

**Khat Use Patterns, Associated Features
Psychological and Neuropsychological
Problems in Counseling Seeking Student
Sample in Ethiopia**

**Dissertation zur Erlangung des akademischen Grades eines
Doktors der Naturwissenschaften**

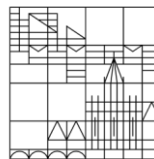
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Abstract

This dissertation focuses on identifying the challenges for khat and comorbid mental health problems among selected khat using Jimma university students in the southwest of Ethiopia. The study assesses the habit of khat use and associates it to alcohol use, motivation to change, neuropsychological and intelligence test results as well as to trauma and mental health symptoms including real and khat-induced psychotic symptoms. We conducted two studies using cross-sectional designs. The selected participants were a second year and above khat using students who were motivated to reduce or stop khat use. Results from this work can be steppingstones for planning interventional strategies.

In **study 1**, guided self-report assessment using tablet computers was employed to present standard psychological instruments: TLFB (khat), SRQ-20, PCL-5, LEC-5, AUDIT and SOCRATES. Moreover, socio-demographic, economic variables, and functioning problems due to mental health problems were assessed. The study intended to describe khat use, psychological problems, and motivation to change and to determine associated factors of khat use among Ethiopian university students who are seeking khat counseling. A convenient sample of 717 counselling-seeking khat using students participated in a cross-sectional study. Five hundred seventy-five participants' results were included into the final analysis. Translated versions of instruments were available in the two widely spoken languages (Amharic and Afan Oromoo) together with English. Participants had the chance to select preferred languages. The participants reported high alcohol and khat use. The AUDIT mean score was 15.79 ($SD = 8.45$), which is in the range of medium risk alcohol use. Scores above the cut-off of 8 (hazardous alcohol use) were reached by 47.1%. The sample showed high khat use in the past month ($M = 31.55$ bundles, $SD = 28.53$), 17% indicated as highly problematic khat use. The sample was extremely burdened with psychiatric and comorbid problems that is, 21.6% reported functioning

problems due to past mental disorder, 60.2% scored above the cut-off for current common mental disorders, 37.9% screened positive for PTSD. More than half of the respondents reported most traumatizing events on the PCL-5, including human-made and natural accidents, abuses, and loss of loved ones. The reported incidents happened either directly to participants or respondents witnessed the incidents. Motivation to change, measured by SOCRATES, indicated low scores in all three subscales. Small to medium intercorrelations between variables were detected, and in hierarchical regression models, higher motivation to change khat use was associated with higher use of the substance.

Study 2 investigated the relationship between neuropsychological executive functions and the amount of khat and alcohol use controlling for intelligence and psychopathology. Three hundred twenty-two khat using students of Jimma university were recruited in a cross-sectional study (data of 286 were included into the analysis). Screening using tablet computers for CMD, PTSD, alcohol use, khat use and trauma load and, furthermore trained counselors evaluated neuropsychological executive functions: Tower of Hanoi (ToH), Corsi block-tapping task (CBT), intelligence RAVEN's Standard Progressive Matrices (RAVEN's SPM) and psychotic symptoms (khat-induced or real) in a one-to-one session. The study revealed participants are regular and heavy khat users, in the 28 days before the assessment that is on average 29.0 standard units ($SD = 27.9$) and 14.4 use days ($SD = 8.64$). Participants experiencing psychotic symptoms 6 hours after khat use accounted for 25% of the sample. The results from the ToH and CBT assessment results were in a normal range. The neuropsychological executive cognitive functions and khat use were weakly related. Executive functions were not associated with alcohol use, trauma load and common mental problems but they were correlated with the intelligence test results.

The two studies revealed that Jimma university students are highly burdened with khat and alcohol use, trauma exposure, and psychological disorders. Despite of heavy substance use and extreme burden with comorbid psychiatric problems, executive cognitive functions seemed to be normal in the group. This is most probably related to the not yet chronic use patterns. Prevention and intervention strategies will have a good chance to reduce the negative impact of long-term khat use. Further research is required to develop programs that are practical. A particular approach is mandatory for female substance-using students. More validation studies are needed so that the psychopathological, neuropsychological and intelligence tests should have country- or East African-specific norms for interpretation. The results obtained from the studies will help to develop research instruments that can be used for screening purposes.

ZUSAMMENFASSUNG

Die Dissertation befasst sich mit der Identifikation von Herausforderungen von Khat und komorbiden psychischen Problemen bei Khat konsumierenden Studierenden der Universität Jimma im Südwesten Äthiopiens. Die Studie erfasst das Konsumverhalten von Khat und setzt diesen in Zusammenhang mit Alkoholkonsum, Änderungsmotivation, neuropsychologischer Diagnostik und Intelligenzdiagnostik als auch traumatischen Erfahrungen und psychischen Problemen wie (drogeninduzierten) Psychosen. Es wurden zwei Querschnittstudien durchgeführt. An den Studien nahmen Studierende ab dem 2.Studienjahr teil, die motiviert waren, ihre Khatkonsum aufzugeben bzw. zu reduzieren. Die Ergebnisse dieser Arbeit können Wegweiser für die Entwicklung von Interventionen darstellen.

In **Studie 1** wurde folgende psychologischen Standardinstrumente mithilfe von Tablets im angeleiteten Selbst-Bericht erfasst: TLFB (khat), SRQ-20, PCL-5, LEC-5, AUDIT und SOCRATES. Darüber hinaus wurde soziodemografische und ökonomische Variablen sowie durch die psychische Erkrankung verursachte Funktionsprobleme erfasst. Die Studie hatte das Ziel, Khatkonsum, psychische Probleme und Änderungsmotivation zu beschreiben und damit verbundene Faktoren bei Khat konsumierenden Studierenden, die sich in Beratung begeben hatten, zu bestimmen. An der Querschnittsstudie nahmen 717 Studierende teil, die Khat konsumierten und sich diesbezüglich in Beratung begeben hatten. Der finale Datensatz für die Analyse beinhaltete die Daten von 575 Studienteilnehmer:innen. Erhebungsinstrumente wurden in Englisch und zwei weit verbreiteten Sprachen (Amharic und Afan Oromoo) präsentiert. Studienteilnehmer:innen hatten die Möglichkeit, die Sprache frei zu wählen. Sie gaben hohen Alkohol- und Khatkonsum an. Der Mittelwert des AUDIT betrug 15.79 ($SD =$

8.45), was auf einen moderat riskanten Alkoholkonsum hinweist. 47.1% der

Studienteilnehmer:innen hatten Summenwerte über dem cut-off von 8 Punkten (riskanter Alkoholkonsum). Die Gesamtstichprobe wies einen hohen Khatkonsum im vergangenen Monat auf ($M = 31.55$ Bündel, $SD = 28.53$), 17% konsumierten in hoch riskanten Mengen. Die Stichprobe war durch psychiatrische und komorbide Probleme stark belastet, 21.6% berichteten von, durch die psychische Störung ausgelösten, Funktionsproblemen, 60.2% hatten Werte über dem cut-off für eine aktuelle psychische Störung, 37.9% erfüllten die Kriterien für PTBS. Mehr als die Hälfte der Teilnehmenden berichteten von schweren Traumaerfahrungen gemessen mit dem PCL-5, wie (menschlich verursachte) Unfälle, Misshandlungen und dem Verlust von Angehörigen. Diese Erfahrungen wurde entweder selbst oder als Zeuge erlebt. Die mit dem SOCRATES gemessene Änderungsmotivation war auf allen drei Subskalen niedrig. Die Variablen wiesen kleine bis mittlere Interkorrelationen auf. Eine hierarchische Regressionsanalyse zeigte einen Zusammenhang zwischen höherer Motivation, den Khatkonsum zu verändern und erhöhtem Substanzkonsum.

