor of success: external acceptance (HMOs)	0,261	0,005	2,75
4.1.3 Factor of success: internal accept.– top management	0,336	0,000	2,73
4.1.4 Factor of success: internal accept. - users	0,207	0,028	3,20
4.1.5 Factor of success: acceptance - patients	0,227	0,016	1,30
4.2.2 Factor of success: institutions politics/strategy	0,404	0,000	2,37
Management (Manag_2, factor 8 of 10 PCA factors)	0,286	0,000	3,00
4.3.1 Factor of success: project management	0,450	0,000	2,75
4.3.2 Factor of success: real-time coordination	0,341	0,000	2,75
Cost efficiency and workflow	PCA-factor not significant		
4.6.3 Factor of success: health care efficiency	0,238	0,012	2,85
4.11.1 Factor of success: influence of fast respond times	0,226	0,016	3,56
Accuracy (Accur_2, factor 6 of the 10 PCA factors)	0,615	0,022	3,74
4.5.2 Factor of success: accurate sample preparation	-0,188	0,048	3,77
4.5.3 Factor of success: accurate micro examination	-0,191	0,043	3,73

p=significance value between ratings; r=correlation (0,0-0,15=no correl.; 0,15-0,3 low; 0,3-0,60=middle; 0,6-0,9=high correlation).

Schedule 28: Factor ratings in relation to participants' attitude towards new technologies.

The results above show that there is a correlation in the ratings of politics and acceptance criteria (PCA-factor 'surrounding') and the attitude towards new technologies. It is likely

that participants, who are more positive about new technologies, already use computers at their offices. Therefore they may have experienced that acceptance and politics can become a barrier within an introduction process. This may be the reason for their significantly higher ratings. Experience within the introduction process may also be the reason for the significantly higher ratings of management factors by participants with a positive attitude in new technologies. Further the ratings of the influence of the variables 'health care efficiency' and 'fast respond time' also correlates positively with the attitude of participants in new technologies.

In contrast, there is a significant negative correlation within the ratings of accuracy aspects. That is that the more skeptical a participant is, the more important he/she recognizes diagnostic accuracy as a barrier of telepathology introduction. In summary all these correlations are similar to the rating values of computer experience. That is that management aspects were also rated higher by computer experienced persons, whereas diagnostic accuracy was rated higher by less experienced participants.

Significance Analysis of Dis-/Advantages in Relation to Technology Attitude

Advantages / Disadvantages Considered by Ratings of the Attitude to Technology N=112 (40 users, 72 non-users)	**Significance Correlation Analysis**		
	r	p	Mean all
Judgement of Advantages			
More Efficiency (Effic_3, factor two of six)	0,545	0,000	1,64
A5.1.1 Advantage: improved diagnostic quality	0,452	0,000	1,85
A5.1.2 Advantage: improved pat. treatment process	0,428	0,000	1,61
A5.1.3 Advantage: same quality of medicine	0,401	0,000	1,91
A5.2.1 Advantage: efficient processes (resources)	0,419	0,000	1,71
A5.2.2 Advantage: cost reduction, savings	0,429	0,000	1,27
A5.2.3 Advantage: additional revenues	0,413	0,000	1,15
A5.2.4 Advantage: high utilization	0,320	0,001	1,20
A5.2.5 Advantage: improved reputation of institute	0,276	0,003	2,13
High Medical Standards (Qual_3, factor 3 of six)	0,451	0,000	2,21
A5.1.5 Advantage: better communication	0,487	0,000	2,22
A5.1.6 Advantage: improved research	0,254	0,007	1,88
A5.1.7 Advantage: improved access to medicine	0,337	0,000	2,33
A5.1.8 Advantage: improved know-how standard	0,381	0,000	2,44
Judgement of Disadvantages			
Fears (Fear_03 – factor one of six factors)	-0,376	0,000	1,76
D5.3.1 Disadvantage: higher expenses	-0,245	0,009	2,43
D5.3.2 Disadvantage: less diagnostic accuracy	-0,306	0,001	1,97
D5.3.6 Disadvantage: reduced education quality	-0,355	0,000	0,97
D5.3.10 Disadvantage: technology not reliable	-0,278	0,003	1,67
D5.3.11 Disadvantage: loss of information	-0,339	0,000	2,12
Uncertainty (Uncer_3)	-0,200	0,035	2,59
D5.3.9 Disadvantage: uncertain reimbursement	-0,199	0,036	2,46
On Call Services (Oncall_3 – factor with only one variable)	0,345	0,000	0,94

p=significance value between ratings; r=correlation (0,0-0,15=no correl.; 0,15-0,3 low; 0,3-0,60=middle; 0,6-0,9=high correlation).

Schedule 29: Dis-/Advantage ratings in relation to participants' attitude towards new technologies.

The correlation in the schedule above can be clearly and quickly distinguished. Participants, who are skeptical in introducing new technologies expect less advantages, but higher disadvantages than did participants with a positive attitude.

19.1.5 Summary of Rating Difference in Relation to Participants' Personality

In this sub-chapter the personal characteristics age, computer experience and the attitude towards new technology were analyzed. Regarding the distribution of telepathology users' age, no significant differences occur within the groups. That is that older pathologists are willing to employ telepathology systems in the same way as younger ones do. Yet, there is a positive correlation of the attitude towards new technologies with the computer experience ($r=0,41$, $p<0,000$). That is that participants, who have computer experience are more curious in using new technologies. No statistically significant correlation could have been investigated between participants' age with the computer experience and the attitude of new technologies. Nevertheless, when regarding the differences in the ratings of variables and factors, there are some interesting results. The ratings of the interest in telepathology services are significantly higher by younger, more computer experienced and less technology skeptical persons. Especially the positive attitude towards new technologies showed at all telepathology service types a more positive rating. The influence of the acceptance, political factors and of management criteria were rated significantly higher by these type of people, too. It can be assumed that participants with a positive attitude towards technology have already introduced computer systems and therefore know that management and acceptance have to be taken seriously.

Accuracy aspects were rated significantly higher by older, less experienced and technology skeptical persons. Since diagnostic accuracy criteria got very high ratings in the meaning of telepathology's success, this type of people need specific training and information to overcome prejudices and reluctance. Finally this type of participants, especially the one with a skeptical attitude in new technologies, rated all advantages significantly lower, and all disadvantages significantly higher than did the younger, computer experienced persons with a very positive attitude towards new technologies.

19.2 Characteristics of Employers

19.2.1 Institution Type

Distribution of Institution Type of Participants

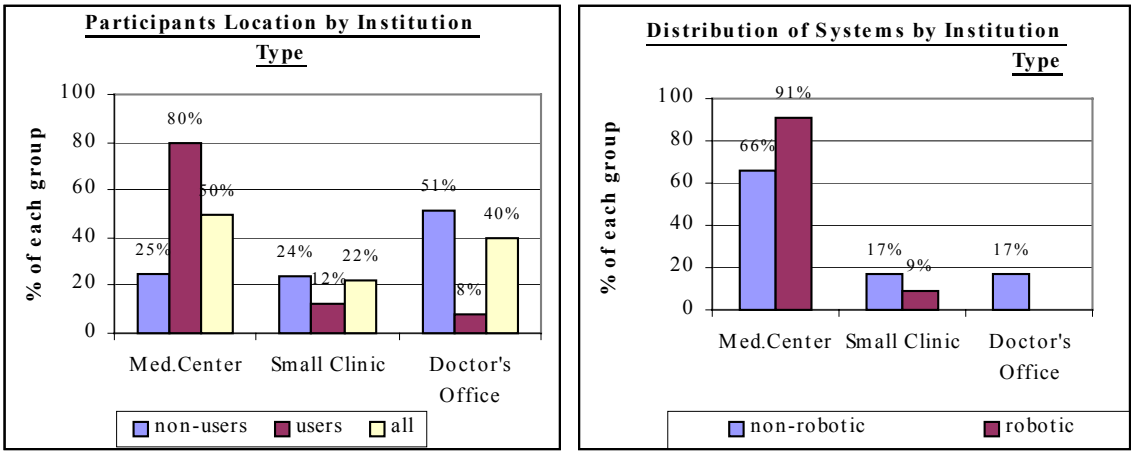


Figure 60: Institution type of participants.

Considering participants, ¼ of the **non-users** are working at a medical center, ¼ at small clinics, and ½ at doctors' offices. 80% (32) of the **users** are employed at medical centers,

12,5% (5) at small clinics, and 7,5% (3) at doctors' offices. The different distribution of institution type between users and non-users is highly significant ($Chi^2(7,8)=32.91$, $p<0,000$). 66% (12) of the participants, who use **non-robotic systems,** are at university hospitals, 17% (3) at small hospitals, and 17% (3) at doctors' offices. 91% of the **dynamic-robotic system** users (20), who have answered the questionnaire, are employed at university hospitals and 9% (2 systems) at small clinics. That is that most of the currently used telepathology systems are introduced at medical centers. This result may emphasize the research character in which telepathology systems, especially robotic-dynamic ones, often got stacked. Yet, it could also just indicate that clients are not willing to participate at research studies as experts at medical centers are where research studies are common. Participating doctors' offices only employed static systems at the study in Constance. One reason could be the lower investment costs. Another the structural situation (large amount of pathologists per square kilometers), or by the kind of service they want to execute (e.g. communication with colleagues or second look consultations; at both services static systems already proved to be an appropriate tool).

Significance Calculations of Service Interest by Referring to the Institution Type

Interest in Telepathology Services Considered by Institution Type	**Current Interest**							**Future Interest**						
	M Mean n=50	**S** Mean n=22	**D** Mean n=40	**All** Mean n=112	F	p	betw. which group	**M** Mean n=50	**S** Mean n=22	**D** Mean n=40	**All** Mean n=112	F	p	betw. which group
Interest in diagnostic services	**1,88**	1,42	1,25	1,57	5,80	**0,004**	1->3	**1,96**	1,64	1,40	1,70	4,64	**0,012**	1->3
I2.5.1 Primary diagnoses in emergency	**0,92**	0,76	0,71	0,81	0,49	0,615	-	**0,98**	1,08	0,79	0,93	0,83	0,439	-
I2.5.2 Primary diagn. – frozen sections	**2,35**	1,17	1,11	1,68	8,80	**0,000**	1->2/3	**2,50**	1,77	1,42	1,97	7,08	**0,001**	1->3
I2.5.3 Primary diagn. – routine basis	**1,25**	0,81	0,47	0,88	5,28	**0,007**	1->3	**1,16**	1,09	0,75	1,00	1,52	0,223	-
I2.5.4 Second look consultation	**2,74**	2,36	2,10	2,44	2,34	0,101	-	**2,76**	2,32	2,01	2,47	2,07	0,131	-
I2.5.5 Reference consultations	**2,92**	2,46	2,38	2,64	2,12	0,125	-	**2,95**	2,39	2,37	2,64	3,20	**0,044**	1->3
I2.5.6 On call support – 24hours/day	**1,11**	0,95	0,72	0,94	1,28	0,284	-	**1,41**	1,16	0,58	1,16	2,34	0,101	-
Interest in services to impr. know how	**2,70**	2,14	1,68	2,22	13,2	**0,000**	1->2/3	**2,73**	2,27	1,88	2,34	9,50	0,000	1->3
I2.5.7 Interdisciplinary cooperation	**2,78**	2,15	1,52	2,20	9,22	**0,000**	1->3	**2,74**	1,93	1,63	2,18	8,30	**0,000**	1->2/3
I2.5.8 Central case archiving	**2,20**	1,05	1,20	1,62	8,80	**0,000**	1->2/3	**2,21**	1,43	1,44	1,78	4,65	**0,012**	1->2/3
I2.5.9 Online education	**2,96**	2,18	1,49	2,28	14,2	**0,000**	1->2/3	**2,93**	2,64	1,91	2,51	7,94	**0,001**	1->3
I2.5.10 Discussions, forums, etc.	**3,06**	2,73	2,24	2,70	5,07	**0,008**	1->3	**3,12**	2,75	2,32	2,76	5,52	**0,005**	1->3
I2.5.11 Quality assurance	**2,27**	2,18	1,35	1,92	5,21	**0,007**	1->3	**2,38**	2,09	1,48	2,00	4,84	**0,010**	1->3
I2.5.12 Internet info., WWW	**2,91**	2,57	2,29	2,62	2,55	0,083	-	**3,00**	2,78	2,49	2,78	1,73	0,183	-

(M=medical center; S=small clinic; D=doctor's office); at the significance values the groups are given, between which the significance occurred.

Schedule 30: Schedule of the significant differences of interest in services related to institution type.

The data in the schedule above clearly shows that the interest of participants, located at medical centers in most cases is significantly higher than the one of pathologists, who are employed at small hospitals or work at a doctor's office. This could indicate that pathologists at medical centers wish to distributing their specialized know-how, whereas colleagues at small clinics and doctors' offices may see a threat in telepathology. There are no significant differences in the ratings of telepathology service interest between small clinics and doctors' offices. Fortunately, all three groups show an interest in telepathology services – especially in online discussions and education, as well as in reference and in second look consultations. The future interest is rated slightly higher at all groups than the current one.

Significance Calculations of Factors of Success Referring to the Type of Institution

Factors of Success Considered by Type of Institution	Medical Center(1)		Small Clinic(2)		Doctor's Office(3)		All F(2,109)				
Size of group: M=50, S=22, D=40	Mean	St.D	Mean	St.D	Mean	St.D	Mean	St.D	F	p	groups
Factor referring to Surrounding (Surr_2)	**2,65**	0,67	2,19	0,99	2,32	0,72	2,44	0,78	3,50	0,034	1->2
4.1.3 Internal acceptance – top management	**3,10**	1,12	2,43	1,50	2,44	1,21	2,73	1,27	4,06	0,020	1->3
4.1.4 Internal acceptance - users	**3,53**	0,88	2,52	1,48	3,15	1,16	3,20	1,17	6,34	0,002	1->3
4.1.5 Acceptance - patients	**1,65**	1,31	1,04	1,03	0,99	1,24	1,30	1,26	3,80	0,025	1->3
4.2.2 Institutions politics / strategy	**2,75**	1,27	1,91	1,37	2,14	1,25	2,37	1,32	4,29	0,016	1->2/3
Management Aspects (Manag_2)	**3,26**	0,54	2,91	0,64	2,72	0,90	3,00	0,74	6,82	0,002	1->3
4.3.1 Project management	**3,17**	0,93	2,54	1,17	2,32	1,25	2,75	1,16	7,10	0,001	1->3
4.3.2 Real-time coordination	**3,21**	0,95	2,64	1,12	2,22	1,41	2,75	1,24	8,16	0,000	1->3
Legal / Costs / Workflow	PCA-factors did not show significant differences										
4.4.2 Qualification (licensing agreements)	3,29	1,12	3,52	0,79	**3,80**	0,55	3,52	0,91	3,63	0,030	1->3
4.6.1 Influence of investment and subsequent costs	2,85	1,06	3,06	0,90	**3,38**	0,84	3,08	0,97	3,48	0,034	1->3
4.11.1 Influence of fast respond times	**3,74**	0,43	3,55	0,65	3,34	0,88	3,56	0,68	4,02	0,021	1->3

The column 'groups' gives the groups, between which the significant values occurred (1=med. centers; 2=small clinics; 3=doctor's office).

Schedule 31: Schedule of the significant differences of the factors of success related to the type of institution.

The influence of the internal **acceptance** of the top **management** and physicians was seen as a more important factor of telepathology's success by participants of medical centers, than by physicians located at doctors' offices. Also the influence of internal politics and strategies is rated higher in this group. These differences in the ratings could have been caused by the higher meaning of internal structures at huge organizations. At such organizations decision making processes are sometimes time consuming, since a lot of people have to be involved. At smaller organizations or doctors' offices just one person (leader) is making all decisions. The lower coordination effort at smaller organizations may also have caused the lower ratings of management criteria. If organizations are big, many people and resources have to be coordinated. Therefore telepathology introduction and utilization (especially real-time sessions) have to be planned carefully.

The meaning of partner's qualification (**licensure regulations**) was rated significantly higher by pathologists of doctors' offices. Pathologists at medical centers are more likely to be a consultant of telepathology. Consequently they do not have to fear an unqualified diagnosis, since its their own one. Yet, if a pathologist is working in an isolated situation at a doctor's office, he knows that he has to rely on the specialist he is attending for help. In summary all three groups rated the question of licenses and qualification very high. Also the influence of **investment costs** was rated significantly high by pathologists at doctors' offices. This difference may have been caused by the type of employment. At medical centers physicians are generally on a salary. Such physicians may be little incentive to take on what appears to be additional work or increased clinical responsibility with no time savings elsewhere. When a physician is in private practice, reimbursement for consultation becomes an issue, especially if it is necessary to take time out of a busy schedule or if the telepathologist has to go to a telemedicine studio that is located at some distance from the office. This was investigated at a study by Grigsby, too [Grigsby, 1995/(1), p. 25].

Finally there also occurred significant differences in the rating of fast respond times. These may have been caused by the utilization of robotic-dynamic telepathology systems, which are more often employed at medical centers than at doctors' offices. As it was mentioned before, most doctors' offices of this study employ static systems.

Significance Calculations of Dis-/Advantages in Relation to the Type of Institution

Advantage- and Disadvantage Ratings Considered by Institution Type Size of group: M=50, S=22, D=40	Medical Center		Small Clinic		Doctor's Office		All F(2,109)				
	Mean	St.D	Mean	St.D	Mean	St.D	Mean	St.D	F	p	group
Judgement of Advantages											
More Efficiency (Effic_3, factor two of six)	**1,95**	0,90	1,41	0,75	1,27	1,02	1,60	0,97	6,69	0,002	1->2/3
A5.1.1 Advantage: improved diagnostic quality	**2,38**	1,58	1,49	1,40	1,39	1,69	1,85	1,64	5,01	0,008	1->3
A5.1.2 Advantage: improved pat. treatment proc.	**2,08**	1,52	1,44	1,26	1,11	1,15	1,61	1,41	6,02	0,003	1->3
A5.1.3 Advantage: same quality of medicine	**2,24**	1,29	1,86	1,36	1,54	1,08	1,91	1,26	3,57	0,032	1->3
A5.2.1 Advantage: efficient processes (resources)	**2,34**	1,15	1,51	1,25	1,03	1,14	1,71	1,30	14,6	0,000	1->2/3
A5.2.2 Advantage: cost reduction, savings	**1,74**	1,41	0,99	0,96	0,84	1,24	1,27	1,33	6,19	0,003	1->2/3
High Medical Standards (Qual_3, factor 3 of 6)	**2,64**	0,99	2,08	0,95	1,74	1,03	2,21	1,07	9,33	0,000	1->3
A5.1.5 Advantage: better communication	**2,66**	1,24	2,15	1,12	1,66	1,32	2,20	1,31	7,25	0,001	1->3
A5.1.7 Advantage: improved access to medicine	**2,93**	1,20	2,15	1,32	1,67	1,26	2,33	1,36	11,8	0,000	1->2/3
A5.1.8 Advantage: improved know-how standard	**2,83**	1,25	2,29	1,20	2,03	1,36	2,41	1,32	4,43	0,014	1->3
Judgement of Disadvantages											
Fears (Fear_03 – factor one of six factors)	1,41	1,06	1,75	0,88	**2,20**	0,91	1,76	1,03	7,38	0,001	1->3
D5.3.1 Disadvantage: higher expenses	1,90	1,31	2,38	1,21	**3,13**	1,26	2,43	1,38	10,3	0,000	1->3
D5.3.10 Disadvantage: technology not reliable	1,35	1,45	1,56	1,33	**2,13**	1,26	1,67	1,40	3,80	0,025	1->3
D5.3.11 Disadvantage: loss of information	1,73	1,53	2,19	1,22	**2,56**	1,45	2,12	1,48	3,73	0,027	1->3
Uncertainty (Uncer_3, factor 4 of six)	2,34	1,12	2,55	1,08	**2,92**	1,08	2,59	1,12	3,03	0,052	1->3
D5.3.9 Disadvantage: uncertain reimbursement	2,07	1,28	2,11	1,50	**3,12**	1,26	2,46	1,40	7,98	0,001	1->2, 2->3

The column 'groups' gives the groups, between which the significant values occurred. (1=med. centers; 2=small clinics; 3=doctor's office).