Studie 2 untersuchte den Zusammenhang zwischen neuropsychologischen exekutiven Funktionen und der Menge des Khat- und Alkoholkonsums, es wurde für Intelligenz und Psychopathologie kontrolliert. Für die Querschnittsstudie wurden 322 Studierende, die Khat konsumierten, rekrutiert (in die Analyse wurden 286 Studierende eingeschlossen). Anhand von Tablets erfolgte ein Screening auf CMD, PTBS, Alkoholkonsum, Khatkonsum und Traumabelastung, darüber hinaus bewerteten geschulte Berater:innen neuropsychologische exekutive Funktionen in Einzelsitzungen: Tower of Hanoi (ToH), Corsi block-tapping task (CBT), Intelligenz (RAVEN's Standard Progressive Matrices, RAVEN's SPM) sowie (Khatinduzierte) psychotische Symptome. Die Studie ergab, dass die Teilnehmenden regelmäßig und viel Khat konsumierten: In den 28 Tagen vor Erhebung wurden durchschnittlich

29.0 Standardeinheiten ($SD = 27.9$) konsumiert, die durchschnittliche Anzahl der Konsumtage betrug 14.4 ($SD = 8.64$). 25% der Stichprobe entwickelte sechs Stunden nach Khatkonsum psychotische Symptome. Die Ergebnisse des ToH und CBT waren im Normbereich. Neuropsychologische exekutive kognitive Funktionen und Khatkonsum wiesen einen schwachen Zusammenhang auf. Die exekutiven Funktionen hingen weder mit Alkoholkonsum, Traumabelastung und generellen psychischen Problemen zusammen, sie korrelierten jedoch mit Intelligenz.

In den zwei Studien konnte gezeigt werden, dass es sich bei den Studierenden der Universität Jimma um eine hoch belastete Gruppe mit Khat- und Alkoholkonsum, Traumaerfahrung und psychischen Störungen handelt. Trotz des hohen Substanzkonsums und der Belastung durch komorbide psychiatrische Probleme, wiesen die exekutiven Funktionen keine Auffälligkeiten auf. Grund hierfür könnte vermutlich sein, dass es sich bisher nicht um chronische Konsummuster handelt. Aufgrund dessen könnten vermutlich durch Präventions- und Interventionsmaßnahmen die negativen Auswirkungen des langfristigen Khatkonsums reduziert werden. Es ist weitere Forschung nötig, um praktische Behandlungsprogramme zu entwickeln. Insbesondere für weibliche Khatkonsumentinnen sind spezifische Ansätze

1.Preface

Khat leaves are consumed for centuries in the countries around the Horn of Africa (Krikorian, 1984). The leaves' main psychoactive ingredient is the amphetamine-like alkaloid Cathinone (*S-a-aminopropiophenone*), which resembles amphetamine in its chemical structure and is referred to as natural amphetamine (Kalix, 1990, 1992). Cathinone is highly concentrated in young and fresh leaves. When khat loses its freshness cathine and to a lesser extent, norephedrine become dominant; both alkaloids are less potent than cathinone (Zelger, Scho Rno, & Carlini, 1980). Cathinone is the reason for the preference for the young fresh leaves and stems, which are harvested in the morning and sold in bundles wrapped in false banana leaves to preserve freshness in the late morning (Valente, Guedes de Pinho, Lourdes Bastos, Carvalho, & Carvalho, 2014; Kalix, 1992). The production and consumption of khat in Africa and the Arabian Peninsula have increased considerably during the past decades and before khat leaves were not consumed for many centuries by the majority group of people (Odenwald et al.,2010). The largest khat producer is Ethiopia. During the past couple of decades, the substance's availability has increased enormously (Haile & Lakew, 2015).

According to WHO, khat is classified as a drug of abuse that can cause mild to moderate psychological dependency (Balint et al., 1991). Today more than 20 million people from Arabian Peninsula and Eastern Africa use khat in their day-to-day life (Teklie et al., 2017).

Among the reasons for the increment of khat trade and khat consumption are the advantages for farmers and small hold entrepreneurs (secure and stable income compared to other crops). Due to its contribution to the country's economy, most coffee-growing areas shifted the production of coffee and other cash crops to khat (Gebissa., 2008). However, today, the leaves constitute a concern from the health perspective (Odenwald & Al'Absi, 2017). Until the late 19th century, in Ethiopia khat was consumed only by the political elite, religious leaders,

and wealthy urban people of Harreri. The leaves lose their central stimulating properties with their freshness after two days, and that prevented the plant to circulate inside the country (Gebissa., 2008). The construction of the Ethio-Djibouti railway in 1902 accelerated the leaves' circulation without the loss of freshness after harvest time. As stated in the study by Miheretu et al. (2017), the chewing habit has changed over time. It is common these days to observe the younger generation using khat. It is still not typical to buy, hold or chew khat in public for women. According to demographic and health survey data (Haile & Lakew 2015), the overall 30 days prevalence of the khat chewing among the general Ethiopian adult population was 15.3%; with noticeable regional differences, Harrari had ranked first with 53.2% and Tigray regional state had the lowest chewing practice, which was only 1.1%. A study by Teklie et al. (2017) reported from 513 specified areas in Ethiopia and 10,260 households, that 19% of the respondents had chewed khat ever during their lifetimes and the current chewing rate at the study point was 15.8%.

In the following synopsis, a summary of the current knowledge on Ethiopian students' khat use habit will be presented, contextualizing the two studies. First, the prevalence rate of khat use in various universities will be reported and the related challenges will be discussed. Next, the relationship between psychological disorders, psychotic symptoms, and khat use will be discussed.