Schedule 32: Schedule of the significant differences of dis-/advantages related to institution type.

Considering the ratings of advantages and disadvantages at all significant differences medical centers rated the advantages higher and the disadvantages lower than did the pathologists of doctors' offices (and small clinics). Again, pathologists of doctors' offices are in a different situation and therefore may be more skeptical than pathologists, employed at a medical center.

19.2.2 Rating Results by Department Size (Pathologists and Examinations)

19.2.2.1 Size of Department

To investigate the size of the pathological department at which a participant is employed, participants were asked to give the amount of colleagues (pathologists) and the number of examinations at their department. The question aims to investigate, whether the participant is facing a situation of isolation or not. Further more the numbers allows to compare the total of departments' examinations with the amount of telepathology examinations per year see chapter 19.3.2.4).

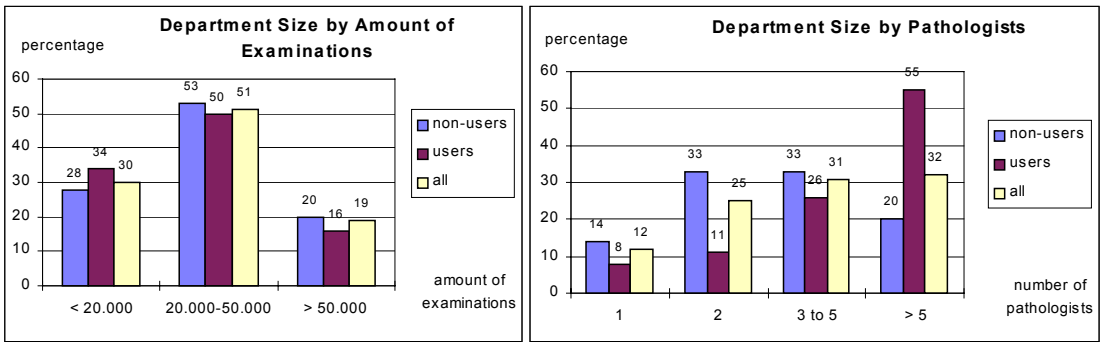


Figure 61: Department size of participants by examinations and employed pathologists.

The left graphic shows that most of the participating users and non-users are employed at hospitals with 20.000-50.000 examinations. The distribution of users and non-users referring to examination numbers does not show a significant difference. In contrast, the distribution of users and non-users in the context of the department size by number of employed pathologists testified a highly significant difference ($Chi^2(4,53)=16.05$, $p<0,001$). Interestingly many users are working at institutions with more than five pathologists, whereas only 8% are employed at institutions with one pathologist. Regarding the situation of users more detailed, there are often more than 5 pathologists employed, whereas the amount of examinations per year ranges between 20.000 to 50.000. That indicates that many telepathology systems are used at departments, which are either very specialized, or where staff energy is not only used for examinations, but also for research and other activities. Telepathology systems are good tools to overcome isolation. Nevertheless, there were only three users without a colleague. Whether the price of systems is too high for very small institutions, or whether such pathologists are used to work without the help of other colleagues and therefore do not use a system, is difficult to say. Further investigation is necessary.

19.2.2.2 Significance Analysis Related to Department Size

Statistical Analysis of Department Size in Relation to Type of Institution

The following schedule gives the relation between institution type, department size by pathologists, and department size by amount of examinations per year, analyzed by Scheffe's statistical procedure.

	Medical Center (n=47)	**Small Clinic (n=22=**	**Doctor's Office (n=40)**	**Total (n=109)**	**F**	**p**	**'p' between groups** (Scheffe)
Correlation between institution type and amount of pathologists					38,4	0,000	between all 1,2,3
Pathologists: 1	2 (2%)	1 (1%)	**10 (9%)**	13 (12%)			
Pathologists: 2	3 (3%)	**6 (6%)**	**19 (17%)**	28 (26%)			
Pathologists: 3-5	**10 (9%)**	**13 (12%)**	**10 (9%)**	33 (30%)			
Pathologists: >5	**32 (29%)**	2 (2%)	1 (1%)	35 (32%)			
Correlation between institution type and examinations/year					2,36	0,099	no significance
<20.000	13 (12%)	**10 (9%)**	**11 (10%)**	34 (30%)			
20.000-50.000	**31 (28%)**	**8 (7%)**	**16 (15%)**	55 (51%)			
>50.000	3 (3%)	4 (4%)	**13 (12%)**	20 (19%)			
Correlation between examinations/year and amount of pathologists							
	<20.000	20. -50.000	>50.000		2,90	0,038	between 1->3/4
Pathologists: 1	9 (8%)	3 (3%)	1 (1%)	13 (12%)			
Pathologists: 2	**10 (9%)**	9 (8%)	**7 (6%)**	26 (24%)			
Pathologists: 3-5	**8 (7%)**	**18 (16%**	**7 (6%)**	33 (31%)			
Pathologists: >5	5 (5%)	**25 (23%)**	5 (5%)	35 (32%)			

Schedule 33: Characteristics of participants in relation to institutions type and department size.

As the distribution shows, there is a significantly high correlation between the type of institution and the department size by amount of pathologists. That is that many medical centers employ three and more pathologists, whereas doctors' offices have often only one or two pathologists at the place. Comparing the type of institution with the amount of examinations/year, the differences in the distribution are statistically not significant. In summary, medical centers often employ more than two pathologists, but do only execute 20.000-50.000 examinations per year, whereas at doctors' offices the distribution looks quite heterogeneous – that is the more pathologists are at the place, the more examinations are carried out.

Due to the specific distribution at medical centers the correlation of amount of pathologist and examinations per year is not very significant, but still shows a value of $p<0,038$.

Significance Analysis of Factor / Variable Ratings by Referring to Department Size

Interest in Telepathology Services Considered by Employed Pathologists	1 (n=13)	2 (n=28)	3-5 (n=33)	>5 (n=35)	Significance Correlation Analysis and Multiple Range Test by Scheffe				
N=112 (40 users, 72 non-users)	Mean	Mean	Mean	Mean	r	p	F	p	Scheffe p
Interest in Services – 'great know how'	1,69	2,02	2,18	**2,67**	0,31	0,001	4,04	0,009	1->4
I2.5.7 Current inter.: interdisciplinary cooperat.	1,48	1,88	2,10	**2,84**	0,31	0,001	4,02	0,009	1,2->4
I2.5.8 Current interest: central case archiving	1,17	1,57	1,32	**2,20**	0,22	0,024	2,98	0,035	3->4
I2.5.9 Current interest: online education	1,77	1,73	2,12	**3,08**	0,35	0,000	6,12	0,001	1/2/3->4
Future Interest in Services – 'know how'	1.92	2.28	2.31	**2.60**	0,26	0,039	not significant		
I2.6.7 Future inter.: interdisciplinary cooperation	1,50	1,95	2,03	**2,77**	0,29	0,002	3,63	0,015	1->4

Schedule 34: Significant differences at the interest in telepathology services due to employed pathologists.

Significant differences occurred in the ratings of the interest in relation to the number of employed pathologists. That is that the more pathologists are employed, the higher is the interest in interdisciplinary cooperation, central case archiving, and online education. It can be assumed that the more pathologists are at the place, the more specialized the single pathologist is. Yet, the more specialized a pathologist is the more he may wish to cooperate with other experts, and participate at highly specialized education sessions to distribute his know-how to other pathologists. In addition, such institutions seem to recognize a bigger need in central case archiving. The amount of cases is huge and therefore central case archiving guarantees a correct documentation of cases. In addition it enables fast scientific research analyses. There were no significant differences comparing the amount of examinations made per year.

Significance Analysis of Ratings Related to Employed Pathologists

Interest in Telepathology Services Considered by Employed Pathologists	1 (n=13)	2 (n=28)	3-5 (n=33)	>5 (n=35)	Correlation Analysis and Multiple Range Test by Scheffe				
N=112 (40 users, 72 non-users)	Mean	Mean	Mean	Mean	r	p	F	p	Scheffe p
Factors of Success: Surrounding	1,69	2,02	2,18	**2,67**	0,31	0,001	4,04	0,009	1->4
4.1.4 Internal acceptance of physicians	2,17	3,41	3,23	**3,39**	0,22	0,025	4,42	0,006	1->2,3,4
Factor of Success: Management	2,77	2,77	3,05	**3,19**	0,23	0,015	2,19	0,094	-
4.3.1 Project management	2,31	2,40	2,87	**3,00**	0,23	0,017	2,14	0,099	-
4.3.2 Real-time session coordination	2,31	2,45	2,73	**3,05**	0,22	0,023	1,78	0,155	-
Advantage: High Medical Standards	1,69	2,16	2,09	**2,57**	0,23	0,015	2,59	0,057	1->4
A5.2.1 More efficiency	1,09	1,18	1,81	**2,18**	0,33	0,000	4,59	0,005	1,2->4
A5.2.2 Cost reduction, savings	0,50	0,97	1,42	**1,56**	0,26	0,006	2,73	0,047	-
A5.1.3 Same quality of diagnosis	1,22	1,63	2,33	**2,00**	0,21	0,030	3,25	0,025	1->3
A5.1.7 Improved access to medicine	1,64	2,21	2,20	**2,79**	0,25	0,010	2,70	0,050	1->4

Schedule 35: Significance of ratings of factors of success and dis-/advantages due to amount of pathologists.

Significance Analysis of Ratings in Relation to Participants' Examination Numbers

Interest in Telepathology Services Considered by Examination Numbers per Year	<20 T (n=32)	20-50 T (n=55)	>50 T (n=20)	Correlation Analysis and Multiple Range Test by Scheffe				
N=112 (40 users, 72 non-users)	Mean	Mean	Mean	r	p	F	p	Scheffe p
Factor of Success - Management Aspects	**3,11**	3,05	2,60	-0,21	0,028	3,46	0,035	1->3
4.3.2 Coordination of real-time sessions	**2,91**	2,82	2,07	-0,21	0,032	3,35	0,039	1,2->3
Uncertainty (Disadvantage)	2,58	2,44	**3,04**	PCA-factor is not significant				
5.3.9 D Uncertain reimbursement	2,26	2,29	**3,20**	0,021	0,034	3,66	0,029	1/2->3

* the PCA-factor ‚uncertainty' includes also ‚uncertain legal situation and data security' – both did not show significant rating differences.

Schedule 36: Significant differences in the ratings of service interest due to department size by examinations.

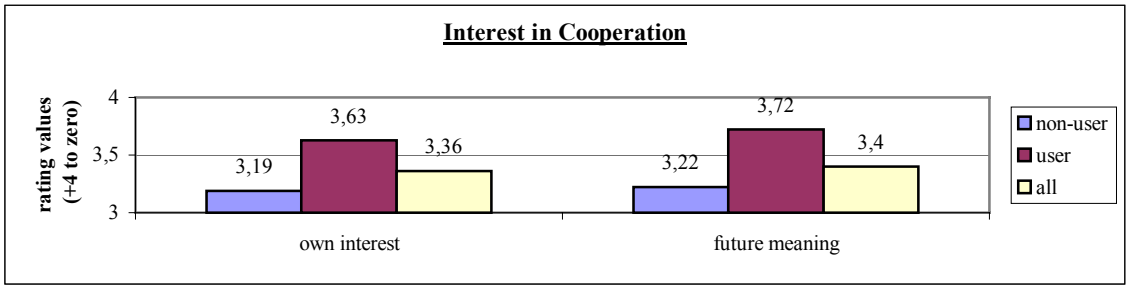
The meaning of 'internal acceptance by users' was rated significantly higher by pathologists working with many colleagues. That indicates that the more pathologists are at the place, the more people have to be positive about telepathology to increase its utilization.

There is an interesting correlation within management aspects, especially at the coordination of real-time sessions. Participants of departments with low examination numbers rated the meaning of management aspects significantly high. In contrast, departments with one or two pathologists rated this aspect significantly low. Departments with many pathologists may recognize the difficulty of coordinating many users, whereas departments with low examination numbers mostly employ less pathologists and therefore staff capacity is limited and inefficient working time has to be avoided.

Uncertain reimbursement is seen as a significantly more important disadvantage at departments with high examination numbers. The reason for this may be explained by the ratings of the advantages 'cost efficiency' and 'cost reduction'. Departments with many pathologists and consequently with high examination numbers expect telepathology to be a tool, which decreases cost efficiency (e.g. by 'selling' their specialized know-how). Yet this is only possible if services are reimbursed. In addition, such departments also rated the advantage 'improved diagnostic quality' and 'improved access to medicine' significantly higher than did small departments. Such departments seem to recognize in telepathology systems a tool, which helps to support strategic decision and to improve the overall situation of the department.

19.2.3 Participants Wish to Cooperate

19.2.3.1 Participants Interest in Cooperation



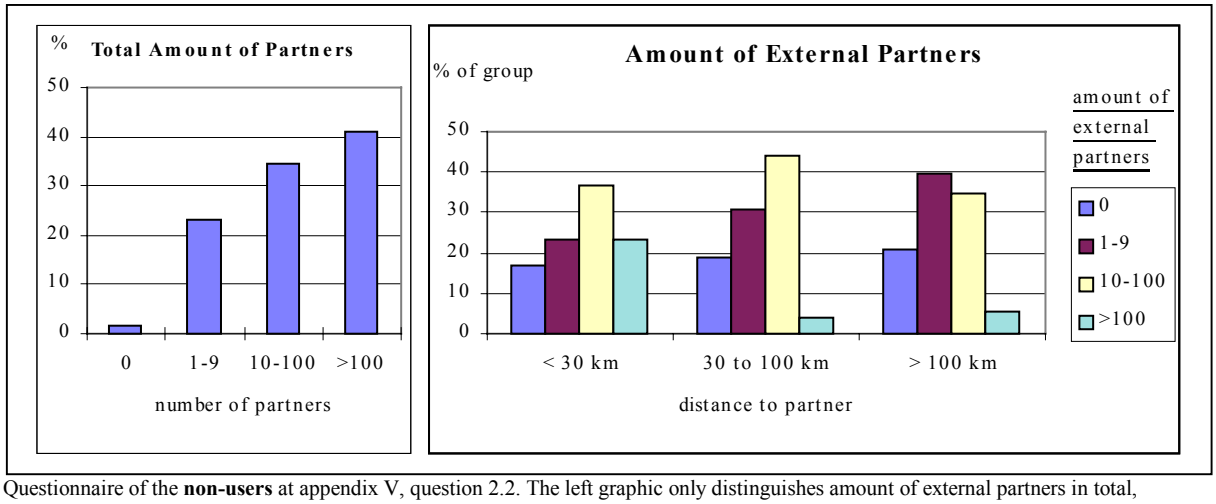
Question 3.10 of the questionnaire at appendix V: a) "What about is your interest in cooperation?" b)"How do you assess the importance of cooperation in future?" Ratings: +4= great interest / very important, zero = no interest / not important.

Figure 62: Interest in cooperation partners.

Telepathology systems offer new possibilities of collaboration. To investigate the willingness of participants to cooperate with other pathologists, they were asked to give their overall interest in cooperation. The first question was: „What about is your interest in cooperation?", and second: „How do you assess the importance of cooperation in the future?" The ratings of both, users and non-users, were very high (single rating, see schedule appendix VIII), although the judgement of the non-users was slightly lower. In summary the ratings of both groups do not show a statistical significant difference ($Chi^2(0,35)=13.7$, $p<0.18$). The personal interest of users was rated in average with 3,63 and with 3,19 by the non-users. The judgement of the meaning of cooperation in the future was rated by the users with 3,72 and with 3,22 by the non-users. The total judgement of all participants was 3,36 for their own interest and 3,4 for the future meaning of cooperation. These results show that in general both groups are interested in cooperation, since all ratings are higher than three.

Situation of Non-Users – Current Partnership

To discover the wish to cooperate and the support possibilities of telepathology of non-users, they were asked to give their current amount of cooperation partners distinguished by distance (for example, pathological examinations for other hospitals). It was assumed that within a distance of 30 km it is possible to transport specimens, such as tissues of frozen sections by car (compare chapter 13.6.2.3). Within a distance of 30 to 100 km it depends on the geographical and structural situation whether a manual transportation makes sense or not. At distance of more than 100 km, specimen transportation is very critical. The final data of non-users are as follows:



Questionnaire of the **non-users** at appendix V, question 2.2. The left graphic only distinguishes amount of external partners in total, whereas the right graphic gives the amount of external partners distinguished by distance and amount of examinations.

Figure 63: Graphic gives the amount of external partners of non-users.

The **left graphic** shows that only 1,6% (one) of the non-users do not have an external partner for whom they provide pathological services, 23% (14) have one to nine external partners, 34% have ten to hundred external partners, and 41% (25) have even more than hundred external partners.

The **right graphic** gives the distribution of these external partners by distances. Finally 16,7%[119] of the non-users answered that they do not have any partner within a distance of 30 km, 23% do have one to nine partners within this distance, 37% have 10-100 partners within this distance, and 23% have even more than 100 partners within a distance of 30 km. 18% do not have a partner within 30-100 km, 31% do have one to nine partners within this distance, 44% have 10-100 partners and 4% have more than 100 partners within a distance of 30-100 km. 20,7% do not have any partner further than 100 km apart, 40% of the non-user have one to nine partners within this distance, 35% have 10-100 partners and 5% have more than 100 partners, who are more than 100 km apart (detailed data see schedule in appendix VIII).