2.Theoretical background

2.1 Khat use habit among students

Several studies reported the growing khat use among Ethiopian students. One of the main reason's university students engaged in khat use is the wrong assumption: Khat use improves academic performance. Many khat-using students believe khat increased concentration and reduces tiredness (Abdeta, Tolessa, Adorjan, & Abera, 2017; Astatkie, Demissie, Berhane, & Worku, 2015a; Gebrehanna, Berhane, & Worku, 2014a; Reda, Moges, Biadgilign, & Wondmagegn, 2012). However, various research findings illustrate, the desired goals of better academic performance by using khat has never been achieved: A study with high school students in Sidama, an autonomous region in the southern part of Ethiopia, confirmed that the likelihood of performing below average or failing or scoring below 50% is twice as high for those students who were using khat than for those who were not (Kassa, Loha, & Esaiyas, 2017). The wrong assumption is confirmed by another study that compared the mean Cumulative Grade Point Average (CGPA) of khat users and non-users among 500 Jimma University students (Ayana & Mekonen, 2004); the study concluded that khat chewing is not helpful for better academic performance. Another study conducted among secondary school students in 11 colleges in the region of Jazan of Saudi Arabia revealed a higher risk of poor academic performance among students chewing khat (Al-Sanosy, 2009). Additionally, khat consumption is related to sleep problems among many Ethiopian college students, directly or indirectly impacting academic achievements (Lemma, Berhane, Worku, Gelaye, & Williams, 2014).

2.2 Khat use and psychological disorders

From various research findings, there is limited knowledge about khat use and its impact on mental health, but findings also pointed out the relationship between mood disturbance and khat consumption. A study by (Cox and Rampes, 2003) illustrated khat use could be associated with mental illness such as psychotic disorders and depression. The relationship between heavy together with early engagement in khat could be a marker for psychotic symptoms development. According to a critical review of khat use and mental illness from 1945-2006 (Warfa et al., 2007), four studies had reported a direct association of moderate and severe mental problems with the heavy consumption of khat. In contrast, twelve reports did not report any association between mental illness and khat consumption. The same study report signified khat users had more suicidal thoughts than non-khat users (Bhui et al., 2007). A community-based pilot study on outpatient treatment signified khat use was a risk factor for the development of psychosis. The data from the chronic psychotic patients explained the complex effect of khat use which induces psychotic symptoms or cause exacerbation of preexisted psychotic disorder (Odenwald et al., 2012). In another cross-sectional study that assess a psychological health outcome among 148 khat users and 150 non khat users in Yemen revealed the association of stress, sleep disturbance and anorexia were significantly higher among khat users. Moreover, sleep disturbance and anorexia were also significantly associated with stress (Ali et al., 2015). A cross-sectional study indicated khat use as a risk factor for the development of psychotic symptoms (Odenwald et al., 2005): Individuals with psychotic disorder were retrospectively compared to age- and gender-matched healthy controls in respect to their khat use; the former had commenced to use khat earlier in their life and at the age when they developed psychotic symptoms (8.6 years after khat use onset) they used it in larger quantities. The study further indicated that patients who showed psychotic symptoms had an excessive khat use pattern, which exceeded two bundles per day. In a study conducted among 330 khat-

using Somali refugees in Kenya (Widman et al., 2017), 22% (73) had at least one khat-related psychotic symptom. Khat Withdrawal symptoms are described as mild and occur after prolonged usage (Odenwald, Klein & Warfa, 2015).

As indicated in the introduction, Khat production and consumption are increasing. It is also easily accessible around the university campuses. A study at Jimma University revealed that 68% of khat-using students report withdrawal symptoms (Abdeta et al., 2017). Several studies also reported that khat using students use additional substances (Abdeta et al., 2017). A study by (Gebreslassie et al., 2013) revealed that psychoactive substances such as khat, alcohol, and cigarettes were current concerns among university students in Ethiopia.

Like other substances of abuse, chronic khat use causes a typical neuropsychological deficit syndrome (Odenwald, Klaiien & Warfa, 2015). According to (Ersche & Sahakian, 2007), visual-spatial span, working memory and problem solving are neuropsychological functions that can be impaired by chronic substance use. Amphetamine users showed a great degree of impairment in planning, pattern recognition, memory, and paired associated learning (Ersche et al., 2006). These functions were also impaired by chronic khat use (Colzato, Ruiz, van den Wildenberg, & Hommel, 2011). The result from multiple linier regression analysis with adjusted mean score for age, education, and interaction of group with age showed khat chewers performed significantly poor in 3 out of 14 neuropsychological subsets, namely: serial digit learning test, taps of non-performed hand and trial making (Ismail et al., 2014). The above studies indicated the association between substance use, chronic khat chewing habit and neuropsychological malfunctioning.

Since current khat use problems are escalating and no care system exists that addresses users' needs, various researchers called for preventive measures to reduce the use among students (Gebrehanna et al., 2014; Astatkie et al., 2015; Gebreslassie et al., 2013). The problem corresponds

to the increasing international knowledge of khat's dependency syndrome (Odenwald, Klein, & Warfa, 2015). Unaided quit attempts are often unsuccessful, as reported by a study at Adama Science and Technology Campus among regular khat-using students:

Only 7% maintained abstinence in the 28 days following an unaided quit attempt (Duesso, Bruno, Matthews & Ferguson, 2018); the authors call for studies to develop sustainable intervention tools for this group of users. In sum, there is a high need for research that develops and evaluates behavioral and psychotherapeutic intervention tools to reduce khat use among Ethiopian students (Odenwald & Al'Absi, 2017). Furthermore, such methods need to be adapted to the local context and to be sustainable.

3.Study 1

Khat use patterns, associated features, and psychological Problems in a counseling-seeking student sample in Ethiopia

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3.1 Abstract

Khat (*catha edulis*) is a traditionally used substance in African and Arab countries that contains the amphetamine-like alkaloid cathinone. Khat use among Ethiopian students is a growing concern. This study aims to describe khat use, psychological problems and motivation to change and to determine associated factors of khat use among Ethiopian university students who are seeking Khat counseling.

Methods: In a cross-sectional study, a counseling-seeking sample of 575 students from Jimma University, Ethiopia, who seek assistance to reduce khat use were recruited. The study used Amharic and Afaan Oromoo language versions of common psychological instruments and employed them as part of a comprehensive tablet computer-delivered self-report assessment battery, comprising the SRQ-20, the PCL-5, the LEC-5, the AUDIT, and the SOCRATES. In addition, socio-demographic, economic variables, and functioning problems due to severe mental disorders were assessed. The analysis used clinical cut-off values to describe this treatment-seeking sample and hierarchical regression models to determine variables associated with khat use.

Results: The sample showed high khat use in the past month ($M = 31.55$ bundles, $SD = 28.53$, on $M = 15.11$ days, $SD = 8.54$); 17.0% showed highly problematic use. The sample was extremely burdened with comorbid psychiatric problems, that is, 21.6% reported functioning problems due to past mental disorder, 60.2% scored above the cut-off for current common mental disorders, 37.9% screened positive for PTSD and 47.1% reported hazardous alcohol use. Small to medium intercorrelations between variables were detected, and in hierarchical

regression models, higher motivation to change khat use was associated with higher use of the substance.

Conclusions: This study clearly shows the need to develop research instruments, screening methods, and assistance services for khat using students at Ethiopian universities. The high mental health burden of study participants shows the need for targeted intervention programs that go beyond khat counseling. Furthermore, the study highlights challenges for the implementation of such services, i.e., the barriers to utilization for females and for khat users without comorbid mental health problems.