In summary, the right graphic shows that many non-users have partners, who are further apart than 30 km, often even more than 100 km. In addition, both graphics (left and right one) emphasize that many non-users have more than ten partners, yet often even more than 100 external partners.

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[119] These percentage calculations are oriented on the distance. That is that for example the total of all partners within a distance of less than 30 km (first column) is 100%.

To confirm the given answers, non-users were further requested to write down the approximately percentage of external examinations compared to the overall amount of examinations of their department. Unfortunately 35% did not answer this question. Of the remaining non-users, 24% answered that the share of external examinations is between 0-50%, 41% stated it is something about 51-89%, and 35% estimated that it is between 90-100%.

All these comments reflect clearly that there would be a market for telepathology services, since many pathologists offer services for distant partners.

Situation of Partnership of Current Telepathology Users

Participating users were asked to give their amount of telepathology partners, distinguished by type of partner (client or consultant) and by distance. The situation looks as follows:

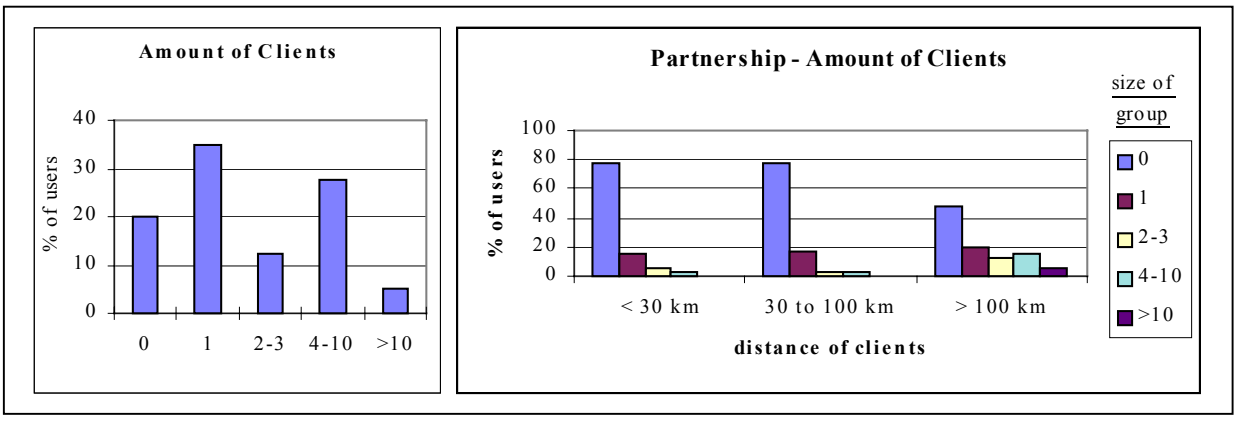
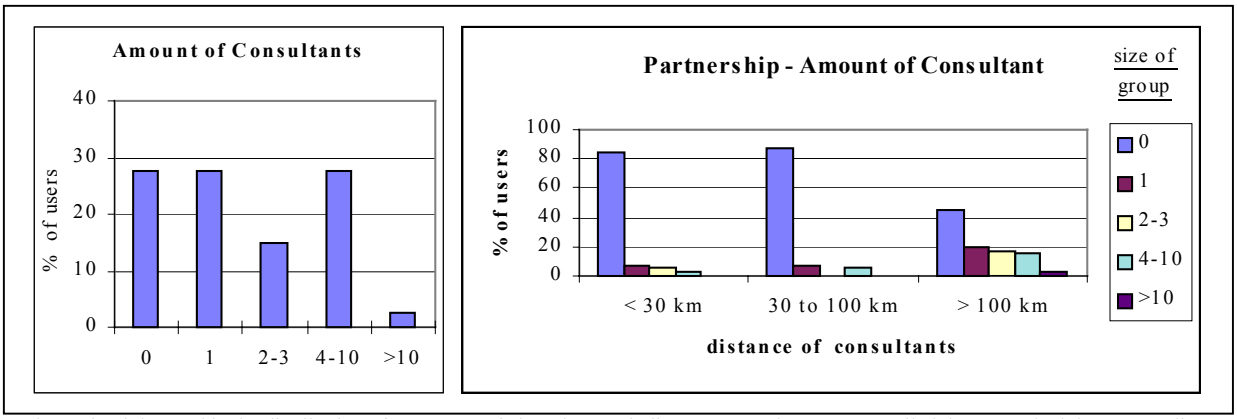


Figure 64: Amount of client partnerships.



Again, at the right graphic the distribution of percentages is based on each distance group by 100%. Detailed data see schedule at appendix VIII.

Figure 65: Amount of consultant partnerships.

Consideration of the Distribution of Client Partners

Considering the **clients**, 20% of the users do not have a client partner (this is because they are clients), 35% have one client partner, 13% have 2-3 client partners, 27% have 4-10 client partners, and 5% have more than 10 client partners.

If the amount of client partners is distinguished by distance group, 77% of the users have no client partner within a **distance of 30 km**, whereas 23% do have client partners. These 23% are divided up in 15%, who have one client partner, 5 % have 2-3 clients, and 2,5% serve 5-10 clients. Considering the next distance group, at a **distance of 30-100 km,** again 77% do

not have a client partner, whereas 23% serve clients within this distance. These are divided up in 17,5% who have one client partner, 2,5% have 2-3 client partners, and another 2,5% have 4-10 client partners. And last but not least, at the last distance group, which shows the client partner further than **100 km apart**, 47% of the users have no client partners, whereas 53% do. These 53% are divided up in 20% who have one client partner of this distance, 13% have 2-3 partners, 15% have 4-10 partners, and 5% even serve more than 10 clients further than 100 km apart (here especially the AFIP cooperates with many clients).

Consideration of Distribution of Consultant Partners

Consultant partners are telepathologists, who render (primary diagnosis) or verify (second opinion) a diagnosis for the partner. The left graphic referring to **consultant partner** distribution shows that **27,5%** are experts who do only cooperate with one client, but do not have any contact to other tele-experts for further consultations. Another **27,5%** do only collaborate with one tele-consultant. These are in general users, who serve one client and if an examination is not clear, they create a link to another expert for a second opinion consultation. Two of these users have no client but communicate with another (one) expert for second opinion consultations. **15%** of the users have contact to 2-3 other consultants, **27%** collaborate with 4-10 other tele-experts, and the AFIP even cooperates with more than ten consultants.

Considering the distribution of consultant partners by distance, 85% (34 users) of the tele-participants answered that they do not have a consultant partner within a **distance of 30 km**, whereas 15% (6 users) do. Of these 7,5% have one consultant partner, 5%, have 2-3 partners, and 2,5% have 4-5 partners. The **distance group of 30-100 km** looks quite similar. 87% (35 users) do not cooperate with any other consultant partner within this distance, whereas 13% (5 users) do. These 13% are divided up in 8% who have one partner, and 5% who have 4-10 partners. Finally, 45% (18 users) of the users replied that they do not have a partner **more than 100 km apart**, but 55% (22 users) answered that they are cooperating with a telepathologist at this distance. These 55% are divided up in 20% who have one consultant partner, 17,5% who have 2-3 partners, 15% who have 4-10 partners, and one user (AFIP) cooperates even with more than 150 other consultants all over the world.

Both graphic show that many client and consultant partners are more than 100 km apart. It reflects that if users want to contact a consultant, they either prefer to contact a highly specialized expert who is often more than 100 km apart, or that the pathologists, who have a telepathology system available, are often far away (e.g. telepathology cooperation between Heidelberg (D), Boston (USA), Tromsoe (Norway), and Dijon (F)).

Summary of Situation of Partnerships

In summary the answers of the non-users reflect that pathologists do serve a lot of externals with their services. In addition, users as well a non-users remarked that their interest in co-operation is very high. Nevertheless, considering the answers of users, although there is a high request for external examinations, telepathology is mostly only employed with a small amount of client and consultant partners. This means that although there is a situation where telepathology would fit positively, its distribution is rather poor and its utilization and acceptance quite low (see chapter 13.4.3.2 and 19.3.2.4).

19.2.3.2 Analysis of Telepathology Interest in Relation to Wish to Cooperate

Interest in Telepathology Services Considered by Wish of Cooperation	Current Interest		Future Interest	
	Correlation	Significance	Correlation	Significance
Interest in diagnostic services	0,331	**0,000**	0,338	**0,000**
I2.5.1 Primary diagnoses in emergency	0,114	0,230	0,099	0,301
I2.5.2 Primary diagn. – frozen sections	0,299	**0,001**	0,355	**0,000**
I2.5.3 Primary diagn. – routine basis	0,262	**0,005**	0,222	**0,019**
I2.5.4 Second look consultation	0,290	**0,002**	0,344	**0,000**
I2.5.5 Reference consultations	0,302	**0,001**	0,287	**0,002**
I2.5.6 On call support – 24-hours/day	0,123	0,197	0,126	0,186
Interest in services to improve know how	0,315	**0,001**	0,307	**0,001**
I2.5.7 Interdisciplinary cooperation	0,272	**0,004**	0,257	**0,006**
I2.5.8 Central case archiving	0,154	0,106	0,170	**0,073**
I2.5.9 Online education	0,255	**0,007**	0,249	**0,008**
I2.5.10 Discussions, forums, etc.	0,266	**0,005**	0,264	**0,005**
I2.5.11 Quality assurance	0,259	**0,006**	0,256	**0,007**
I2.5.12 Internet info., WWW	0,184	**0,052**	0,181	**0,057**

Since the ratings of the wish to cooperate as well as the judgements of the interest in telepathology services were rated on a scale from zero to +4, a correlation analysis was executed to investigate significance. Values of correlation: 0,0-0,15=no correlation / correlation could be caused by coincidence; 0,15-0,3 low; 0,3-0,60=middle; 0,6-0,9=high correlation.

Schedule 37: Significance analysis of the interest in telepathology services in relation to the wish to cooperate.

At most of the judgements of the interest in telepathology services there is a significant low correlation with the wish to cooperate. The highest correlation occurred at frozen section tele-examinations, at second look and at reference consultations. The interest in these services was higher by participants, who wish to cooperate. Also high correlation were analyzed for interdisciplinary cooperation and for online discussions. These results clearly show that if a pathologist is willing to cooperate, he is more interested in telepathology services.

At the ratings of the factors of success there occur no significant differences in the judgements, except of the 'meaning of improved health care efficiency' due to shorter procedures ($r=0,269$, $p<0,004$). That is that the higher the wish to cooperate is, the more meaningful the overall efficiency of telepathology for health care structures is rated.

Significance Analysis of Dis-/Advantage Ratings due to Wish to Cooperate

Advantages / Disadvantages Considered by Ratings of the Wish to Cooperate	Correlation Analysis	
	r	p
More Efficiency (Effic_3, factor two of six)	0,393	0,000
A5.1.1 Advantage: improved diagnostic quality	0,347	0,000
A5.1.2 Advantage: improved pat. treatment process	0,327	0,000
A5.1.3 Advantage: same quality of medicine	0,286	0,002
A5.2.1 Advantage: efficient processes (resources)	0,318	0,001
A5.2.2 Advantage: cost reduction, savings	0,309	0,001
A5.2.3 Advantage: additional revenues	0,274	0,003
A5.2.4 Advantage: high utilization	0,186	0,050
A5.2.5 Advantage: improved reputation of institute	0,207	0,028
High Medical Standards (Qual_3, factor 3 of six)	0,280	0,003
A5.1.5 Advantage: better communication	0,260	0,005
A5.1.6 Advantage: improved research	0,207	0,028
A5.1.7 Advantage: improved access to medicine	0,234	0,013
A5.1.8 Advantage: improved know-how standard	0,204	0,031
On Call Services (factor with only one variable – 5.1.4)	0,204	0,031

Advantages / Disadvantages Considered by Ratings of the Wish to Cooperate N=112 (40 users, 72 non-users)	Significance Correlation Analysis	
	r	p
Uncertainty (Uncer_3)	-0,226	0,017
D5.3.7 Disadvantage: uncertain legal situation	-0,175	0,065
D5.3.8 Disadvantage: uncertain data security	-0,209	0,027
D5.3.9 Disadvantage: uncertain reimbursement	-0,176	0,064
D5.3.6 Disadvantage: reduction of education quality	-0,280	0-003

Schedule 38: Significance values of dis-/advantages in relation to the wish to cooperate.

The results of the correlation analysis shows that there is a significant positive correlation in the ratings of the wish to cooperate and the advantage judgements. At the disadvantages only the uncertain legal situation and the fear of reduced educational quality show significant differences. The higher the wish to cooperate was, the lower these disadvantages were rated. The judgement of variables referring to fears and inefficient workflow did not show significant differences in the relation to the wish to cooperate. A reason is that if a pathologist is interested in cooperation, he is more conscious about the advantages a telepathology system could offer. But such pathologist seem to be also aware of the uncertainty, which often goes along with its utilization.

19.2.3.3 Summary of the Findings Related to the Wish to Cooperate

In summary, users as well as non-users are very interested in cooperation (ratings between 3,2 and 3,7). Regarding the current situation, many non-users already cooperate with partners, who are not rarely more than 100 km apart. Users employ their telepathology system to communicate with tele-partners, who are also often more than 100 km apart. Many of these users only have one client or consultant partner with whom they cooperate. But there are also users, who have even more than 10 partners (e.g. AFIP).

At the comparison of ratings, there occurred significant positive correlation in the wish to cooperate with the interest in telepathology services and in the judgements of advantages. No correlation could have been analyzed for the ratings of the different factors of success with the wish to cooperate. Disadvantages showed only a negative correlation at the judgements of legal uncertainty. A reason is that if a participant wishes to cooperate, he is more aware about the current uncertainty of several legal aspects at telepathology utilization.

19.2.4 Summary of the Influence of Employers' Characteristics

Currently most telepathology systems are introduced at medical centers. Unfortunately the utilization of telepathology systems at doctors' offices is rare, although over ½ of the pathological departments are of this type. The overall interest in cooperation of all participants is high, yet slightly higher by users of telepathology systems. Interestingly, there is a correlation between the wish to cooperate and the attitude towards new technologies ($r=0,238$, $p<0,011$). Persons that are less skeptical towards new technologies seem to be more interested in cooperation.

Considering the ratings of the interest in telepathology services, values were significantly higher at participants whose wish to cooperate is high, who work at medical centers and whose amount of pathologist colleagues at the department is high. The interests ratings of services were not influenced by the department size in the context of the amount of examinations/year. In general at these groups (high interest in cooperation, medical centers, higher amount of

employed pathologists), advantages were rated (often significantly) higher and disadvantages lower. Especially participants of doctors' offices rated advantages lower and disadvantages higher. At the ratings of the factors of success the main significant differences occurred in the judgements of acceptance, management and efficiency aspects. Participants of medical centers expect that the acceptance of internal decision makers and of physicians have a higher influence on telepathology's success than the ones of doctors' offices suppose. Participants of medical centers, and departments with more pathologists at the place rated the meaning of a good project management and the coordination of telepathology sessions significantly higher. This may have been caused by experience with other projects, or these participants have to put more effort in management criteria due to their bigger department size. Finally, participants of a doctor's office saw a significantly barrier in investment costs. Departments with more than three pathologists and high numbers of examination point at the strategic advantages, which are that they hope to increase cost efficiency and diagnostic quality.

In summary, the significance analyses proved that the characteristic of a department has an influence on the judgement of telepathology. Therefore, the situation should be carefully investigated and project leaders have to adapt their introduction plan to the characteristics of their department.

19.3 Area of Occupation

19.3.1 Occupation of Participant (Specialization)

19.3.1.1 Profession of Participants

Profession	To which occupational group do you belong to?					
Group	**general pathologist**		**specialized pathologist**		**reference pathologist**	
	total	**%**	**total**	**%**	**total**	**%**
N-User	56	77,8	6	8,3	10	13,9
User	24	60,0	10	25	6	15
All	80	71,4	16	14,3	16	14,3

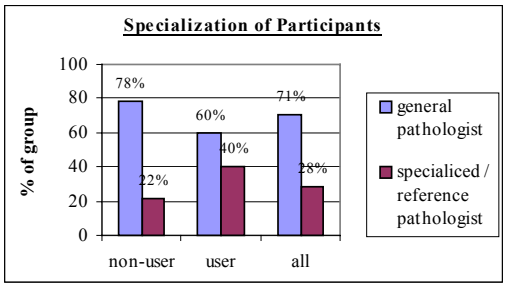


Figure 66: Profession of participants.

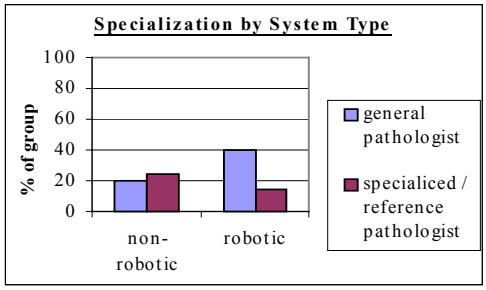
71% of the participants are general pathologists, 14% are specialized pathologists, 14% are reference pathologists. Considering users and non-users, 78% of the non-users are general pathologists and 22% are specialized or reference pathologists. Of the users 60% are general pathologists and 40% are specialized / reference pathologists. The difference in specialization of users / non-users is significant ($Chi^2(11,4)=3,98$, $p<0,046$). At the study in Constance **users of telepathology systems** proved to be significantly **more specialized than non-users**. This result could indicate that specialized pathologists are rather interested in distributing their specialty know-how, or that there is a higher interest in discussing cases with other colleagues, since cases are often rare and difficult. But it could also confirm that specialists are located at medical centers (60%), which are more involved in scientific research activities and in the test of new technologies such as telepathology.

	General Pathologists (n=80)	**Specialized Pathologists** (n=32)	**All**	**Chi^2 = 0.100**
Medical Center	31 (39%)	19 (60%)	50 (45%)	(F=4,6)
Small Clinic	16 (20%)	6 (19%)	22 (20%)	
Doctor's Office	33 (41%)	7 (21%)	40 (35%)	

Schedule 39: Schedule about distribution of pathologists degree of specialization with institution type.

19.3.1.2 Degree of Users Degree of Specialization in Relation to System Type

Profession	Profession of participating users in relation to system type					
	general pathologist		specialized pathologist		reference pathologist	
	total	%	total	%	total	%
Static system	7		4		2	
Dynamic, non-rob.	1	20	1	7,5	3	12,5
Dynamic-robotic	16	37,5	5	12,5	1	2,5
All users	24	57,5	10	20	6	15



* the percentage at the right graphic was calculated by the summary of all the systems = 40.

Figure 67: Specialization of users by system type.

From the replying users, general pathologists, eight (7+1) use a non-robotic system and sixteen a dynamic one. From the specialized pathologists, four users use a static system and five a robotic-dynamic one. Five (2+3) non-robotic systems and one robotic systems are employed by reference pathologists. One static system and one dynamic system is operated by a physician (surgeon), and another dynamic systems by a medical technician.

It was expected that consultants are mainly specialized pathologists. Yet, the structure of tele-participating users reflects that many tele-pathologists are general pathologists, who often work at a medical center. This may indicate that telepathology systems are not only a tool to transfer the high expertise of specialists to the periphery, but that telepathology has already been recognized as a good tool to increase the communication between colleagues (e.g. for second look consultations). The results of the questionnaires further shows that many of the dynamic-robotic teleconsultants are general pathologists. This underlines the intention of robotic systems, which is to serve small hospitals without a pathologist with basic pathological services. If the general tele-consultant is not sure, he still can contact a more pathological specialized telepathologist within minutes, how the study of Kayser proved [Kayser, 1995/3; Kayser, 1996, p. 411].

19.3.1.3 Analysis of Significant Differences

Significance Analysis	General (n=80)		Special (n=32)		All			
Considered by Degree of Specialization of Participant	Mean	St.D	Mean	St.D	Mean	St.D	F	p
Current Interest in Services – 'High know how'	2,09	1,02	**2,54**	1,01	2,22	1,03	4,32	0,040
I2.5.8 Current interest: central case archiving	1,44	1,34	**2,07**	1,51	1,62	1,42	4,69	0,033
I2.5.9 Current interest: online education	2,06	1,44	**2,83**	1,37	2,28	1,46	6,64	0,011
I2.6.8 Future interest: central case archiving	1,60	1,36	**2,24**	1,29	1,78	1,36	5,27	0,024
Factors of Success	no significant differences at PCA-factors*							
F4.1.1 Success factor: availability of advisory desks	**3,22**	1,09	2,69	1,33	3,07	1,18	4,65	0,033
F4.2.1 Success factor: influence of health care politics	**3,09**	1,14	2,34	1,49	2,88	1,29	8,22	0,005
F4.9.3 Success factor: image orientation, focusing	**3,83**	0,43	3,39	0,96	3,70	0,66	10,98	0,001
F4.10.1 Success factor: influence of system reliability	3,19	0,97	**3,56**	0,60	3,29	0,90	4,01	0,048
Advantage: High Quality Medicine	2,08	1,08	**2,53**	0,99	2,21	1,07	4,05	0,047
A5.1.6 Advantage: improved research	1,69	1,25	**2,33**	1,26	1,88	1,28	5,98	0,016
A5.1.7 Advantage: improved access to medicine	2,14	1,37	**2,80**	1,23	2,33	1,36	5,68	0,019

The significance values of the other factors can be seen in appendix X. *Factor 10 only consists of one variable ‚image handling'.

Schedule 40: Significance values referring to the degree of specialization of participants.

The comparison of the ratings shows that specialized pathologists are significant more interested in central case archiving and online education services than general pathologists

are. Similar results were discovered at the comparison of ratings of the department size by amount of pathologists. The Chi square analysis shows that the distribution is significant.

	1 pathologist	2 pathologists	3-5 path.	>5 path.	(F=12,3), Chi2 = 0,007
General Pathologists	12 (92%)	24 (86%)	23 (70%)	18 (51%)	total 77 general pathologists
Specialized Pathologists	1 (8%)	4 (14%)	**10 (30%)**	**17 (49%)**	total 32 specialized path.

Only the comparison of degree of specialization with department size by pathologists showed significant values (p<0,007); the comparison with department size by amount of examinations did not show a significant value (p<0,461).

Schedule 41: Significance analysis of degree of specialization and amount of pathologists employed.

As it already had been argued at the comparison of the ratings of department size by pathologists, specialized pathologists seem to have a high interest in distributing their know-how and to communicate with highly specialized colleagues to discuss difficult cases. They also have a higher interest in central case archiving to improve documentation and to enhance the possibility to execute scientific research analyses.

Considering the ratings of the factors of success, general pathologists rated the 'availability of advisory desks' significantly as more important. Specialized pathologists are often located at medical centers how the comparison before showed. Such centers mostly employ IT-specialists - that is that the advisory desks is at the place. Why general pathologists also rated the influence of health care politics higher than specialists did, is difficult to say. Since many pathologists are located at doctors' offices, they may feel a higher threat by the changes caused by political health care decisions. Also the necessity of flexible 'image handling tools' was rated significantly higher by general pathologists, whereas the influence of system reliability was rated significantly higher by specialists. Specialized pathologists may have already made positive experience with screen image examinations at their medical center, whereas general pathologists are focused on the flexibility of a direct light microscope. In addition the ratings could have been influenced by the kind of service a pathologist had in his mind (primary diagnosis, consultation, education) when answering this question. Specialists often operate as a reference consultant, who gets his images from a qualified pathologist and therefore the scanning process is reduced. That system reliability is rated higher by specialists could be caused by the utilization of already existing systems (medical centers do more often test systems), which unfortunately were poor in its technical reliability at the beginning.

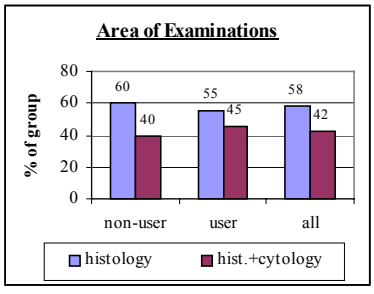
That 'improved research' and 'improved access to care' was rated high by specialists was expected, since this type of pathologist are heavily involved in research activities and are keen on distributing their know-how, or vice versa to have access to highly specialized know-how.

19.3.2 Areas of Examination (Cytology, Histology)

19.3.2.1 Survey of Areas and Organs Examined by Telepathology

Specialty Areas of Participating Users

Specialty	Area of occupation (macroscopy = MA; histology = HI; cytology = CY							
Group	**HI**		**MA + HI**		**HI + CY**		**MA+HI+CY**	
	total	**%**	**total**	**%**	**total**	**%**	**total**	**%**
N-User	38	52,8	5	6,9	13	18,1	16	22,2
User	19	47,5	3	7,5	8	20	10	25
All	57	50,9	8	7,1	21	18,8	26	23,2



For the significance calculation the area of examination was summarized in 'only histology' (HI) and 'histology and cytology'.

Figure 68: Areas of participants occupation.

Regarding the specialty areas where users are active, 47% (19 users) are working in histology only. Another 7,5% (3 users) are busy in macroscopy and histology, and 20% (8 users) in histology and cytology. 25% (10 users) are busy in all specialties - macroscopy, histology and cytology. There was no telepathology user only doing cytology. Finally for significance calculations the area of occupation was summarized into 'only histology' and 'histology and cytology'. The differences in the distribution of users and non-users is not significant. This could indicate, that telepathology is equally appropriate at both fields.

Yet, considering the utilization of telepathology systems in this chapter, most of the tele-examinations are executed with surgical specimens and frozen sections, but only a few with cytological smears. Following the schedule, the number of pathologists working in histology is very high at both groups, users and non-users. Consequently it could be assumed that this is the reason why telepathology systems are more employed in histology. Another reason could refer to the fact that histological examinations are more appropriate for telepathology utilization than are cytological examinations. Further investigation is desirable.

19.3.2.2 Investigation of Statistical Significant Differences of Ratings

The ratings of the interest in telepathology services, of the factors of success, of the advantages and disadvantages and of aspects referring to diagnostic accuracy were analyzed with regard to statistically significant differences between participants, who are only active in histology and those who are involved in histology and cytology. Significant differences are expressed with the following variables:

Comparison of Ratings	**Histol.** (n=52)		**HI + CY** (n=40)		**All**			
Considered by Area of Participants' Occupation	Mean	St.D	Mean	St.D	Mean	St.D	F(1.90)	p
Factors of Success: Cost Efficiency (factor is signif.)	**3,16**	0,74	2,80	0,87	2,98	0,81	3,61	0,060*
4.6.2 Cost effectiveness of services	**3,14**	0,92	2,75	1,13	2,97	1,03	3,49	0,065*
4.6.3 Health care efficiency	**3,10**	0,62	2,64	1,21	2,90	1,17	3,52	0,064*
Further Factors of Success, Advantages	no significant differences at PCA-factors							
4.7.3 Factor of success: influence of used networks	3,47	0,62	**3,71**	0,55	3,57	0,60	3,48	0,065*
4.9.2 Factor of success: flexible image handling	3,81	0,47	**3,97**	0,16	3,88	0,38	4,12	0,045
5.1.1 Advantage: improvement of diagnostic quality	1,73	1,57	**2,45**	1,66	2,04	1,64	4,52	0,036
Accuracy Aspects	no significant differences at PCA factors							
6.5.3 Not enough education in practicing telepathology	2,55	0,67	**2,85**	0,79	2,68	0,74	3,91	0,051
6.5.8 Incorrect interpretation	1,56	0,70	**1,85**	0,85	1,69	0,78	3,30	0,073*
6.5.11 Not enough case information available	1,04	0,45	**1,38**	0,93	1,19	0,72	5,22	0,025

For detailed variance analysis results see appendix X, please. * Only a statistical significant trend in the different ratings.

Schedule 42: Significance values referring to the area of participants' occupation.

Participants, who are just busy in histology, rated the influence of 'cost effectiveness' and the 'efficiency in health care' higher than the ones who are also active in cytology. Telepathology has already increased the efficiency in histology as the tele-examinations of frozen sections have proved. Transport time is reduced to zero and therefore the unproductive time of the operating theater team is reduced, too. Pathologists only working in histology may be very glad about this advantage. In contrast to efficiency criteria, the influence of network connection and the flexibility of image handling was rated higher by the pathologists who work in both specialties. Also the advantage of improved diagnostic quality was rated higher by this group. The reason for these differences should be further investigated, since the utilization of histological specimens and cytological cells may claim different requests. Interestingly there

occurred also differences within the ratings of accuracy aspects. Again, the reasons for these rating differences have to be specified in a further study.

19.3.2.3 Areas and Organs Examined by Telepathology

One hypothesis of this study was that the usage of telepathology systems and the accuracy of diagnoses is dependent on the areas and kind of organs examined. To investigate the fields of telepathology utilization, participants were asked to name the areas and organs, which are examined by telepathology. The following schedule contains the most common areas of telepathology utilization of participants.

„For which areas do you use telepathology?“			„Which organs are examined by telepathology?“		
	User total	**User %***		**User total**	**User %***
Histopathology	34	85	Breast, mammary gland	22	55
Cytopathology	16	40	Lymph node	19	47,5
Immunopathology	11	27,5	Gynecological; ovary, uterus	18	45
Dermatology	10	25	Gastrointestinal	16	40
DNA-Analysis	5	12,5	Thyroid gland	16	40
Hematology	4	10	Lung	15	37,5
Parasitology	2	5	Soft tissue	14	35
Cytogenetics	1	2,5	Skin	13	32,5
Forensic Pathology	1	2,5	Head, neck	12	30
Molecular Pathology	1	2,5	Prostate	12	30
Ophthalmology	1	2,5	Bladder	11	27,5
Electromicroscopy	0	0	Bones	10	25
Microbiology	0	0	Nervous system	10	25
Toxicology	0	0	Kidney	8	20

* 100% = 40 users.

Schedule 43: Areas and organs were telepathology is employed.

The most common areas of telepathology usage is in histopathology, cytopathology, immunopathology and in dermatology. Considering the examined organs, telepathology diagnostic is often used for breast specimens, mammary gland, lymph nodes and gynecological examinations. A more detailed list of organs examined by telepathology is given in appendix VII. It contains also a survey of the examined organs at several accuracy studies mentioned in recent literature of telepathology.

19.3.2.4 Number of Examined Telepathology Cases at Participating Users

Participants were also asked to give the number of examined cases, distinguished by types. The results are the following (the given amount is the summary of all users):

Number of telepathology examinations by participating users	Year 1998	Year 1999
Intraoperative frozen sections (microscopical)	1070	4684[1]
Cytological smear (microscopical)	259	213
Surgical specimens (microscopical)	1230[2]	1363[2]
Biopsy specimens (microscopical)	246	378
Quantitative evaluation (DNA-cytometry, histometry, PCR, FISH, CEH)	1050[3]	1770[3]
Expert consultations (general)	913[4]	1222[4]

The amount is the summary of the examinations of all 40 users.
1) 4000 of these 4684 examinations were executed by one user with a static system in 1999.
2) 1000 examinations in 1998 and 1000 examinations in 1999 are examined by one user with a dynamic-robotic system.
3) 900 examinations in 1998 and 1100 in 1999 are executed by one user employing a dynamic system; this user is strongly involved in DNA-cytometry.
4) 700 examinations in 1998 and 900 in 1999 are executed by one user who employs static and dynamic systems.

Schedule 44: Amount of telepathology examinations per year.

Most primary diagnoses were executed with intraoperative frozen sections and with surgical specimens. Many participants also used their system for expert consultations. A further field of high telepathology utilization was quantitative evaluation. In comparison, the amount of examined cytological smears and of biopsy specimens was rather low. The results of this study also reflect that several users are quite specialized in the kind of telepathology utilization, since four users show a very high amount of examinations of a certain specimen type. (For current utilization of telepathology, see also chapter 19.3.2.4).

19.3.3 Summary of the Influence of Area of Occupation

There occur significant correlation between the degree of specialization, the type of institution, and the amount of pathologists employed. That is that many specialized pathologists work at medical centers, at which more than two pathologists are employed. This fact may have caused the significant higher ratings of specialized pathologists for 'central case archiving' and 'online education' services. Also the advantage of 'improved research' and 'improved access to high quality medicine' was rated higher by this group. In contrast, general pathologists rated the meaning of advisory desks and the influence of health care politics significantly higher.

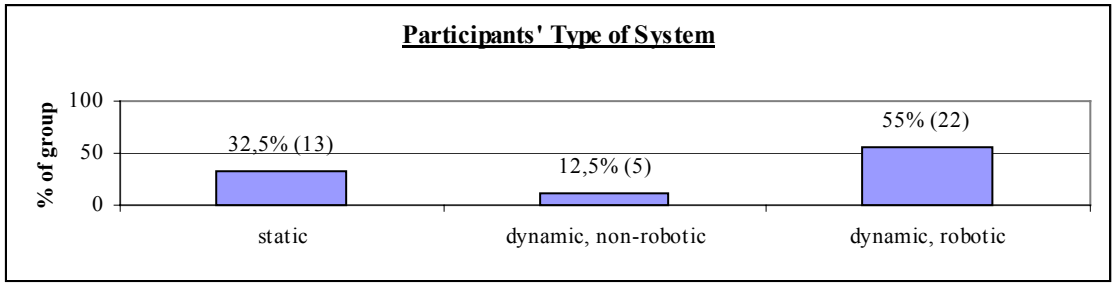
Pathologists, who only work in histology, rated cost efficiency aspects significantly higher than did pathologists, who are also active in cytology. This could indicate the higher need of improved efficiency in histology. In contrast, histo-cyto pathologists rated the meaning of 'network connections' and the 'flexibility of image handling' (focusing, objective change) significantly higher. Also several accuracy criteria were rated higher by this group. All these differences could be related to the kind of examination or service executed by telepathology, or indicate that requirements in histology and cytology are different.

To analyze the current utilization, users specified their telepathology utilization. The highest employment took part for frozen section and surgical specimen examinations, for quantitative evaluations and for expert consultations. The highest utilization rates occurred in histopathology, cytopathology, immunopathology and dermatology. The most often examined organs were mammary gland, lymph node, gynecological, gastrointestinal, and thyroid gland.

19.4 Specific Characteristics of Users

19.4.1 Static versus Dynamic Systems

19.4.1.1 Distribution of Systems at Participating Users



Some of the dynamic-robotic systems are hybrid systems. That is that they can be used as simple static or as a robotic-dynamic system.

Figure 69: Participants' distribution of static and dynamic telepathology systems.

Considering first of all the type of systems used, thirteen of the participating users make use of a static system, five of a dynamic non-robotic system, and twenty-two are operating with a dynamic-robotic system.

19.4.1.2 Judgement of Accuracy Factors by Referring to System Type

Users of telepathology systems were asked to rate the reasons, which could cause failures in diagnostic accuracy. For this, users were subdivided in users of static systems (13 participants), users of non-robotic systems (18, thirteen static and five dynamic non-robotic systems), and users of dynamic-robotic systems (22 participants).

Accuracy - Considered by System Type	**static (n=13)**			**non-robotic (n=18)**			**robotic (n=22)**			**all – significance (n=40)**			
	Mean		St.D	Mean		St.D	Mean		St.D	Mean		p (s)	p (r)
Examination Process	3	**2,29**	1,16	3	2,14	1,17	3	1,88	1,35	3	1,98	0,309	0,482
6.5.5 Errors in the selection of the **tissue sample**	3	**2,80**	1,25	3	**2,86**	1,19	1	2,45	1,53	2	2,62	0,647	0,427
6.5.7 Inaccurate **field selection**.	2	**3,00**	1,26	2	**2,93**	1,22	4	2,28	1,63	3	2,56	0,282	0,235
6.5.9 Insufficient quality of **video images**.	7	**2,00**	1,15	7	1,92	1,21	8	1,84	1,27	7	1,88	0,741	0,863
6.5.10 Not enough **images available** (e.g. long transfer time)	10	1,67	0,82	11	1,38	0,92	6	**1,94**	1,30	9	1,70	0,924	0,215
6.5.11 Not enough **case information** available	8	**2,00**	1,33	10	1,62	1,33	12	0,89	1,02	12	1,19	**0,022**	0,108
Know-how of examiner	1	**2,46**	1,45	1	2,44	1,38	2	1,93	1,42	2	2,12	0,428	0,315
6.5.1 Low **expertise** (e.g. know-how is not sufficient).	4	**2,67**	1,41	4	**2,54**	1,39	5	1,95	1,47	5	2,19	0,279	0,281
6.5.2 Insufficient diagnostic **experience** (low examin. rates).	5	2,25	1,48	5	**2,33**	1,37	7	1,90	1,37	6	2,06	0,693	0,419
Insufficient education in telepathology	2	**2,30**	1,28	2	**2,31**	1,28	1	2,17	1,27	1	2,23	0,745	0,651
6.5.3 Not enough education and **training** in practicing TP	1	**3,20**	0,75	1	**3,07**	0,88	2	2,40	1,35	1	2,68	0,118	0,120
6.5.4 Not enough **experience** with tele-features and tools	6	2,14	1,46	6	2,09	1,38	3	**2,32**	1,30	4	2,23	0,858	0,676
6.5.6 Incorrect preparation or **staining** of tissue samples.	11	1,56	1,64	9	**1,77**	1,58	9	**1,79**	1,15	8	1,78	0,579	0,968
Interpretation at stress situation	4	1,19	1,07	4	**1,47**	1,27	4	**1,45**	1,40	4	1,46	0,542	0,941
6.5.8 Incorrect **interpretation**.	9	**1,67**	1,25	8	**1,85**	1,29	10	1,58	1,31	10	1,69	0,958	0,587
6.5.12 Psychological **stress** at tele-ad-hoc examinations	12	0,71	0,88	12	1,09	1,24	11	**1,32**	1,49	11	1,23	0,327	0,692
Amount of participants	13			18			22			40			

Detailed values please see appendix VIII, chapter 5 and appendix X. Significance values are distinguished in p (s) = static / dynamic and p (r) = robotic / non-robotic;. F values see appendix X; the higher means are emphasized (fat) in the schedule.