3.2. Introduction

The leaves of the khat tree (*Catha edulis*) are a traditional psychoactive substance that is deeply rooted in the cultural and religious practices of certain ethnic groups in parts of both Africa and the Arab Peninsula (Ethiopia, Kenya, and Yemen; Krikorian, 1984). Throughout the last century khat developed from a niche crop to a cash crop, its production became widespread across the whole region and consumption spilled over to the general population (Odenwald et al., 2010). The leaves are typically chewed for the mildly stimulating effects, mainly during social gatherings. Fresh khat leaves contain several psychoactive alkaloids of which the main psychoactive principle is cathinone, S (-)- α -aminopropiophenone (Kalix, 1992). Cathinone acts in the central and peripheral nervous systems in a similar way to amphetamine and humans experience its effect as euphoria, making them confident, alert, and focused (Wabe, 2011); that is the reason why it has been called “natural amphetamine” (Kalix, 1992). Khat use has been linked to numerous health problems (Odenwald and Al'Absi, 2017), it is legally banned in many countries outside the khat belt (Klein, 2014), and its increased production in the traditional use countries is discussed in the context of environmental challenges, income generation for small farmers, and food insecurity (Dessie, 2016). In general, in all traditional use countries, there is a controversial societal debate about the substance (Odenwald et al., 2010).

Khat use is a common practice in Ethiopia (overall 30-day prevalence rate 15.3%; Haile and Lakew, 2015) and especially among Ethiopian university students (23% on a national level; Gebrie et al., 2018). Previous studies with representative student samples from Jimma University found rates of 26% (Abdeta et al., 2017) and 25% (Ayana and Mekonen, 2004); in a sample with high school students, a prevalence of 16% was observed (Dires et al., 2016). The subjective positive effects on alertness and concentration increase the substance's attractiveness for high school and university students as well as young professionals to improve intellectual

performance (Gebrehanna et al., 2014; Mihretu et al., 2017). But the currently 80 available evidence from cross-sectional studies points into the direction that students' khat use is related to worse academic performance (Ayana and Mekonen, 2004; Abdeta et al., 2017; Kassa et al., 2017) and higher mental distress (Dires et al., 2016; Kerebih et al., 2017b). Several studies found increased rates of depression, posttraumatic stress disorder, or common mental disorders (CMD) among khat users (e.g., Widmann et al., 2017; Bahhawi et al., 2018; Yitayih et al., 2019). Studies with representative samples from Jimma town revealed a prevalence of

CMD among the general population of 25.8% (Damena et al., 2011) and 33.6% (Kerebih and Soboka, 2016) and among medical students of 35.2% (Kerebih et al., 2017b); in all three studies, CMD was positively associated with khat use. A recent meta-analysis (Mekuriaw et al., 2020) found a pooled prevalence of CMD among Ethiopian students of 37.73% (95% CI: 30.43, 45.03) and a clear association to khat use (*OR* 2.01; 95% CI: 1.38, 2.95). Excessive khat use is related to the development of an addiction syndrome (for a review see Odenwald et al.,

2020). A study conducted in the psychiatric wards of Amanuel and St. Paul hospitals (Addis Ababa, Ethiopia) by Fekadu et al. (2007) revealed that the most common substance of abuse among psychiatric patients is khat (21%). Several studies revealed that khat use in Ethiopia is associated with the use of other substances, especially alcohol (e.g., Teklie et al., 2017; Yitayih et al., 2018), and that khat users with mental distress used alcohol more often to cut down stimulant effects of Khat (Damena et al., 2011). Furthermore, khat use has been associated with the occurrence of psychotic symptoms and disorders (for review see Odenwald, 2007). It is unclear whether khat users seek psychological assistance or counseling because of their khat use as it seems that users reject assistance (Kerebih et al., 2017a; Odenwald and Al'Absi, 2017).

Currently, the prevalence of mental problems among khat users who look for psychological assistance is unknown. Because khat use has been linked to mental distress, we want to expand the scope of

research by studying khat use and psychological health in a sample of university students who are actively seeking khat counseling (in the context of our study, we offered khat counselling that otherwise did not exist). This study aims to get further information on who is seeking psychological assistance, information that is useful for the planning of counseling services. In addition to describing a treatment-seeking student sample in detail, we hypothesize that the severity of khat use is related to (1) the severity of comorbid mental health problems, alcohol use, and trauma load as well as (2) to a higher level of motivation to change khat use.

3.3. Methods

Study location

The study was conducted at Jimma University, which is located in the southwestern part of Ethiopia. The university has been established in 1952, the number of students is currently 42,000, the number of staff members 2,600. It is one of the countries 's largest institute of higher education. Currently, the university consists of four different campuses located in different parts of Jimma town. Jimma is located in one of the country's traditional khat growing regions with above-average use of the substance (Haile and Lakew, 2015).

Study design and sampling

Using a cross-sectional design, the study included a convenience sample of khat using Jimma University students of the second study year or higher who wanted to reduce or stop their khat use and who had a strong interest to use a free counseling service to support them to achieve this goal. We excluded first-year students because khat use onset is often during university education (Abdeta et al., 2017). This study served as a preparatory study for a randomized controlled trial and had the aim to screen and recruit participants. The recruited subjects should be considered a treatment-seeking sample.

Recruitment, study procedures and participants

Using information leaflets that were distributed with the assistance of student committees in the different campuses and that informed potential participants about study purposes (i.e., a study on khat counseling) and selection criteria (i.e., student status at JU, second study year or higher, having used khat in the last month, motivation to reduce or stop khat use). Potential participants were invited to take part in a brief preparation workshop in which detailed

information on the study was given. Participants who gave informed consent were admitted to the screening assessment. The screening was a detailed self-report that was implemented with tablet computers using the assessment software Qualtrics (<https://www.qualtrics.com>).

Participants did not report their names in the electronic assessment but received a code (pseudonym). After a brief individual instruction, participants worked on the tablets on their own, sitting in a classroom with up to ten others who also completed the assessment; if needed, they received assistance from a supervising staff member who was present in the classroom but did not see the participants' data entry. Instructions, questions, and predefined answers were either presented in Amharic, Afaan Oromoo, or English; participants selected their preferred language from these possibilities. The assessment took on average 45 min. Participants were reimbursed for their expenses for public transport and they received a lunch voucher in case they missed their university-provided lunch because of the assessment. The screening took place from November 5, 2018, to November 23, 2018. In total, 717 subjects

(708 males and 9 females, i.e. 98.7 % vs. 1.3%) decided to participate in the screening. $N = 575$ could be included in our analyses. We excluded all females to be able to interpret results clearly because, in the Ethiopian societal context, khat use among women has to be considered a distinct phenomenon to male khat use (Mihretu et al., 2017) and the small number of female participants did not allow for any analysis of potential gender differences. In line with our recruitment criteria, we also excluded all first year and non-regular students ($N = 13$ and $N = 3$, respectively) that took part in the screening. In addition, we excluded 65 students because they did not report any khat use the previous month, 15 students because they reported in review extreme amounts of khat use that were implausible (see below the definition of extreme cases), and 37 students because they had left out three or more items in one or more of the questionnaires (for more information see below section *statistical procedure*). The average age of participants was 22.1 years ($SD = 1.58$; ranging between 17 and 28 years). The median reported study year was 4 (M