Schedule 45: Significance Analysis of Accuracy Factors – distinguished by system type.

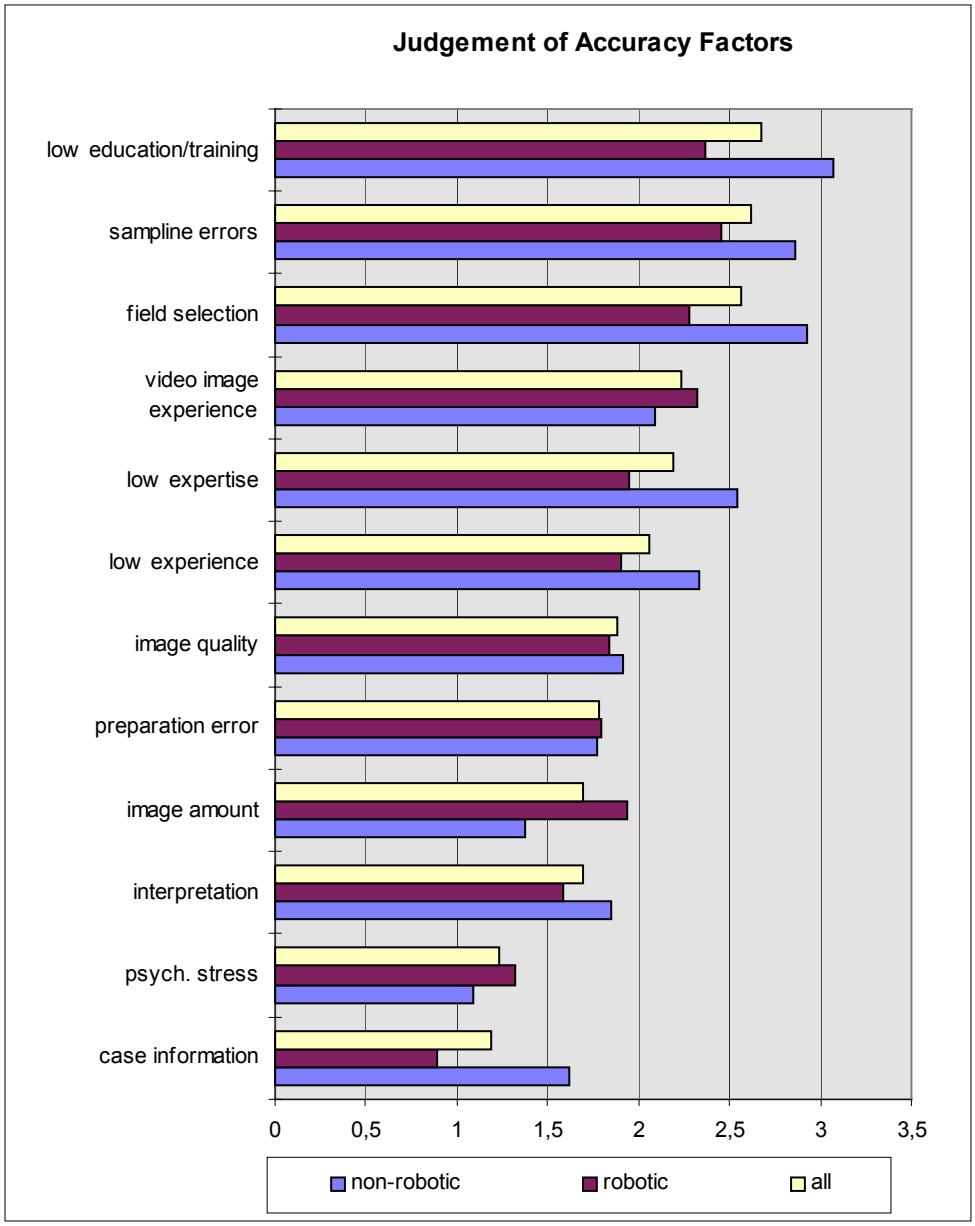


Figure 70: Diagram of accuracy factor rating.

The aspect, which got the highest rating in causing inaccurate diagnoses was **'too less education and training in practicing telepathology'**. Especially if users are not experienced with the use of computers and with image interpretation at the screen, they need good training and support. Regarding the single judgements, the users of static / non-robotic systems rated training higher (mean of 3,2) than robotic system users did (mean of 2,4). This could reflect the problem that with static systems the client is forced to execute pathological tasks, which otherwise the examining pathologist is doing. That this can cause problems is reflected by the second and third highest rated factors of inaccuracy - **'errors in the selection of the right tissue sample'** (overall mean of 2,62) and **'inaccurate field selection'** (overall mean of 2,56). The users of static systems rated these factors higher (sample error: mean of 2,80, field error: mean of 3,0) than users of robotic systems did (sample error: mean of 2,45, field error: mean of 2,28). Especially field selection showed a difference of 0,72 points. The fourth highest rated reason also goes along with education and training. **'Not enough experience with robotic microscopes and screen image interpretation'** was judged by static users with a

mean of 2,14 (place six of overall rating) and by robotic users with a mean of 2,32 (place three of the overall rating).

'Low expertise' (pathological know-how) was judged with an overall mean of 2,19 and with this the fifth highest reason for inaccurate diagnoses. That the rating of the static system users (mean of 2,67) is again higher than the one of the robotic system users (mean of 1,95) was expectable, since at robotic systems the expert is totally controlling the examination process. **'Insufficient diagnostic experience'** (e.g. due to low examination rates) was set on place six of the overall rating (mean of 2,06). The robotic system users judged this point similar as the expertise with a mean of 1,9. The static system users judged it 0,42 points lower with a mean of 2,25. This indicates that for a static system user it is more difficult to increase the overall pathological expertise than to get familiar in making diagnoses in general. In summary, the relatively high ratings of expertise and diagnostic experience emphasize how important it is to have access to good education and fundamental pathological training.

'Insufficient quality of video images' was rated with a mean of 2,06 (place 7). Although three users mentioned their satisfaction with the quality of images, image quality still got a high rating for diagnostic errors. The problem seems to occur with high magnifications. Hopefully, as the quality of equipment improves, this cause of failures will diminish. Almost the same rating was given for **'incorrect preparation or staining of tissue samples'** (static users: mean of 1,56; robotic users: mean of 1,78). This was to expect, since sample preparation is not dependent on the type of system, but is always done by the client. That this point occurs on place eight reflects that especially staining of specimen is a complex procedure, which demands experience (selection of staining type) and concentration in the execution. It also points at the close relation between staining and image quality. Yet, after sufficient training the clients are usually able to execute staining properly.

'Not enough images available' was rated with an overall mean of 1,70 and thereby got the ninth highest rating. When asking this question, first of all it was thought at static systems, where a specific amount of images is selected and sent to the expert for examination. Since mostly less experienced clients have to decide how many and which images have to be selected and sent, there is the risk that images are sometimes not satisfying for the consultant to make a clear diagnosis (see discussion in chapter 16.2.2.8). This problem is rated by the static system users with a mean of 1,67. Static system users were further asked about the amount of transferred images per case. The amount of images varies a lot, depending on the case examined. In average they send between 5 to 10 images per case. Interestingly the robotic system users also rated the problem of image amount very high with a mean of 1,94 and set it at their overall rating on place six. What appears here is the problem of speed. Dynamic-robotic systems demand a lot of network capacity to allow a satisfying image transfer. If speed is low, images are blurry. The expert often tries to reduce his dynamic movements and by this diminishes the amount of transferred images. In this way the telepathologist could lose the orientation and has less images available for his examination result.

'Incorrect interpretation' of case information and images was rated with an overall mean of 1,69 as a matter for diagnostic inaccuracy (static system users: mean of 1,67; dynamic users: mean of 1,58). Incorrect interpretation is not just a reason for inaccurate diagnoses in telepathology, but also in conventional glass slide pathology (see appendix I). The factor, which may increase the risk in telepathology is that the expert is sometimes influenced by the pre-judgement of the client and therefore he/she may come to an incorrect diagnosis. Another reason for inaccuracy, which occurs more likely at frozen section examinations, is **'psychological stress at tele-ad-hoc examinations'** (overall mean of 1,23). Frozen sec-

tions generally increase the stress-factor, because the operation theater is waiting for the result. Considering telepathology, this stress may even be increased. The examination pro??cess at the monitor is more complex and therefore more stressful than the one at the direct microscope due to slow transmission speed, process splitting between client and consultant, or the low experience to examine images at the screen for example. Regarding the single judgements, the users of static systems rated stress as matter for inaccuracy with a mean of 0,71, whereas users of dynamic systems rated it 0,6 points higher with a mean of 1,32. Firstly, most frozen section tele-examinations are executed with dynamic systems and secondly the ratings reflect the pressure of real-time communication between the client and consultant, which is strongly dependent on a reliable working system.

The lowest rated aspect of inaccuracy is **'insufficient available case information'** (overall mean of 1,19). This aspect was set on place eight of the overall judgement by the users of static systems (mean of 2,00), whereas dynamic users judged this factor 1,10 lower with a mean of 0,89. This difference is significant ($F(1,38)=5.68$, $p<0.022$). At static system the communication between client and consultant is divided in time and tasks. The consultant only gets the case information the client is sending (see chapter 16.2.4). Just if the telepathologist has doubts about a case, he is talking with the client on the telephone and requests additional information. In contrast, at real time systems the examination process is accompanied by an ongoing acoustic communication. Consequently the lack of information is less a problem.

In summary, the judgement of the different reasons for diagnostic inaccuracy were judged between 2,68 and 1,19 (static system users vary between: 3,20 and 0,71; non-robotic users vary between: 3,07 and 1,09; dynamic users vary between: 2,45 and 0,89). Unfortunately, most differences are statistically not significant. Perhaps accuracy is less dependent on the type of system, but on the type of service executed (primary / secondary diagnosis) and the type of specimen examined. Considering the different aspects, training with the system, sampling errors, and inaccuracy in field selection were by all system types rated the highest, whereas psychological stress and insufficient available case information were rated rather low. For results of various accuracy studies from recent literature, please see appendix VI.

19.4.1.3 Difference in Interest Ratings by Referring to the Type of System

The ratings of the interest in telepathology services, of factors of success, and of advantages and disadvantages were statistically analyzed by referring to differences between the judgements of users of static, dynamic non-robotic, and dynamic-robotic systems.

Significance Analysis of Different Ratings Considered by System Type	**static**		**non-robotic**		**robotic**		**all**			
	Mean	St.D	Mean	St.D	Mean	St.D	Mean	St.D	p(s/d)	p(r)
Significant Values of Interest Judgements	the PCA-factors die not show a significant difference									
I2.5.2 Current interest: primary diagn. – frozen sections	1,87	1,50	1,80	1,54	**3,12**	1,34	2,53	1,56	**0,066**	**0,006**
I2.5.3 Current interest: primary diagn. – routine basis	0,60	0,64	0,92	1,05	**1,58**	1,51	1,29	1,34	**0,023**	0,128
I2.5.12 Internet info., WWW	**3,27**	0,74	**3,31**	0,68	2,68	1,31	2,96	1,11	0,226	**0,074**
I2.6.2 Future interest: primary diagn. – frozen sections	2,15	1,28	2,33	1,37	**3,31**	1,05	2,87	1,29	**0,012**	**0,014**
I2.6.3 Future interest: primary diagn. – routine basis	0,77	0,60	1,17	1,10	**1,68**	1,49	1,45	1,34	**0,024**	0,231
I2.5.12 Internet info., WWW	3,26	1,20	**3,46**	1,07	2,63	1,31	3,01	1,26	0,391	**0,037**

Significance values are distinguished in p (s/d) = static / dynamic and p (r) = robotic / non-robotic;. F (1,38) values see appendix X; the higher means are emphasized in the schedule.

Schedule 46: Significance values distinguished by kind of system (static/dynamic, robotic/non-robotic).

The current interest as well as the future interest in frozen sections was rated significantly higher at users with robotic systems (current interest: $F(1,38)=8,47$, $p<0,006$; future inter-

est: F(1,38)=6.62, p<0,014). At frozen sections a fast, highly qualified result is needed. Robotic-dynamic systems already proved to be a good tool to serve remote located hospitals with this service (e.g. Norway or Switzerland). There occurred also higher ratings for primary diagnoses on a routine basis. There again the current interest (F(1,38)=5,62, p<0,023), as well as the future interest (F(1,38)=5,56, p<0,024) were significantly higher at dynamic systems compared to static ones. One example, where telepathology is already executed successfully on a routine basis is at the Zablocki VAMC in Milwaukee with the Iron Mountain Veterans Affairs Medical Center, located in the Upper Penisula of Michigan (see chapter 9.2.1). Since telepathology systems in this case simulate the pathologist at the place, dynamic systems seem to be preferred, how the ratings prove. The last service, which showed a significant difference in the ratings was the interest in Internet services. Non-robotic users judged this service higher than robotic ones did. If a client uses a static system, he/she may wish to increase his/her know-how. Therefore for such users the access to Internet information may be more important.

19.4.1.4 Significance Analysis of Factors of Success and Dis-/Advantages

Significance Analysis of Different Ratings Considered by System Type	**static**		**non-robotic**		**robotic**		**all**			
	Mean	St.D	Mean	St.D	Mean	St.D	Mean	St.D	p(s/d)	p(r)
Significant Values of Factors of Success	the PCA-factors did not show a significant difference									
4.3.2 Coordination of system utilization	2,85	1,34	2,92	1,16	**3,58**	0,68	3,28	0,97	**0,049**	**0,030**
4.11.1 Influence of fast respond time	3,54	0,66	3,53	0,61	**3,84**	0,36	3,70	0,50	0,153	**0,049**
4.4.1 Factors of success: Clear legal liability regulation	**3,70**	0,43	3,50	0,69	3,12	1,02	3,29	0,89	**0,045**	0,177
4.11.3 Influence of user support (training, help menu)	**3,32**	0,62	**3,30**	0,57	2,60	1,10	2,91	0,96	**0,061**	**0,019**
4.9.1 Quality of textual data	**3,73**	0,44	3,67	0,45	2,80	1,03	3,19	0,92	**0,008**	**0,002**
4.4.4 Regulations about data protection	**3,42**	0,75	3,03	1,19	2,83	1,06	2,92	1,11	**0,044**	0,581
4.8.4 External system integration	**2,58**	1,11	**2,87**	0,96	2,04	1,04	2,41	1,00	0,294	**0,013**
Significant values of advantages and disadvantages										
Disadvantage: Uncertainty (4th factor)	**2,69**	0,98	**2,56**	1,06	1,90	1,00	2,20	1,07	**0,040**	**0,053**
D5.3.7 Disadvantage: uncertain legal situation	**2,98**	0,91	**2,87**	0,96	2,18	1,40	2,49	1,26	**0,088**	**0,080**
D5.3.8 Disadvantage: uncertain data security	**2,68**	1,17	**2,55**	1,33	1,61	1,31	2,03	1,38	**0,037**	**0,031**
Disadvantage: Inefficient workflow (6th factor)	**2,60**	1,01	**2,52**	1,05	1,39	0,96	1,90	1,14	**0,005**	**0,001**
D5.3.3 Disadvantage: Overtaxing of expert	**2,25**	1,64	**2,29**	1,49	1,10	1,03	1,64	1,38	**0,048**	**0,005**
D5.3.4 Disadvantage: Inefficient work routine	**2,96**	0,83	**2,75**	1,11	1,69	1,33	2,17	1,33	**0,007**	**0,011**
Disadvantage: fears (1st factor)	PCA-factor is not significant								0,868	0,366
D5.3.5 Disadvantage-fear: Loss of jobs	0,34	0,67	**2,29**	1,49	1,10	1,03	1,64	1,38	**0,074**	0,487
D5.3.10 Disadvantage – fear: technology not reliable	1,38	1,66	**2,55**	1,33	1,61	1,31	2,03	1,38	**0,097**	**0,027**
Advantage: high medical standard (factor 3)	**3,20**	0,57	**3,22**	0,54	2,61	0,90	2,89	0,81	**0,084**	**0,017**
A5.1.6 Advantage: improved research	**2,76**	1,24	**2,77**	1,12	1,77	1,31	2,22	1,31	**0,070**	**0,014**
A5.1.7 Advantage: improved access to medicine	**3,54**	0,78	**3,56**	0,71	3,01	1,06	3,26	0,94	0,197	**0,071**
Advantage: more efficiency (factor 2)	PCA-factor is not significant								0,961	0,782
5.2.3 Advantage – more efficiency: additional revenues	**2,17**	1,13	**2,18**	1,13	1,20	1,05	1,64	1,18	**0,050**	**0,007**

Schedule 47: Differences in the ratings of factors of success and dis-/advantages due to system type.

Considering the values at the ratings of the factors of success, dynamic-robotic system users judged the criteria 'coordination of sessions' and 'fast respond times' significantly higher than users of non-robotic systems did (F(1,38)=5,06, p<0,030 and F(1,38)=4.13, p<0,049). The problem systems and people coordination mainly occurs at real-time sessions with dynamic systems. Therefore the higher rating was to expect. Also respond times are mainly important for dynamic systems, since the expert has to rely on a fast image transfer during his scanning process.

In contrast, static and dynamic non-robotic system users rated the aspects 'clear legal liability' ($F(1,38=4.29, p<0,045$), 'the influence of user support such as training' ($F(1,38=5.95, p<0,019$), the 'quality of textual case data' ($F(1,38)=00.0, p<0,002$), and 'the availability of data protection regulations' ($F(1,38)=4.32, p<0,044$) significantly higher than did users of dynamic-robotic systems. At static systems the client has to execute the field selection of images without direct control and acoustic communication with the tele-expert. Therefore the expert may be more keen on **exact case data** to get a detailed impression of the case. Yet, if more case data reach the expert electronically the need of clear **data protection** regulations become obvious. That static system users claim **legal clarity** significantly more urgent (mean of 3,70 at a rating up to +4) may also be caused by the splitting of tasks, the missing direct control and the low(er) qualification and specialization of clients. Employing static systems, the client is executing tasks, which are at the common method under the 'direct' control of the pathologist. Therefore legal clarity, and good training and support is essential. The significantly higher ratings of the disadvantages 'uncertain legal situation' and 'uncertain data security' underline the meaning of these areas for static and dynamic non-robotic system utilization, too.