= 3.46, $SD = 1.05$). The participants belonged to the following faculties, colleges, and departments: 362 (63.0%) participants were from the Institute of Technology, 64 (11.1%) from the Faculty of Natural Sciences, 58 (10.1%) from the College of Business & Economics, 45 (7.8%) from the Faculty of Medicine and Health, and 46 (8.0%) from Law, Social Science, and Humanities. Participants selected the following languages to fill the questionnaires: 365 (63.5%) Afaan Oromoo, 197 (34.3%) Amharic, and 13 (2.3%) English. Students described their monthly income as follows: 59 (10.3%) participants had less than 100 Ethiopian Birr, 152 (26.4%) students indicated 100–300 Birr, 146 (25.4%) of them 301–500 Birr, 104 (18.1%) indicated 501–700 Birr, 49 (8.5%) of them 701–900, and 46 (8.0) participants said they had more than 900 Birr; 19 (3.3%) participants were not willing to give information on monthly income. At the time of the study, 100 Birr was approximately \$3.50. The mean cumulative grade point average was 3.01 ($SD = 0.44$, ranging between 1.63 and 3.89).

3.4 Instruments

All instruments and manuals had been made available in the two widely spoken languages in the region as well as inside the campuses (Afaan Oromoo and Amharic) and in English. If validated versions of the instruments had not been available, we used a combination of the back-translation standard and the committee approach to develop the missing versions (van de Vijver and Tanzer, 1997): To do this, instruments were first translated and then independently back-translated; additionally, an international committee of Ethiopian and German scholars discussed the properness of the translated and back-translated contents, comparing it to the original versions of the instruments and modifying it, if necessary; at last, the instruments and the conceptual correctness of their translation were again discussed during the training of local counselors who learned to apply the instruments in a standard way by role plays and supervised field tests and adapted if problems emerged.

Severe mental and neurological disorders

We assessed severe functioning problems caused by psychiatric and neurological disorders with a series of questions that had been validated and used in previous research in the region (Odenwald et al., 2005): *“Have you ever been unable to work, go to school, or fulfill your household or childcare duties for at least 4 weeks because of mental or nerve-related problems?”* “If the participant answered yes, the follow-up questions were *“Have you been unable to work, go to school, or fulfill your household or childcare duties because of mental or nerve-related problems in the last four weeks?, “Have you ever sought assistance from a counselor, medical doctor, priest, sheikh, or healer because of mental or nerve-related problems?”* and *“Have you*

sought for such assistance in the last 4 weeks?" We used the first question to screen for the lifetime presence of any mental disorder.

The Timeline Follow Back (TLFB)

The *Timeline Follow Back* (TLFB) method is a well-validated and frequently employed calendar-based self-report assessment originally developed for alcohol use but appropriate for other substances, too (Robinson et al., 2014). It has been validated in cross-cultural studies (Sobell et al., 2001). In previous research projects in the Jimma region, the TLFB was adapted and used for the assessment of khat and alcohol (Adorjan et al., 2017). For this study, participants used the TLFB calendar to report the consumed standard bundles of khat as well as days with khat use in the last 28 days before the assessment. Standard units of different khat qualities had been determined beforehand by a local expert committee using a market survey and consensus discussions as outlined by Widmann et al. (2014). Respondents received descriptions and photos of the different standard units. As a common definition of problematic khat use does not yet exist (Mihretu et al., 2017), we used the quantity of consumption as a marker for highly excessive khat consumption. In previous studies, a khat use of two or more bundles a day (Dhadphale and Omolo, 1988; Odenwald et al., 2007) was a marker for problematic khat use. Here we used 56 or more bundles of khat in 28 days (i.e., on average, two or more bundles per day) as a marker for highly problematic khat use.

The Alcohol Use Disorder Identification Test (AUDIT)

The Alcohol Use Disorder Identification Test (AUDIT) (Barbor et al., 2001) is a brief screening instrument with 10 items developed by the WHO to identify individuals with problematic alcohol use. A sum score of 8 and above is recommended as the cut-off for hazardous and harmful alcohol use; scores of 8 to 15 are interpreted to represent a medium-level and scores of

16 or above a high-level alcohol problem. An Amharic version had been developed by Gebrehanna et al. (2014) and was tested with a sample of Ethiopian university students. We developed an Afaan Oromoo version and found good Cronbach's alpha coefficients for the three language versions of the instrument (Amharic; $\alpha = .77$; Oromoo: $\alpha = .81$; English: $\alpha = .81$).

Symptoms of common mental disorders (CMD)

The 20-item version of the *Self-Report Questionnaire* (SRQ-20) which was developed by the WHO (Harding et al., 1983) comprises 20 simple questions that need to be answered in a "yes" or "no" format. A validated Amharic version of the instrument exists (Hanlon et al., 2008) and an Afaan Oromoo version was developed in one of our previous studies (Adorjan et al., 2017). The instrument had been used to screen for CMD among JU students with the frequently used cut-off score of 7/8, identifying a proportion of 35.2% (Kerebih et al., 2017b). The Cronbach's alphas for the three language versions of the SRQ-20 in our study reported were good to excellent (Amharic: $\alpha = .90$; Afaan Oromoo: $\alpha = .90$; English $\alpha = .71$).

Traumatic experiences

To assess traumatic experiences, we used the Life-Event Checklist (LEC-5), a well-validated instrument that assesses 17 types of potentially traumatic experiences (Gray et al., 2004). Respondents report whether each item happened to them personally, whether they witnessed that it happened to somebody else, whether they learned that it happened to a close person, or whether it is part of their job. Simplified Amharic and Afaan Oromoo versions of the instrument, that just asked in a single item whether each event type has ever happened to the respondents personally, whether they have ever witnessed it happen to somebody else, or whether this experience had been part of their job had been used to assess traumatic experiences in a previous study (Adorjan et al., 2017). We also used the simplified version in English.

Trauma load was calculated by summing up the event types that had been experienced, witnessed, or had been part of the job. In our study, the Cronbach's alpha for the simplified

LEC-5 in the three languages were good (Amharic: $\alpha = .87$; Oromo: $\alpha = .89$; English: $\alpha = .88$).

Posttraumatic Stress Disorder (PTSD)

The PTSD Checklist (PCL-5) is a well-validated self-report instrument to assess symptoms of Posttraumatic Stress Disorder that has recently been adapted to the criteria of DSM-5 (Bovin et al., 2016). The instrument asks respondents to indicate and categorize the most distressing event and asks for the intensity of 21 symptoms in the last month. Amharic and Afaan Oromoo versions of the instrument had been developed for this study. For screening PTSD, a cut-off score of 32/33 is recommended (Bovin et al., 2016). Cronbach's 257 alpha of the three language versions used in our study can be considered good to excellent ($\alpha > 0.80$). The Cronbach's alpha coefficients for the PCL-5 subscales in three languages were good to excellent, with coefficients ranging from .83 to .97.

Motivation to change khat use

The Stages of Change Readiness and Treatment Eagerness Scale (SOCRATES (Miller and Tonigan, 1996)) is an instrument that assesses the motivation to change substance use and is closely related to the transtheoretical model of behavior change (Prochaska and Velicer, 1997).

This theoretical approach had recently been used in Ethiopia and has been found applicable in Ethiopian culture (Girma et al., 2010). The SOCRATES consists of 19 items (Likert scale from 1 "strongly disagree" to 5 "strongly agree") and three subscales: Recognition (7 items; high scores mean respondents acknowledge problems with substance use, low scores that they deny problems with substance use), Ambivalence (4 items; high scores reflect more

Ambivalence, low scores more certainty; this subscale should be interpreted in relation to Recognition), and Taking Steps (8 items; high scores mean that respondents already started to change substance use behavior, low scores mean inactivity regarding change). For this study, the questionnaire was translated and adapted for the assessment of motivation to change khat use and versions in Amharic and Afaan Oromoo were developed. We used the original wording and replaced the word “drug” with the word “khat”. We found good to excellent Cronbach

’s alpha for two subscales in the three different languages: Recognition Amharic ($\alpha = .799$), Afaan Oromoo ($\alpha = .798$), and English ($\alpha = .748$); Taking Steps Amharic ($\alpha = .860$), Afaan

Oromoo ($\alpha = .820$), and English ($\alpha = .858$). The internal consistency coefficients of

Ambivalence ranged between poor and acceptable, Amharic ($\alpha = .573$), Afaan Oromoo ($\alpha = .603$), and English ($\alpha = .477$). This mirrors the results of Miller and Tonigan (1996) who also found the Ambivalence subscale the least internally consistent. In the English version, the deletion of item 6 (Ambivalence subscale, “Sometimes I wonder if my khat use is hurting other people”) would have increased Alpha to .750. Because of the small number of participants who filled the questionnaire in English we used all items in the analyses. For the interpretation of the results, we use the guidelines provided by Miller and Tonigan (1996) that are based on the results of the Project MATCH with alcohol users, for instance, we used the reported median scores to define groups of subjects with high and low values in each of the three subscales.

Academic performance

The participants' academic performance was assessed asking for the cumulative grade point average (CGPA) of the previous study year as it has been frequently done by other studies (Ayana and Mekonen, 2004).

Ethics

The Institutional Review Boards of Jimma University (Ethiopia) and the University of Konstanz (Germany) approved this study. Informed consents were prepared, translated, and back translated in Amharic and Afaan Oromoo, and participants were only included in the study after they had read, agreed, and signed the translated informed consent according to their language preferences. The study was part of a trial with the registry number NCT03730805.

Statistical procedure

SPSS 25 had been used to analyze the data. For statistical testing two-tailed $\alpha = 0.05$ was used. Outliers were identified by the procedure suggested by Hoaglin and Iglewicz (1987): Any score greater than the upper quartile plus 1.5 times the interquartile range was identified as an outlier and any score greater than the upper quartile plus 3 times the interquartile range was identified as an extreme case (Field, 2013). Therefore, reporting consumption of more than 143 khat bundles in 28 days was defined as an extreme case, and based on that 15 participants were excluded from the study. Because statistical pre-requirements of multiple imputation techniques were not given in all the self-report instruments (some individuals had left out a high number of items), we adopted the following procedure: all participants were excluded from data analysis who had left out more than two items in the same self-report instrument; for the remaining cases, missing items were replaced by the respective scale mean. Differences between categories of participants were tested with one-way ANOVAs or t-tests (when variances were not equal: Man-Whitney U tests). The relationship between khat use measures (days of khat use in last 28 days and bundles of khat used in the last 28 days) with psychopathology, trauma load, alcohol use, and motivation to change was computed with the non-parametric Spearman rank-order correlation coefficient because of deviations from normality (Kolmogorov-Smirnov and Shapiro-Wilk tests with $p < .001$). Linear regressions were used to identify predictors of the two

khat use variables (bundles of khat and days with khat use in the past 28 days). The assumptions for linear regression were tested: normality was checked using the Kolmogorov-Smirnov and Shapiro-Wilk tests and inspection of QQ-plots for khat bundles, AUDIT, SRQ, LEC, and PCL. The results show that normality cannot be assumed ($p < .001$). Homoscedasticity was assured by visual inspection of scatter plots of residuals. We found no sign of Multicollinearity ($VIF < 2.16$, Tolerance $> .46$). Cook's Distances revealed no highly influential cases (values ranged between .39 and .12) Because of the high number of participants and because of the robustness of the method we decided to use linear regressions despite violations against assumptions. In Step 1, we entered the independent variables age, CGPA, and AUDIT. In Step 2, we entered the sum scores of the SRQ-20, the PCL-5, and the LEC. In Step 3, we entered the three subscales of the SOCRATES. For each step, we calculated the goodness-of-fit for the overall model using the Akaike information criterion (AIC) and calculated R^2 and adjusted R^2 . Finally, we used an automated stepwise procedure to remove non-significant predictors from the model using the F value ($p > 0.10$) to establish a final model.