That the **external system integration** also was rated significantly higher by static and dynamic non-robotic users surprises ($F(1,38)=6.72, p<0,013$), since external integration is especially a difficulty at dynamic-robotic systems, where the incompatibility of robotic features often caused problems. Yet, since at static systems the expert demands more case information, he may not wish to type all these data again and therefore the ratings were higher. Another reason could be caused by the simplicity of static systems. Since data are not always standardized, the integration into the database may be more difficult. Therefore new approaches, for example research tests at Udine (Italy) and Berlin (Germany), employ Internet standards to diminish integration difficulties.

Considering the advantages and disadvantages due to the difference in system type, static and dynamic non-robotic system users rated the advantage of '**improved research'** and '**improved access to medicine'** significantly higher than did dynamic robotic system users. Analyzing the degree of specialization with system type, there occur no significant differences. Consequently the degree of specialization is not the main reason for higher ratings of improved research and medical access. Yet, the higher ratings could point at the possibility to get a fast, low-cost access to these sources, whereas at dynamic robotic systems investment costs are high. These low cost systems also allow to '**increase efficiency due to additional revenues'** (mean of 2,17 in comparison to robotic-dynamic systems with a mean of 1,20). The AFIP is a good example, since it became a high-quality service provider in pathology worldwide by employing static systems. However, the easy access also increases the risk for experts to be '**overtaxed by simple cases**'. The static and dynamic non-robotic system users rated this disadvantage with a mean of 2,25, whereas the dynamic-robotic ones with a mean of 1,10 ($F(1,38)=9.03, p<0,005$). The risk of '**inefficient work routines**' was also rated higher by static and dynamic non-robotic system users. Something that surprises, since inefficient workflow can mainly be expected due to coordination difficulties at real-time sessions, which only occur at dynamic systems. Yet again, the reason of the very significant higher ratings of static and dynamic non-robotic system users could have been caused by the fear of being overtaxed by simple cases.

Finally the fear of '**job reduction**' and the fear of '**not reliable technology**' was rated significantly higher by dynamic non-robotic users. The client at this type of system may feel to be reduced to a simple robotic assistant of the tele-expert, or may recognize that a dynamic-robotic system could replace his task. Such type of users also seem to feel a

higher dependency of reliable technology (mean of 2,55). However, the fact that dynamic-robotic system users rated technology reliability lower (mean of 1,61) surprises, since they are also heavily dependent on reliable technology. Perhaps this may be caused by the experience. Participating users rarely reported system interruptions (see chapter 18.3.3.4)

19.4.2 Judgements in Relation to Clients' Profession

19.4.2.1 Profession of Client and System Type

Profession	Which profession does the staff at the client's side have? The client is a:				
	pathologist	**surgeon**	**surgeon and med. technician**	**medical technician**	**no comment**
static system	10	0	0	0	3
dynamic non-robotic	4	0	1	0	0
dynamic robotic syst.	9	8	3	1	1
all systems	23	8	4	1	4

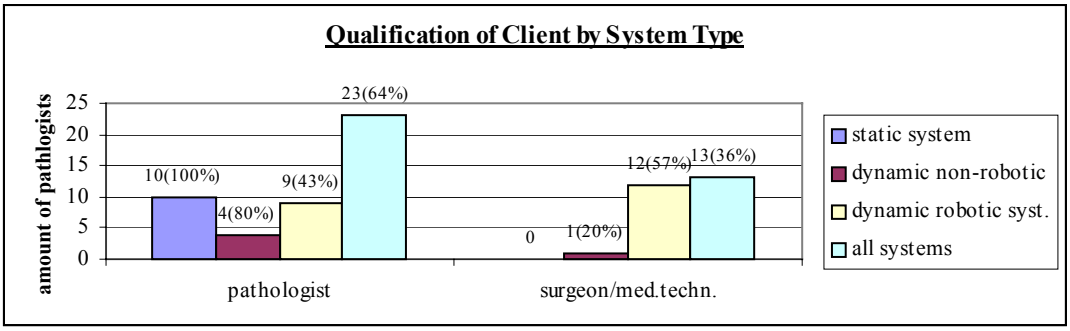


Figure 71: Profession at client's side.

Considering the profession at the client's side in terms of system type, all users with a static system replied that there is a pathologist at the client's side (10 users, 100%). At the five dynamic non-robotic systems, four (80%) are handled by a pathologist and one system is handled by a surgeon together with a medical technician at the client's side. Nine (43%) of the dynamic systems are handled by a pathologist, eight by a surgeon, three by a surgeon in cooperation with a medical technician, and in one case there is only a medical technician doing all tasks.

Asking the users how they guarantee staff qualification, all answering users (32 users, 8 did not answer the question) said that they know their telepathology partner personally. In addition, one user replied that at his project it is set great store by excellent training. Another one stated that they execute proficiency studies to guarantee the professionalism of participants.

19.4.2.2 Accuracy Judgements in Relation to Clients' Qualification

The ratings of the different accuracy factors were set in relation to the profession of the client. At three aspects a significant difference could have been analyzed:

Accuracy Ratings Considered by the Clients' Profession	**Pathologist**			**Surgeon/Tech**			**all**				
	Mean		St.D	Mean		St.D	Mean		St.D	F(1.3)	p,
Examination Process	2	**2,24**	1,17	3	1,54	1,26	3	1,98	0,94	4,31	**0,045**
6.5.5 Errors in the selection of the right **tissue sample**	3	**2,90**	1,24	1	**2,12**	1,56	2	2,62	1,41	2,67	0,112
6.5.7 Inaccurate **field selection**.	2	**2,96**	1,29	6	1,86	1,45	3	2,56	1,50	5,60	**0,024**
6.5.9 Insufficient quality of **video images**.	7	2,03	1,15	9	1,61	1,26	7	1,88	1,24	1,04	0,314
6.5.10 Not enough **images available** (low transfer time)	9	1,70	0,96	8	1,70	1,36	9	1,70	1,19	0,00	1,000
6.5.11 Not enough **case information** available	10	1,59	1,19	12	0,48	0,67	12	1,19	1,21	9,68	**0,004**
Know-how of examiner	3	**2,15**	1,32	1	2,09	1,29	2	2,12	1,21	0,02	0,895
6.5.1 Low **expertise** (e.g. know-how is not sufficient).	5	2,24	1,41	2	**2,09**	1,44	5	2,19	1,47	0,09	0,762
6.5.2 Insufficient diagnostic **experience** (exam. rates).	6	2,05	1,43	3	**2,08**	1,19	6	2,06	1,39	0,00	0,949
Insufficient education in telepathology	1	**2,50**	0,91	2	1,76	0,77	1	2,23	0,87	6,01	**0,020**
6.5.3 Not enough education and **training** in practicing TP	1	**3,12**	0,92	5	1,90	1,24	1	2,68	1,21	11,3	**0,002**
6.5.4 Not enough **experience** with tele-features and tools	4	**2,44**	1,22	7	1,86	1,22	4	2,23	1,33	1,86	0,181
6.5.6 Incorrect preparation or **staining** of tissue samples.	8	1,93	1,37	10	1,52	1,12	8	1,78	1,34	0,83	0,368
Interpretation at stress situation	4	1,44	1,25	4	1,50	1,33	4	1,46	1,04	0,02	0,883
6.5.8 Incorrect **interpretation**.	11	1,52	1,14	4	**1,98**	1,42	10	1,69	1,31	1,08	0,305
6.5.12 Psychological **stress** at tele-ad-hoc examinations	12	1,36	1,35	11	1,02	1,23	11	1,23	1,41	0,55	0,468
Amount of participants	23			13			36 (4 did not answer)				

Schedule 48: Accuracy aspects in relation to clients' qualification.

Considering the order of ratings distinguished by the qualification of the client several differences occurred. If there is a pathologist at the place, the most important reason for diagnostic inaccuracy was seen in '**insufficient system training and education**' (mean of 3,12). At the second and third place appeared **sampling errors** such as the selection of the wrong part of a specimen or inaccurate field selection (mean of 2,9). Comparing these ratings with the ratings of the factors of success, users (mean of 3,66) and non-users (mean of 3,84) set this criterion on place three in its importance for telepathology's success[120]. The fourth highest reason was seen in **insufficient experience** handling the tele-features (mean of 2,44).

If the client is not a pathologist (e.g. surgeon or medical technician), the most occurring cause of accuracy errors was seen in errors at the **tissue sample selection**. This indicates that macroscopy is problematic, although in most of the cases (except of one user) dynamic-robotic systems are employed, which in general include a video-gross station. The fears of non-users seem to be justified. They rated the influence of accurate macroscopy significantly higher (mean of 3,82 / place 4 of the 39 criteria) than the users did (mean of 3,51 / place 9; $F(1,110)=5.55$, $p<0,020$). The second, third, and fourth highest reason of inaccurate diagnoses

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120 Rating values of factors of success (39 criteria) referring to diagnostic accuracy	**non-users**		**users**		**ANOVA**
	place	**mean**	**place**	**mean**	**p**
Quality of **monitor** images (resolution, color, contrast)	1	3,90	1	3,81	not signif.
Guarantee of quality sample **preparation** and field selection	3	3,83	3	3,66	not signif.
Accuracy of **micro examination**	2	3,84	8	3,53	0,028
Accuracy of **macro examination** (correct gross examination)	4	3,82	9	3,51	0,020
Quality of **image handling** (orientation in image, focusing)	5	3,81	10	3,50	0,028

refer to the **qualification of the client**. These are 'low expertise' (mean of 2,09), insufficient diagnostic experience' (mean of 2,08), and 'incorrect interpretation (mean of 1,98).

The final rating of 'image quality' carried out a surprise. Image quality occurred on place one of the ratings of the factors of success. Yet, in relation to the clients' qualification it is set on place seven and nine, and in relation to the system type on place seven (static systems) and eight (robotic dynamic systems). This seems to confirm the results of Doolittle (Chapter 16.2.2.4), who found out that image quality is subjective and dependent on the impression of the user. His study even proved 8-bit images to be preferred with comparison 16-bit images.

Analyzing significant differences within the ratings of both groups, '**inaccurate field selection**' ($F(1,3)=5,6$, $p<0,024$; mean of 2,96 and 1,86), '**not enough case information available**' ($F(1,3)=9,68$, $p<0,004$; mean of 1,59 and 0,48), and '**not enough training and education in telepathology**' ($F(1,3)=11,3$, $p<0,002$; mean of 3,12 and 1,90) were always rated more important by the users with a qualified pathologist at the client's side. As the distribution of clients' qualification in relation to system type showed, all static systems are handled by pathologists. All three criteria were also rated higher by static system users. Therefore it is to assume that the significant differences are caused by the qualification of a client in connection with the type of system employed.

19.4.2.3 Significant Rating Differences due to Clients' Qualification

Rating Differences in TP Service Interest with Regard to Clients' Profession	Pathologist		Surgeon/Techn.		All		Anova	
	Mean	St.D.	Mean	St.D.	Mean	St.D.	F	p
Interest in Telepathology Services								
I2.5.2 Current interest: primary diagn. – frozen sections	2,15	1,59	**3,51**	0,83	2,64	1,51	8,25	**0,007**
I2.5.3 Current interest: primary diagn. – routine basis	1,07	1,20	**1,91**	1,51	1,37	1,36	3,31	0,078
I2.6.2 Future interest: primary diagn. – frozen sections	2,60	1,41	**3,69**	0,64	2,97	1,30	7,41	**0,010**
I2.6.3 Future interest: primary diagn. – routine basis	1,22	1,24	**2,08**	1,44	1,53	1,36	3,55	0,068
I2.6.8 Future interest: external central case archiving	**2,57**	1,39	1,63	1,17	2,23	1,38	4,28	**0,046**

Schedule 49: Significance of rating values with referring to the profession of the client.

The current interest (mean of 3,51) and future interest (mean of 3,69) in **frozen section examinations** is rated significantly higher by users of systems that are manipulated by a surgeon or medical technician at the client's side ($F(1,34)=8.28$, $p<0,007$ and $F(1,34)=7.41$, $p<0,010$). This emphasizes that robotic-dynamic systems (again, all clients of this type use a dynamic-robotic system) are recognized and accepted as a tool to offer frozen section examinations to hospitals and doctors' offices without a pathologist (e.g. the expert in Basel is serving the hospital in St. Moritz/CH).

A statistical trend can be seen furthermore in the ratings of the interest in '**primary diagnoses on a routine basis'** of the users with a surgeon client (mean of current interest: 1,91, mean of future interest: 2,08) compared to users with a pathologist client. Institutions without a pathologist seem not just to recognize in telepathology systems a tool to execute frozen section examinations, but wish to use telepathology as a routine tool for primary diagnoses.

Finally there occurs a significant difference in the rating of the future meaning of '**external central case archiving'**. The interest of users with a pathologist client (mean of 2,57) indicates that pathologists may recognize in the possibility of central case archiving an improvement of documentation, standardization, performance and scientific research.

Rating Differences in Relation to the Clients' Profession	Pathologist (n=23)		Surgeon/Techn. (n=13)		All		Anova F(1,34)	
	Mean	St.D.	Mean	St.D.	Mean	St.D.	F	p
Factors of Success	PCA-factors did not show a significant difference							
4.3.1 Influence of structured project design	3,03	0,98	**3,69**	0,48	3,27	0,89	5,16	**0,030**
4.3.2 Coordination of system utilization (real time)	2,98	1,13	**3,77**	0,44	3,26	1,01	5,81	**0,021**
4.10.1 Influence of system reliability (total crash)	3,33	0,70	**3,79**	0,57	3,50	0,68	4,13	**0,050**
4.4.1 Explicitness of legal liability regulations	**3,44**	0,65	2,81	1,18	3,21	0,91	4,28	**0,046**
4.9.1 Quality of textual data	**3,61**	0,48	2,27	0,97	3,12	0,94	31,1	**0,000**
4.11.3 Influence of user support (training, help menu)	**3,06**	0,83	2,40	1,06	2,82	0,96	4,35	**0,045**
4.8.3 Internal system integration (HIS)	**2,67**	1,06	1,90	0,84	2,40	1,04	5,06	**0,031**
Advantages and Disadvantages	Only PCA-factors 3 did show a significant difference							
Value of Factor 4 'uncertainty'	PCA-factor didn't show a significant difference						1,00	0,324
D5.3.7 Disadvantage: uncertainty of legal questions	**2,73**	1,21	1,68	1,02	2,35	1,24	6,96	**0,012**
Value of Factor 3 'improved quality'	**3,04**	0,73	2,47	0,83	2,84	0,80	4,62	**0,039**
A5.1.8 Advantage: improved know-how standard	**3,30**	0,93	2,57	1,26	3,04	1,10	4,00	**0,053**
A5.1.7 Advantage: improved access to medicine	**3,43**	0,73	2,79	1,22	3,20	0,97	3,92	**0,056**
A5.1.6 Advantage: improved research	**2,43**	1,31	1,53	0,96	2,10	1,26	4,68	**0,038**

Schedule 50: Significant differences of factors of success and dis-/advantage ratings by considering the profession of the client.

The management criteria '**structured project management**' at the telepathology introduction process (mean of 3,69) and careful '**coordination of telepathology sessions**' (mean of 3,77) were rated significantly higher by the users with a surgeon at the client's side. One reason for these differences may be caused by the type of system used. 92% (12) of the users with a surgeon as client introduced dynamic-robotic systems, whereas only 40% of the users with a pathologist client use this type of system. Hence, since robotic systems are more complex and resource coordination at real time sessions is difficult, good management is necessary to avoid interruptions. In addition, good management guarantees a smooth telepathology process. In this way less trained client surgeons are not burdened by unnecessary additional stress. A further argument, which could also have caused the higher ratings of the criteria 'system reliability' by users with a surgeon client may have been caused by the strong feeling of dependency. It is to assume that the surgeon, who is responsible for the treatment (and surgery intervention) of the patient at the client's side, is also manipulating the tele-features. Such a surgeon needs a fast respond of the tele-expert to continue his medical therapy and treatment process. Reliability of technology is cogent.

The factors of success, which were rated significantly higher by the users, whose client is a pathologist, are also likely to be caused by the differences of the system type employed. '**Clear liability regulations'** (mean of 3,44), '**quality of textual data'** (mean of 3,61), the influence of '**user support'** (mean of 3,06), '**integration aspects'** (mean of 2,67), as well as the disadvantage of '**uncertainty of legal questions'** (mean of 2,73) were also rated significantly higher by the users, who employ a static telepathology system. Considering the legal responsibilities by the different types of system used and the clients' qualification the situation looks as follows:

Distribution of responsibility	only client	each for his part	both together	only tele-expert	total
client is a pathologist	**6 (28%)**	6 (28%)	6 (28%)	**3 (14%)**	21
client is a surgeon	**1 (11%)**	2 (22%)	3 (33%)	**3 (33%)**	9
static	**4 (44%)**	2 (22%)	2 (22%)	**1 (11%)**	9
dynamic non-robotic	**1 (20%)**	1 (20%)	2 (40%)	**1 (20%)**	5
dynamic robotic	**2 (12%)**	5 (31%)	5 (31%)	**4 (25%)**	16
total	**7**	**8**	**9**	**6**	**30**

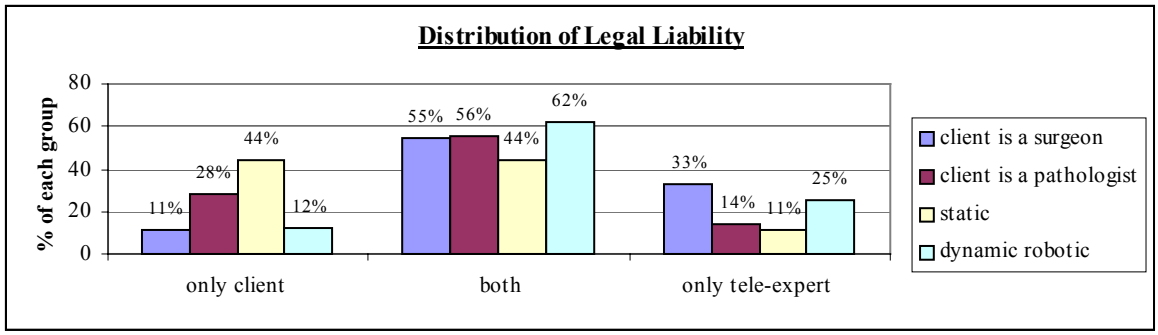

Figure 72: Legal responsibility in relation to the clients' qualification and system type.

Unfortunately there were only 30 users, who answered to the question of legal responsibility. First of all, all these users answered that they know their client personally – consequently they are informed about the client's qualification. Regarding the legal responsibilities, if the client is a pathologist and a static system is in use, the responsibility remains rather at the client's side, whereas if the client is a surgeon and a dynamic-robotic system is utilized, the responsibility is more frequently carried by the tele-expert. This distribution of legal responsibilities explains the significant differences of liability ratings.