3.5. Results

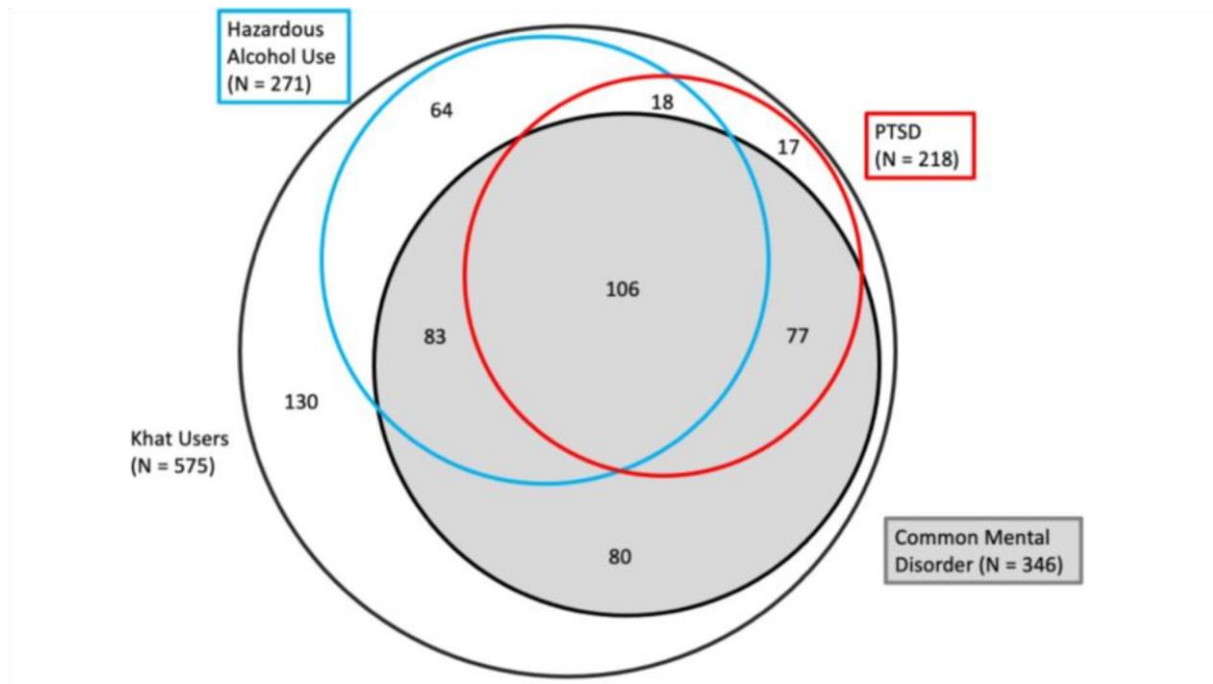
Descriptive analysis

The sample consumed an average amount of 31.55 standard khat bundles ($SD = 28.53$) in the 28 days before the assessment; in this period, khat use was practiced on average on 15.11 days ($SD = 8.54$). Based on the criterion described above, 17.0% ($N = 98$) of the participants showed a highly problematic khat use. Of the 575 participants, 124 (21.6%) reported that there was a time in their lives when they were unable to work, go to school, or fulfill household or childcare duties for at least 4 weeks due to mental or nerve-related problems; of them, 103 (17.9% of the total sample) reported the problem persisted in the last 4 weeks. Ever in their lives, 137 (23.8%) sought assistance from a counselor, medical doctor, priest, sheikh, or healer because of mental or nerve-related problems; of them, 60 (10.4% of the total sample) sought such assistance in the last 4 weeks. Because they had no medical support yet, 64 participants (11.1%) were directly referred by our study team to the university's student clinic. In the LEC-5, on average 5.54 ($SD = 4.56$) types of potentially traumatic experiences were reported. In the PCL-5 a most severe traumatic event was reported by 343 participants. Of them, 135 reported car accidents, 91 sexual, physical, or emotional abuse, 39 deaths of close family members, 35 war and violence, 29 fire accidents, 7 indicated to have witnessed a peer suicide, and 7 experienced a natural disaster. Furthermore, 73 students reported that the stressful event happened directly to them, while 115 students reported that they had witnessed the situation and in 89 cases, it had happened to close family members or friends. Seventeen students reported the stressing incidents have happened in the context of their profession (e.g., paramedic, military, police).

Taken together, the PCL-5 sum 359 score was on average $M = 27.57$ ($SD = 19.88$); 37.9% ($N = 218$) qualified for a positive screening result for PTSD. The AUDIT sum score in the total sample reached a mean of 9.20 ($SD = 10.11$). Among all participants, 240 students (41.7%) reported no alcohol use in the last month; among the last month alcohol users, on average, the

mean AUDIT sum score was 15.79 ($SD = 8.45$), which is in the range of medium risk alcohol use. Scores above the cut-off of 8 (hazardous alcohol use) were reached by 47.1% ($N = 271$) of all respondents. Based on their scores, participants with hazardous alcohol use were grouped into the two severity categories follows: 100 students (17.4% of all participants; $M = 11.14$, $SD = 2.37$) showed a medium level and 171 a high-level alcohol problem (29.7% of all participants; $M = 22.76$; $SD = 5.10$). The mean value of the SRQ-20 sum score (symptoms of Common Mental Disorders, CMD) was $M = 9.81$ ($SD = 5.54$) which is above the cutoff point of 8. In total, 60.2% ($N = 346$) of respondents screened positive for CMD. Of those who screened positive for CMD, 183 (i.e., 31.8% of the whole sample) also screened positive for PTSD, 189 (i.e. 32.8% of the whole sample) also screened positive for hazardous alcohol use and 106 (i.e. 18.4% of the whole sample) also reported a lifetime functioning problem due to a mental disorder. The overlap of the three different bivariate categories of mental health problems among khat users (based on screening by SRQ-20, PCL-5, and AUDIT) in our sample is displayed in Figure 1. Only 22.6% ($N = 130$) did not score positive in any of these categories; 28.0% ($N = 161$) scored positive in one category, 30.9% ($N = 178$) in two, and 18.4% ($N = 106$) in three.

Figure 3-1 : Venn Chart, displaying the overlap between groups of cases screening positive for Common Mental Disorders (CMD), PTSD hazardous alcohol use among 575 students seeking for counselling because of their khat use (areas in the chart are approximately proportional to the size of the respective subsample)



In the Stages of Change Readiness and Treatment Eagerness Scale (SOCRATES-khat), respondents' average score for Recognition was 24.88 ($SD = 5.9$; "very low" according to Miller & Tonigan, 1996), the average score for Ambivalence was 13.74 ($SD = 3.41$; "low"), and the average score for Taking Steps was 26.94 ($SD = 7.04$; "low"). According to the original authors' guidelines and based on the US norms, 88.7%, 54.3%, and 76.5% of participants scored below the median (low magnitude of the motivational component) for the subscales Recognition, Ambivalence, and Taking Steps, respectively. The interpretation of the Ambivalence score is only possible in relation to Recognition, that is, 302 subjects scored low in both subscales (52.8% of the total group), and 10 subjects with low Ambivalence scored high in Recognition (i.e., 1.7%).

Bivariate associations between variables

Bivariate correlations between variables are reported in Table 1. Khat use variables showed weak to medium associations to measures of trauma and psychopathology as well as small associations to motivation to change. However, using on average two or more bundles per day, that is, problematic khat use, was associated with more reported traumatic experiences (LEC, $M = 5.7$, $SD = 4.5$ vs. $M = 6.8$, $SD = 4.9$, $t = -2.276$, $p = .023$) and there were trends towards more PTSD symptoms (PCL-5: $M = 26.9$, $SD = 19.5$ vs. $M = 31.1$, $SD = 21.5$, $t = -1.922$, $p = .055$) but no difference in alcohol problems and common mental disorders (AUDIT: $M = 8.9$, $SD = 9.9$ vs. $M = 10.9$, $SD = 10.1$, $Z = -1.469$, $p = .142$; SRQ-20: $M = 9.7$, $SD = 5.4$ vs. $M = 9.9$, $SD = 6.0$, $Z = -.388$, $p = .698$). The SOCRATES subscales showed no association to problematic khat use ($-.042 \leq rs \leq .08$; $ps \geq .057$). SOCRATES subscales showed small correlations to khat use and alcohol measures, but medium level associations to the clinical scales; thus, the higher the clinical burden, the higher the respective SOCRATES subscale.