And last but not least, users with a client pathologist rated advantages referring to **improved pathological quality** significantly higher than did users with a surgeon client ($F(1,34)=4,62$, $p<0,039$). The team of pathologist (client and expert) may recognize a high potential of improved quality in pathology, whereas the mixed team (surgeon and pathologist) is more interested in serving remote locations with pathological services. This is confirmed by the high ratings of the interests in frozen section and routine examinations by users with a surgeon client.

19.4.3 Summary of Rating Differences due to Users' Characteristic

In this sub-chapter the ratings of users were analyzed referring to the type of system uses and the qualification of the client. At the ratings of the **reasons of diagnostic inaccuracy**, only the point 'not enough case information available' showed a significant difference in relation to the system type employed. The static system users rated this aspect significantly higher than dynamic system users did ($F(1,38)=p<0,022$). Considering accuracy reasons in relation to the clients' qualification (pathologist or surgeon / medical technician), 'inaccurate field selection', 'not enough case information available', and 'not enough education and training in practicing telepathology' were rated significantly higher by users, whose client is a pathologist. It is to assume that the differences at these accuracy aspects are caused by the high amount of static systems employed by this group. To summarize, all static systems (10) are handled by a pathologist at the client's side. Of the dynamic-robotic systems in 50% of the cases (13) the client is a pathologist, and in 50% the system is handled by a surgeon / medical technician at the client's side.

Analyzing the distribution of system type and clients' qualification, there occur also similarities in the ratings of the interest in telepathology services, factors of success and dis-/advantages. The interest in frozen section examinations and tele-examinations on a routine basis were rated significantly higher by users, whose client is a surgeon and whose system is a dynamic-robotic one. These ratings emphasize the interest of hospitals without a pathologist in being served by telepathology. Management aspects (project management and coordination of telepathology sessions), as well as the meaning of fast respond time and system reliability were also rated higher by users, who employ dynamic-robotic sys-

tems and whose client isn't a pathologist. Firstly, dynamic-robotic systems are more demanding in the introduction process as well as in the coordination of resources at real-time sessions. Secondly, if there is no pathologist at the client's side the surgeon is highly dependent on a reliable system to get a diagnostic result.

The aspects, which were rated significantly higher by static system users and users with a pathologist client are: a) the meaning of the quality of textual data, b) the influence of user support, c) the meaning of system compatibility and integration aspects, and d) the meaning of clear liability regulations. That liability has a more important meaning was also confirmed by the considerably higher rating of the disadvantage 'uncertainty of legal questions. Considering liability in more detail, at static systems and client pathologists the responsibility often remains at the client's side, whereas at dynamic systems with a surgeon client the legal responsibility is rather at the tele-expert's side. Finally, the advantage of improved quality in pathology was also rated significantly higher by the static system users with a pathologist at the client's side. The pathologist team (client and expert) seem to appreciate the improvement in pathology, whereas the mixed team (surgeon and expert) enjoy the possibility of pathology service access, although there is no pathologist at the client's place.

19.5 Summary of Characteristic Analysis

Conclusion in the Context of Users' Characteristic

In general recent literature reports about older physicians being reluctant about new technologies. Yet, at this study quite a lot of telepathologists are **older** than 50 years. The **computer experience** of telepathology users is significantly higher than the one of non-users. Still, most non-users judged their computer know-how being average. When asking participants for their **attitude** when faced with new technologies, non-users were more skeptical than users were. This was especially conspicuous in the context of telemedicine and telepathology, where the users were significantly more positive. Considering the current and future interest in **cooperation**, the ratings of the users were higher. Yet, the more detailed analysis of non-users showed that most of them do already cooperate with external institutions, which are not rarely further apart than 30 km. This indicates that there would be a market for telepathology services to bridge distances. Considering the situation of telepathology users, many of the clients and consultants are further than 100 km apart from each other. Approximately 30% of the users only cooperate with one client or consultant, and approximately 40-50% have more partners, hence some (5%) more than ten. This indicates that an increasing number of telepathology users take advantages of bridging distances by networks. Telepathology users are significantly more often located at medical centers, whereas non-users are rather located at doctors' offices. Due to this distribution users further show a significantly higher degree of specialization and departments often do employ more than three pathologists.

Analysis of Correlation within Participants' Characteristics

The analysis of correlation within the examined characteristics of participants first of all showed a relation between computer experience and the attitude towards new technology. The more experience a participant has, the more positive his attitude towards new technologies is. There is also a significant, positive correlation between the attitude in new technologies and the wish to cooperate. A further relation was investigated between the

institution type, the department size by pathologists, and the degree of specialization. That is that pathologists located at medical centers significantly more often show a higher degree of specialization and have more than two pathological colleagues. Finally there is also a correlation between the employed telepathology system and the qualification of the client. If a dynamic-robotic system was used by participating users, in 50% of the cases the client was a surgeon at the client's side, whereas if a static system is utilized in 100% of the cases the client was a pathologist.

Analysis of Correlation within the Ratings of Accuracy Aspects

Various criteria that could cause diagnostic inaccuracy were analyzed. High ratings were given to the aspect 'too less training and experience in practicing telepathology'. The second and third most important reason for inaccuracy was seen in sampling errors (incorrect macroscopy or field selection). Another area, which also got high ratings in the context of accuracy was 'low expertise' and 'insufficient diagnostic experience'.

To investigate significant differences, all accuracy ratings were analyzed in relation to users age, computer experience, degree of specialization, pathological specialty (histology / cytology), type of system used, and the qualification of the client. The age, degree of specialization (general pathologist or specialized), and computer experience did not have a significant influence on the ratings. Yet, the users who are active in cytology (and not only in histology) rated the criteria 'not enough experience in practicing telepathology', 'not enough case information available', and 'incorrect interpretation' significantly higher than specialized histo-pathologists did. This indicates that the telepathological requirements of cytology and histology are different. 'Insufficient case information' was also rated significantly higher as reason of inaccuracy by static system users compared to the robotic-dynamic ones. At static systems the expert needs additional information, since the expert does not select the images by himself, and because in general there is no direct communication between the client and the expert during the examination process. Finally users, who cooperate with a pathologist at the client's side judged 'inaccurate field selection', 'insufficient case information', and 'insufficient telepathology training' as a significant higher reason of inaccuracy than did the users with a client surgeon. Whether this is caused by the system employed (all client surgeons use dynamic systems) or by the difficulty of cases has to be further investigated.

Analysis of Correlation within the Ratings of Telepathology Service Interest

Almost all telepathology services got significantly higher ratings by younger participants, who have a good computer experience, and who are very curious when facing new technologies. Also participants who are employed at medical centers, whose department has more than two pathologists employed, and whose wish to cooperate with other external partners is huge, rated their interest in the different telepathology services higher than did pathologists of doctors' offices or small hospitals. Specialized pathologists are significantly more interested in 'central case archiving' and 'online education' than general pathologists. It was assumed that such pathologists are more keen in creating research databases. They may wish to communicate with other experts and to distribute their know-how. Finally, users who employ dynamic-robotic systems in cooperation with a surgeon as a client are significantly more interested in executing frozen section examinations or even tele-examinations on a routine basis. Telepathology systems seem to gain acceptance as a tool to serve hospitals without a pathologist with pathological services.

Analysis of Correlation within the Ratings of the Meaning of Factors of Success

Younger pathologists, with increased computer experience and a positive attitude towards new technologies rated the meaning of management criteria (project management at introduction and coordination of real time session) and the influence of users acceptance, as well as the meaning of institution's politics significantly high. These criteria were also rated significantly higher by pathologists located at medical centers with a department size of more than two pathologists. It was assumed that these types of pathologists have already introduced new technologies and therefore have experienced that management and acceptance is important. In contrast, older pathologists with low computer experience and a skeptical attitude towards new technologies rated the meaning of accurate diagnoses (accurate macro- and micro-examination) significantly higher for telepathology's success. Such pathologists need sufficient reliable information to overcome unjustified doubts. The meaning of investment costs was judged significant higher by doctors' offices, whose budgets are often limited.

Since general pathologists are often located at small institutions, they feel a significantly higher need for advisory desks for telepathology selection and introduction support. General pathologists further rated the influence of health care politics significantly higher in its meaning for telepathology's success than did specialized pathologists. Pathologists in histology expect from telepathology to be cost-efficient, whereas pathologists who are active in histology and cytology rated the influence of the networks employed and the quality of image handling significantly higher in its meaning for telepathology. The reasons for these differences have to be further investigated with respect on the peculiarities of each pathological specialty.

Finally, there occurred also some differences in the ratings of the factors of success in relation to system type and the qualification of the client. Management criteria, the meaning of fast respond time and of system reliability were seen as more important by users with dynamic-robotic systems and a surgeon client than by static system users. Dynamic systems are very complex and therefore its introduction and utilization has to be well managed. Since there is often no pathologist at the clients place, systems have to be reliable and stabile. In contrast, static system users, who cooperate with a client who is a pathologist, rated the meaning of 'sufficient case data', the quality of 'user support in practicing telepathology', as well as the need of system integration and standards significantly high. Since the static tele-examination process is divided in isolated tasks, good training and case information is necessary to employ telepathology systems in a satisfying way. A further aspect which was higher rated by static system users with a pathologist client was liability. Since the risk of inaccurate diagnoses is slightly higher at static telepathology systems, the increased meaning of clear liability regulations is obvious.

Analysis of Correlation within the Ratings of Dis-/Advantages

In general, the ratings of advantages are higher by younger pathologists, with good computer experience and a positive attitude towards new technologies, whereas disadvantages are higher rated by older pathologists, with low computer experience and a skeptical attitude towards new technologies. Considering the type of institution, the department size and the wish to cooperate, in general medical centers with more than two pathologists and an openness in external cooperation and partnerships rated advantages higher and disadvantages lower than did small doctors' offices. Pathologists at departments with more than two pathologists and high examination numbers recognize strategic advantages in telepathol-

ogy. They expect telepathology to improve efficiency and pathological quality. One example is the success of the AFIP, which is worldwide accepted and known for its high quality pathological services.

Specialized pathologists see telepathology as a tool, which will improve research activities and which guarantees an easy access to high quality medicine. They rated these improvements significantly higher than general pathologists did. Improved medical quality, research, and know-how was also rated significantly higher by static system users, whose client was a pathologist. Static systems seem to be recognized as excellent tools to improve the communication between pathologists and consequently the standard in pathology.

The results show that the characteristic of pathologists and their institution has a huge influence on telepathology's acceptance. Especially older pathologists with less computer experience and a skeptical attitude towards new technologies can be expected to be reluctant against telepathology introduction. This is also the case at pathologists located at doctors' offices or small departments with one or two pathologists. A further aspect of influence is the readiness of pathologists to cooperate with other institutions. If pathologists wish to cooperate with other colleagues it is more likely that they recognize the advantage of telepathology to bridge the kilometer and structural distances. A further factor of influence to the habit on telepathology is the degree of specialization, often related with the kind of institution a pathologist is employed at (medical center or doctor's office). Therefore the situation of potential telepathology users has to be carefully analyzed to meet their specific needs.

20 Conclusion

20.1 Discussion

20.1.1 Interest in Telepathology Services

Telecommunication technologies offer various possibilities of online pathological support and improvement. When considering the most frequented utilization of these services by the participating users of this study, we find telepathology was introduced to execute second opinion consultations, frozen section tele-diagnoses and microscopical analyses of surgical specimens, along with quantitative evaluations. The most common utilization of tele-examinations are in histopathology, cytopathology, immunopathology and in dermatology. The most often regarded organs are mammary glands, lymph nodes, gynecological specimens (ovary, uterus) or gastrointestinal and thyroid gland. Further participating users remarked that they appreciate the access to Internet information or the participation in online education classes, online discussions and forums. Many tele-pathologists also use their computers to improve the interdisciplinary cooperation with other physicians. However not only users, but also non-users of telepathology started to recognize the value of being online. Some of them have already started to access Internet information or to participate in online education programs and online discussions. Quality assurance activities via networks or the achievement of online diagnoses in emergency situations or on a routine basis are services which are yet rather rarely applied. Central electronic case archiving or the creation of online 'on-call' services are the exception.

Participants of this study were also asked about their opinion of how the meaning of various telepathology services will be accepted in the next five years. They replied that they expect that the Internet will become a very important source of knowledge. The meaning of online discussions will improve and also online education will become a common issue. The communication and data exchange via networks between pathologists and other physicians will increase. It is also expected that pathologists will accept and employ telepathology systems for second opinion consultations. The acceptance of online quality assurance activities or the introduction of telepathology systems for frozen section examinations is excepted to be hesitant by participants. Nevertheless, these services will win in importance. Also, the meaning of central case archiving may increase with improved technology and electronic record keeping. Low acceptance is expected for centralized on-call services and for telediagnosis in emergency situations or on a routine basis.

When regarding the interest in telepathology services with the participant's characteristics, most users rated their interest significantly higher than non-users. Also, younger, computer-experienced and technology-interested pathologists were more interested in telepathology services than older, less experienced or technology skeptical ones. Further, the interest in telepathology services was often rated higher by pathologists working at a medical center and with more than one colleague. Many participating pathologists (users as well as non-users) are already cooperating with external institutions. Nevertheless, the pathologists who rated the wish to cooperate with other external pathologists and physicians high, also showed a higher interest in utilizing telepathology services. Interestingly, a correlation within the ratings of the interest in telepathology services and the ratings of advantages and disadvantages was analyzed. Participants which showed higher ratings at the interest

judgements also rated advantages significantly higher and disadvantages significantly lower. That is the more advantages a pathologist expects from telepathology, the higher his interest. Specialized pathologists, who are most frequently employed at medical centers, expect telepathology to improve the quality in pathology due to centralized case archiving and online education. They also hope to be able to distribute their high know-how in online forums and discussions. Finally, dynamic-robotic telepathology is highly accepted by surgeons without a pathologist at the place. Small hospitals can get access to frozen section services, and they could even introduce pathological tele-support on a routine basis.

20.1.2 Judgement of Different Factors for Telepathology's Success

At the study various factors of influence for the success or, respectively, the rejection of the introduction of telepathology systems and service have been investigated. Following are the most important aspects and they will be emphasized by referring to the results of the study and to findings in recent literature.

20.1.2.1 Diagnostic Accuracy

Diagnostic accuracy was judged as the most important criterion at the overall ratings of the factors of influence of telepathology's success at this study (mean of 3,74[121]). Non-users rated this criterion significantly higher in its meaning than users did. Also. older pathologists and pathologists with a rather skeptical attitude towards new technologies rated the meaning of accurate macro- and micro-examinations higher than their younger, technology-interested colleagues did. Another significant difference occurred in the judgements of static and dynamic non-robotic system users, who emphasized the need of accurate diagnostic procedures more urgently than their colleagues who use a dynamic robotic system. When asking participants to give the reasons for the rejection of telepathology systems by colleagues, the fear of inaccurate diagnoses was also set on the highest place. At the judgement of the advantages and disadvantages of telepathology systems the values related to diagnostic accuracy laid in between of all criteria, that is, participants recognized aspects where diagnostic accuracy and quality will improve due to telepathology (e.g., fast second opinion consultations in uncertain cases), but there is also a fear that diagnostic accuracy will be diminished due to the various accuracy problems, which were described in chapter 16. These results confirm the findings of the ANARAD study in radiology, where also factors concerning diagnostic accuracy (e.g., complete availability of case information and satisfying image quality) were seen as significant aspects for a high acceptance. In addition, the increased number of accuracy studies executed by users of telepathology systems further underline that pathologists recognized the importance of high diagnostic accuracy (see appendix VI).

Yet, considering the overall situation, the risk of inaccurate diagnoses can be kept very low since if there is any uncertainty about what is being seen at the video screen, a diagnosis could be deferred until the glass slide is viewed directly. Doing so, even with limited equipment or with a less experienced person at the client's side, the risk of an inappropriate diagnoses could become strongly diminished. Of course such a behavior will increase the amount of deferred diagnoses, yet this is more acceptable than diagnostic errors. The more

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[121] (scale: zero = no influence, not important; +4 = very important, huge influence on telepathology's success).

'tele'-experience the clients and consultants gather, the more fluent and secure diagnostic processes will be run and the more uncertainty will decrease.

There are some areas, where final diagnoses are more difficult to define (see chapter 16.2.1) than in the case of other fields, like for example tumor cells of breast cancer have proved to be easily diagnosed by telepathology. That is why it is recommendable that both sides (client and consultant) are experienced in pathology and aware about the problems of their sub-specialty.

Since the results of the study showed that there is a fear of inaccurate diagnoses due to telepathology, pathologists should be informed about the real risk and about what behaviors diminish it. In doing so, the advantages one can gain with telepathology should be emphasized to non-users, especially the ones which relate to the improvement of diagnostic accuracy (e.g., fast access to a second opinion of a highly specialized pathologist). If a system will be introduced, well designed educational and training programs should make telepathologists sensitive about various sources of diagnostic errors and train them to execute accurate diagnoses on the screen. Analyzing the main reasons of diagnostic inaccuracy in telepathology, not enough training and experience in handling the tele-features, and errors in tissue handling (macroscopy) and in the field selection (microscopy) occurred on the highest places (see chapter 19.4.1). Users of static systems further emphasized the insufficient availability of case information significantly higher as a reason for diagnostic inaccuracy than users of dynamic-robotic systems. To diminish the risk of inaccurate diagnoses, a risk management system could be introduced as it was described in chapter 15.1.2 and 15.9.

20.1.2.2 Quality of Equipment

Another factor that was rated very high at the judgement of the factors of success (place two of the overall ratings, overall mean of 3,52) is the quality of the employed equipment; medical equipment (e.g., microscope), computer equipment, as well as the network connection. The quality of monitor images (resolution, color, contrast) especially was emphasized as extremely important (place one at the ratings of the factors of success). That it is a huge difference whether a static or a dynamic-robotic system is employed as already described in detail. Which system is most appropriate for the user is dependent on the specific situation and expectations of the users. It depends on factors like the equipment already available, the tele-services which should become acquired or offered, the personal expertise which is available at the place, and other aspects which were discussed in chapters 10 to 16. To meet user's needs, users have to be involved in the selection process.

Often it is to recommend to start small and then to expand the system the more the users become familiar in integrating it into the daily working routine. To avoid a wrong decision some participants of this study would appreciate systems, which are modular. This way they would be able to start with a cheap static system to later expanding it with dynamic-robotic features if desirable.

The quality of the network such as speed, security or stability was seen as vital for the success of telepathology, too (place eight and nine of thirty-nine factors). Especially users of dynamic-robotic systems who execute real-time frozen section examinations claimed stabile networks and a fast image transfer. That is that the selected equipment has to be suitable to the available network capacities. Fortunately, the recent developments in digi-

tization and data-compression technologies allow transmission of the enormous amount of information needed for video with much less bandwidth and lower cost, so that affordable transmission of full-motion, moderately high-resolution, color audio-video images over long distances is possible. Improved technology slowly relieves the bottle-neck problem of network capacity of the past.

Another important area of telepathology success was seen in system design and user-friendliness of the interface (place twelve of the 39 factors of success). Especially the flexible image handling process (orientation, focusing, illumination, rotating the objective lenses) was emphasized as important (place five). That systems have to be as simple and as flexible as possible to win acceptance was confirmed by other research studies, too. They have to meet the needs of practitioners and support the working process of tele-physicians. In addition, smooth and secure data storage, long-term archiving and record tracking have to be guaranteed. Participants further remarked that they would appreciate the availability of competent user support and advisory desks.

Considering the overall situation, most of the available equipment on the shelf has an acceptable performance for telepathology. For the users it is vital to match the equipment with their specific needs, and with the financial and human resources being available.

20.1.2.3 Legal Clarity

Behind the judgements of diagnostic accuracy and equipment quality, legal aspects got the third highest rating of their meaning for telepathology's success (overall mean of 3,26). Also at the judgement of the disadvantages, legal uncertainty was set on place one, and at the rating of the reasons for colleagues rejection of telepathology, legal uncertainty got the second highest value. Again, these high ratings are confirmed by many comments in the literature and also at the ANARAD study 'clear liability' was seen as one of the most important arguments for teleradiology's success. Analyzing the legal situation of participating users, interestingly the legal responsibility rather remains at the client's side if static systems are employed, handled by a pathologist at the client's side. Yet, if a dynamic-robotic system is used, handled by a surgeon at the client's side, in most of the cases the tele-expert is carrying the legal risk. As a consequence, especially the static users with a pathologist at the client's side rated the explicitness of legal liability regulations for telepathology's success significant high.

To overcome the problem of missing regulations for telepathology it is first of all to recommend employing the already available laws - if appropriate - to telepathology procedures. If there are still some areas which are not covered yet, there are several steps that could help to diminish the risk of being sued. First of all the insurance company, which covers the liability of the pathologist has be informed about the introduction of telepathology and asked concerning their coverage in the case of diagnostic errors or other tele-accidents. Second, tele-diagnoses and tele-consultations should be based on a written contract, which clearly defines the extent of liability for the client and the tele-expert. Third, if pathological examinations are executed by telepathology, the patient should be ask for his written permission. Fourth, to minimize liability in any case of uncertainty, the tele-expert should deny a diagnosis and wait until the direct glass slide examination is executed. And last but not least, well designed 'risk management strategies' could be introduced, as has been recommended in chapter 15.9.

In any case, since liability claims in medicine can be extremely high, the problem of legal uncertainty has to be taken seriously. It is hoped that national and international politicians will soon introduce regulations that clearly define the legal situation of telepathologist's. In addition, licensure regulations and overall quality control settings for telepathology services should be introduced. Since telepathology services aim to be international, it is desirable that such regulations are internationally valid.

20.1.2.4 Security Aspects

The fourth highest judgement of the participants related to telepathology's success was given to security aspects (overall mean of 3,33). Security fears were also estimated as important factors at the estimation of the reasons for colleagues rejection of telepathology.

Considering the single judgements of security criteria, system instability and data security were rated higher than the fear of unreliable systems (total break-downs) or of unauthorized data access. Especially if dynamic-robotic systems are employed, handled by a surgeon on the client's side, the meaning of reliable technology was rated significantly high. If frozen section examinations are executed, such surgeons are dependent on a fast result via network. Fortunately, system stability does not appear to be a problem at running systems how the investigation at this study proved. Most system interruptions occurred due to network instability or wrong system handling by less trained users. In summary, the interruption rate was far below 1%. Nevertheless, it is recommend that frequent system maintenance be executed and that an emergency plan be available in the case of a total system break-down. Fortunately, access security (access to rooms and systems) does not appear to be a problem, since pathologists mostly work at isolated departments and system access can be controlled by passwords.

Yet, participants recognize the problem of data security. Especially users of static systems, who also underlined the need of sufficient case data being exchanged between the client and the expert, emphasized the need of adequate data security measures and data protection regulations. That is understandable, since the confidence between the physician and his patient is the basis of a satisfying treatment process and therefore all data of the patient has to be processed with respect to his privacy. What matters is the data transfer in open information and communication systems. That is why secure methods like cryptography should be employed. In addition, data should be made anonymous, or alternatively case and patient data could be sent separately, if possible. In parallel it is recommended that the patient is informed about his data being transferred via network. To overcome the fear of non-users, they have to be informed about the tools which are available to avoid loss or unauthorized access to pathological data. If data are used for research and education, the anonymity of data has to be guaranteed.

20.1.2.5 Standard and Compatibility

Now let's come to another aspect of telepathology's success, system compatibility and the utilization of standards. Participants set this factor on place five in the overall meaning for telepathology's success with an overall mean of 3,05. Standards are needed for a smooth communication between systems and to avoid that users invest in isolated solutions, restricted to certain partners with exactly the same system. Non-users rated this factor significantly higher than users did. If a new user wants to integrate a telepathology system, he may wish to communicate with many experts without being restricted by the system.

Non-users are tired of system incompatibility and redundant data keeping, which always demands additional effort. Participants of this study further suppose missing standards as a reason that colleagues did not introduce the actually available systems. Considering the ANARAD study, 'compatibility' was seen as one of the most important aspects in teleradiology, too. Also, in recent literature, compatibility and standards are emphasized as urgent issues in telemedicine (see chapter 14).

At the study in Constance the meaning of standardization and system integration was analyzed in relation to specific characteristics of participants. Pathologists who are rather specialized emphasized the need of system compatibility significantly more urgently than general pathologists. Such pathologists are likely to be more positive about cooperation than their colleagues, since they may wish to distribute their specialized know-how via networks and to communicate with other experts to discuss rare and difficult cases. They are often located at medical centers with more than two pathologists at the place. Since medical centers are frequently involved in scientific research and in the test of new technologies (e.g., the telepathology user Zablocki VAMC in Milwaukee, Wisconsin/USA, is well known for its scientific pioneer work) the barrier of employees towards new technologies is lower compared to the average pathologist. Therefore, such specialists seem to be less reluctant in employing electronic medical records and to store their cases at a central case archive. Yet again, this is only possible if standards are available. Analyzing existing system it was discovered that users of static systems with a pathologist at the client's side also rated the need of standards significantly higher than users with dynamic-robotic systems with a surgeon on the client's side. This rating difference is likely to be caused by the intention of users. Users with a surgeon client are focused on the delivery of pathological services to remote locations, whereas client pathologists may wish to increase the communication and overall quality in pathology.

Investigating the situation of already existing systems of participating users of this study, the employed telepathology system is only rarely directly connected with other internal systems and telepathology is often restricted to certain partners due to organizational, but first of all due to technical difficulties. This is especially obvious if dynamic-robotic systems are employed, which are often dependent on a specific system and microscope supplier.

To overcome incompatibility it is important to employ the already available standards or to adapt them to telepathology. If no standards are available at all, international committees should set them up. In doing so the standards used within the Internet communications could serve as a vital foundation since the Internet is designed for international data exchange. Further the developments in teleradiology could serve as a pattern since, for example, the American College of Radiology has already set up standardization guidelines for teleradiology applications. Considering standardization, one's view should not just be focused on common standards and protocols for communication, compatible equipment (software and hardware), or common data and image formats, but also on the standardization of disease classifications to make diagnoses internationally more consistent, accurate and comprehensive.

This way telepathology systems could be connected across national and international boundaries and guarantee a communication between pathologists independent of their location. On a long run, telepathology systems could be linked to comprehensive tele-health networks that could serve many functions. But not only external communication could be eased, but also the internal integration should be ensured to avoid unnecessary redundant

data processing. Therefore, when selecting and introducing telepathology systems, applications should fit to the already existing infrastructures if possible. Further, they have to be integrated and to support the overall workflow process of the pathologist, to be seen as a tool for the 'everyday' practice of current pathologists.

In summary one can say that standardization is still a concern for telepathology integration and that it would be desirable that international standards are set up and maintained, comparable with the activities in teleradiology.

20.1.2.6 Management Aspects

Management aspects were judged less important than other factors of influence (overall mean of 3,00, place eight of ten PCA-factors). Nevertheless, some authors of recent literature mentioned exactly this point as a reason for the rejection of their trial to introduce telemedicine services. At the study in Constance, participants who already have experience with computers and whose attitude towards new technologies is rather positive, emphasized the meaning of management aspects significantly higher than their colleagues. Such individuals, especially if they are located at huge departments at which resources (equipment and humans) have to be coordinated, are likely to have already experienced that good management at the system introduction and utilization process avoids trouble. The necessity of good management was also highly rated by users of dynamic systems. Such systems are more complex and therefore have to be carefully introduced and real-time sessions have to be thoughtfully coordinated.

Therefore, although the ratings of this study were low, it is to recommend that goals are defined early and that introduction plans are carefully established for not wasting money, misallocating resources, dashing expectations and duplicating efforts. Doing so it has to be analyzed what services are currently lacking and whether these weaknesses can be overcome by telepathology. In addition, users needs and strategic objectives have to be matched. To meet the user's needs again it is to underline, that users should be involved into the planning and selection process. Further, knowing that 'what makes sense today must not tomorrow' and being aware that telepathology technology continues to grow and change permanently, ongoing data collection, evaluation and accountability is from value. Another issue of management, which was mentioned as concern in interviews and which was set on place five at the ratings of disadvantages is the coordination of online sessions. Participants point at the fact that unproductive waiting times will cause frustration and that therefore real-time sessions have to be well matched. In summary, one can say, management itself may not lead to telepathology's success, yet it could help to avoid its rejection. This is confirmed by the experience of telepathology users, who rated the meaning of management factors significantly higher than their non-using colleagues.

20.1.2.7 Efficiency

In medicine there will always occur the discussion of 'how much improved health care is worth for the society'. That is that 'efficiency' of telepathology in general should not just be calculated by simple cost-benefit analysis but be seen in the wider context of 'health as a valuable product for each human individual', or at least efficiency should be regarded with respect to the whole health care delivery system and its overall processes.

However, the single health care provider first of all has to deal with positive balance sheets. That is why he has to optimize his cost/benefit ratio and to follow simple cost recovery and benefit issues - at least in the long run. The investigation of the factors of influence for telepathology's success showed that participants rated efficiency aspects much lower than the factors discussed before (overall mean of 2,95, place 9 of ten PCA-factors). This is in contrast to other judgements. At the rating of the disadvantages 'uncertainty of reimbursement' was set on place two and 'high investment costs' on place four. Especially pathologists located at doctor's offices rated the meaning of investment costs significantly higher than pathologists at medical centers. Such pathologists are a kind of entrepreneur dependent on a cost efficient workflow due to restricted budgets, whereas at medical centers often research money is available. This may also have been the reason for the high ratings of the meaning of efficiency at the assessment of the reasons for colleagues' rejection. Considering the assessments of the advantages, first of all advantages of telepathology are seen in improved quality (e.g., improved education and research, better communication and reduced isolation of physicians), and only second in efficiency. Structure and process efficiency improvements are higher rated than monetary aspects.

Considering the characteristic of participants in relation to efficiency, there occurred significant differences. Since telepathology systems are expensive, but services are often not reimbursed, cost amortization is rarely possible. Consequently improved quality in pathology is currently the main reason for telepathology's introduction. Yet such a situation telepathology is out of the question for small doctor's offices with limited budgets. In contrast, medical centers expect cost reductions and savings due to process efficiency and resource sharing. Examples are the reduced transportation and lower unproductive waiting times of the operation theatre with frozen section examinations via telepathology. Participants with a positive attitude towards new technologies such as telepathology as well as pathologists with a higher wish to cooperate with other institutions, recognize strategic advantages by employing telepathology. They expect telepathology to increase the amount of examinations of their department since telepathology is seen as a tool to improve the pathological quality and with this the reputation of the department. That such a niche strategy could become successful was proved in the example of the AFIP. In contrast, pathologists with a rather skeptical attitude towards telepathology point at the lack of reimbursement. In their opinion money will be wasted until this technology gains advantages.

A lot of comments in this study emphasized the main problem when referring to efficiency - the lack of reimbursement and consequently the problem of monetary cost amortization. A problem which also occurs at other telemedicine disciplines, for example the ANARAD study in teleradiology also recognized 'reimbursement' as an essential issue. Therefore, it is important that licensing and reimbursement policies recognize telepathology services as valuable to improve the quality and structures in pathology and that this quality is worth to be paid for. Otherwise telepathology will get stuck in a voluntary status.

Telepathology systems, especially robotic-dynamic ones are still very expensive. Therefore, the system which finally will be chosen should be matched with user needs and strategy settings. Cost efficiency calculations should include monetary expenses (investment, operational costs) as well as non-monetary costs (e.g., time spend to handle the system, effort due to structural changes, etc.). On the revenue side monetary returns and savings as well as strategic advantages have to be taken in consideration. For pathologists it is to recommend that they choose the method that can provide the desired clinical

outcome at the most reasonable value. That is, that they select the system which fits the best in cost and value.

20.1.2.8 Politics and Health Care Structures

Since in recent literature political factors and management decision were named as reasons for discontinuation of telemedicine projects, participants were also interviewed about this point. Finally, this aspect got an overall mean in its importance for telepathology's success of 2,44. The results showed that younger pathologists and pathologists with a positive attitude towards new technologies rated the meaning of acceptance and politics higher than their older colleagues with a rather skeptical attitude towards new technologies. Especially the influence of user's acceptance and of internal politics and top-managers' positive attitudes were judged as important. These factors were also rated significantly higher at participants of bigger departments and pathologists employed at medical centers. If such pathologists are not able to gain the acceptance of their directors and to prove strategic advantages on a long run, they have difficulties to introduce telepathology. That politics and acceptance have an influence on telepathology's success further was confirmed by the significant higher ratings of users compared to non-users.

In summary, participants recognized that politics as well as the support of projects by institution's decision makers have an influence on the success of telepathology's introduction, although this influence was rated lower compared to the other factors (overall mean of 2,44). It is the same with cultural, structural or geographical factors. Nevertheless, since at one robotic-dynamic system introduction trial in Switzerland as well as at one in Germany the missing support by the hospital manager was a main reason that the system had not settled down, it is to be recommend that if there is a wish to introduce a system, the top managers should be made positive about it. In addition, in Germany a negative statement of the 'German Medical Board of Pathologists' (appendix I) made many German pathologists skeptical if not negative about telepathology. And the restrictive 'reimbursement' policy of insurance companies also led to hesitation by pathologists. Therefore, although the meaning of political influence criteria got a secondary meaning its influence on telepathology's success should not be underestimated. Telepathology interested parties should try to win trust in telepathology and to change the negative mind of pathology committees, insurers and other health care politics.

That geographical and structural criteria were judged very low is also a surprise since many systems are exactly introduced at places which were geographically remote. Yet, geographical aspects may be included in efficiency judgement since with telepathology processes are much more efficient for remote users.

20.1.2.9 Human Factors

As many research studies proved, the introduction of new information technologies often causes fear by the people concerned. In the case of telepathology, pathologists have the fear of inaccurate diagnoses and reduced quality in pathology, the fear of inefficient working routines due to system interruptions or uncoordinated real-time sessions, the fear of lost jobs due to changed structures, or the fear of experts being overtaxed with simple cases due to the easy accessibility how the analysis of the disadvantages and the ratings of the factors of success showed. There was also the argument that the old method is sufficient (place four of the reasons for colleagues rejection of telepathology). Such comments reflect that

pathologists need information about the advantages and possibilities of telepathology. Their fears have to be taken seriously and paid attention. At conferences pathologists could be offered the possibility to come in touch with systems and to test them. System suppliers should match their system with users needs and involve them into the design. Users also have to be involved into the system selection and introduction process to identify themselves with the new system and to overcome the fears. To avoid frustration, the whole introduction process has to be well managed.

20.2 New Structures

Telepathology systems are on their way to conquer the desk of pathologists. In the field of education and communication telepathology is already regarded as a useful tool of the future. But the experience also showed that telepathology will advance diagnostics and quality assurance and by this enhance the overall quality of pathological services. Structures can be optimized since telepathology will improve the coordination and organization of available resources within the pathological delivery system more efficiently. This will not just reform the economic situation of the single pathological institution, but will also improve the efficiency of the whole health care delivery system.

However, the study proved that there are many barriers, reluctance and prejudices against telepathology. To increase acceptance it is important for physicians to understand the principles of telepathology and the method of image delivery. They have to know why this field has suddenly emerged from relative obscurity, where it may lead, and what benefits or pitfalls may exist along the way. Information, which answers the various questions of potential users is therefore very important. The study in Constance tried to analyze and to specify the most important aspects of telepathology's success, which should be considered if telepathology systems are to be introduce and utilized successfully. Factors such as accuracy, equipment quality, system compatibility, legal situation, management or political criteria were analyzed in detailed and discussed. Doing so it was emphasized that the selection of the most appropriate system should be carefully planed and matched with the specific needs of an organization. Pathologists have to be motivated to discover the advantages for their daily routines. Governments or pathology associations may support and coordinate the possibility to participate at pilot projects and field tests to suppliers, hospitals and physicians. Central information desks and emergency would also be valuable, if possible, 24 hours a day.

It is likely that the introduction of telepathology will led to a change of pathological processes and structures, since telepathology allows pathologists to do things differently and not only to do the same things faster. Just adding a system is not the solution, but it is the use of telepathology to change the way pathological services are organized and delivered. For example, with telepathology the knowledge of outstanding experts can become concentrated. Such superb knowledge bases of highly specialized tele-centers can be translated into deliverable services, since health care delivery organization of the future can use telecommunication-based management tools to move their high level specialized care and resources in an affordable way from the central knowledge bases out to the remote sides. This way the feeling of isolation of the personnel on rural institutions could become diminished, since new relationships can be created within the new developed integrated medical networks. This way telepathology is also likely to change the structures of the average pathologist. The technology trend suggest that within the next few years pathologists will be able to communicate with colleagues just by using a desktop

workstation or even a notebook computer in a mobile, wireless configuration. They can select interactive video and store-and-forward modes as needed. Simple, intuitive software shells could allow seamless access to pertinent patient records, pathology slides and other medical information, as well as to billing records. Instant access to on-line libraries of medical information, diagnosis and treatment algorithms, and patient instructional materials will be available. Referral to specialists and allied health personal could be done by computer-based scheduling. Patient information will be stored in archives that can be accessed by authorized medical personal anywhere in the world.

Considering the current situation, all these scenarios are at the beginning of realization. Yet, it is to assume that the more technology will improve and become cheaper the faster they will become reality. For the single pathologist it is to be hoped that telepathology proves to be a reliable and efficient tool for the daily support of their working routines and the difficult tasks they have to execute.

Investigation of the Critical Factors of Success in Telepathology – an International Comparison Study

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