Table 3- 1. Bivariate Spearman rank-order correlations (*p* value)

	Khat use i n bundles (last 28 days)	LEC	PCL-5	SRQ- 20	AUDIT	SOCRATES Recognition	SOCRATES Ambivalence	SOCRATES Taking Steps
Days with khat use in last 28 days	0.831 (<.001)	.066 (.117)	.006 (.115)	.102 (.014)	-.005 (.913)	.095 (.023)	.042 (.315)	-.125 (.003)
Khat use in bundles in the last 28 days		.125 (.003)	.124 (.003)	.112 (.007)	.042 (.317)	.112 (.007)	.065 (.120)	-.086 (.040)
LEC			.523 (<.001)	.360 (<.001)	.200 (<.001)	.199 (<.001)	.162 (<.001)	.101 (.015)
PCL				.557 (<.001)	.225 (<.001)	.348 (<.001)	.311 (<.001)	.199 (<.001)
SRQ					.271 (<.001)	.396 (<.001)	.343 (<.001)	.154 (<.001)
AUDIT						.121 (.004)	.111 (.008)	.067 (.108)
SOCRATES Recognition							.637 (<.001)	.513 (<.001)
SOCRATES Ambivalence								.562 (<.001)

575 khat using Jimma University student's khat use days, khat use in bundles, in relation to trauma load, PCL-5 sum score, SRQ-20 sum score, AUDIT sum score, and SOCRATES subscales.

Linear regression to predict khat use

Hierarchical regression analyses were used to determine predictors of the khat use variables *amount of khat used in the last 28 days* and *days with khat use in the last 28 days* (see Tables 2 and 3). For days of khat use, variables of Step 1 accounted for 1.3% of the variance (overall model test: $F(3, 571) = 2.411, p = .066$). The mental health variables of Step 2 accounted for an additional 1.1% of the variance (overall model test: $F(6, 568) = 2.283, p = .035$). In the third step, motivation to change variables (Recognition, Ambivalence, and Taking Steps) were added and the model accounted for an additional 4.0% of the variance (overall model test:

$F(9,665) = 4.325, p < .001$). After backward stepwise deletion of insignificant predictors, the final model contained the predictors age, Recognition, and Taking Steps and explained 5.8 % of the variance (overall model test: $F(3, 571) = 11.639, p < .001$).

Table 3-2. Summary of the linear regression model of dependent variable days of khat use in the last 28 days

Predictors	Step 1				Step 2				Step 3				Final model			
	B	SE B	β	p	B	SE B	β	p	B	SE B	β	p	B	SE B	β	p
Constant	25.870	5.637		<.001	24.694	5.652		<.001	26.465	5.715		<.001	27.287	5.017		<.001
Age	-.558	.226	-.103	.014	-.568	.225	-.105	.012	-.578	.222	-.107	.009	-.567	.220	-.105	.010
CGPA	.392	.809	.020	.628	.347	.807	.018	.667	.172	.793	.009	.828	-	-	-	-
AUDIT	.043	.036	.051	.230	.010	.038	.012	.795	.005	.037	.005	.901	-	-	-	-
SRQ-20	-	-	-	-	.109	.080	.071	.170	.048	.081	.031	.553	-	-	-	-
PCL-5	-	-	-	-	.010	.023	.022	.680	.007	.023	.015	.775	-	-	-	-
LEC-5	-	-	-	-	.082	.091	.044	.364	.086	.089	.046	.335	-	-	-	-
Recognition	-	-	-	-	-	-	-	-	.245	.086	.171	.004	.326	.070	.227	<.001
Ambivalence	-	-	-	-	-	-	-	-	.126	.149	.050	.397	-	-	-	-
Taking Steps	-	-	-	-	-	-	-	-	-.302	.064	-.249	<.001	-.288	.059	-.237	<.001
F	$F_{3,571} = 2.411, p = .066$				$F_{6,568} = 2.283, p = .035$				$F_{9,565} = 4.325, p < .001$				$F_{3,571} = 11.639, p < .001$			
AIC	2466.629				2466.163				2447.555				2439.738			
R ²	.013				.024				.064				.058			
Adj. R ²	.007				.013				.050				.053			

For bundles of khat use, variables of Step 1 accounted for 1.0% of the variance (overall model test: $F(3, 571) = 1.904, p = .128$). The mental health variables of Step 2 accounted for an additional 1.3% of the variance (overall model test: $F(6, 568) = 2.187, p = .043$). In the third step, motivation to change (Recognition, Ambivalence and Taking Steps) accounted for an additional 2.6% of the variance (overall model test: $F(9, 565) = 3.203, p = .001$). After backward stepwise deletion of insignificant predictors, the final model contained the predictors age, LEC-5 (trauma load), Recognition, and Taking Steps (overall model test: $F(4, 570) = 6.235, p < .001; R^2 = .042$).

Table 3-3 : Summary of the linear regression model of dependent variable bundles of khat use in the last 28 days

Predictors	Step 1				Step 2				Step 3				Final model			
	B	SE B	β	p	B	SE B	β	p	B	SE B	β	p	B	SE B	β	p
Constant	55.153	18.849		.004	53.464	18.884		.005	57.024	19.248		.003	59.007	16.911		.001
Age	-1.333	.755	-.074	.078	-1.426	.753	-.079	.059	-1.443	.747	-.080	.054	-1.381	.742	-.077	.063
CGPA	1.307	2.706	.020	.629	1.120	2.697	.017	.678	.691	2.672	.011	.796	-	-	-	-
AUDIT	.208	.119	.074	.082	.108	.127	.038	.392	.096	.125	.034	.445	-	-	-	-
SRQ-20	-	-	-	-	.002	.266	.000	.993	-.171	.274	-.033	.533	-	-	-	-
PCL-5	-	-	-	-	.098	.078	.068	.208	.088	.079	.061	.264	-	-	-	-
LEC-5	-	-	-	-	.425	.303	.068	.161	.443	.300	.071	.140	.601	.263	.096	.023
Recognition	-	-	-	-	-	-	-	-	.531	.288	.111	.066	.762	.241	.159	.002
Ambivalence	-	-	-	-	-	-	-	-	.662	.501	.079	.187	-	-	-	-
Taking Steps	-	-	-	-	-	-	-	-	-.824	-.216	-.203	<.001	-.721	.200	-.178	<.001
F	F _{3,571} = 1.904, p = .128				F _{6,568} = 2.187, p = .043				F _{9,565} = 3.203, p = .001				F _{4,570} = 6.235, p < .001			
AIC	3853.894				3853.481				3844.000				3837.993			
R ²	.010				.023				.049				.042			
Adj. R ²	.005				.012				.033				.035			

3.6. Discussion

In this study, we report on the characteristics of a student sample of an Ethiopian university in a traditional khat growing region who seek counseling assistance because of their khat use. We studied the relationship of quantitative khat use variables to mental health variables and motivation to change. The sample reported a very high khat use, on average more than 30 bundles in four weeks and use on more than every other day. A highly problematic amount of use was evident in about 17.0% of the sample. Furthermore, the sample reported a high trauma load and a high mental health burden, 17.5% reported current severe functioning problems due to mental health problems, 60.2% screened positive for CMD, 37.9% for PTSD, and 47.1% for hazardous alcohol use. Almost half fulfilled two or more of these mental health criteria in addition to khat use. According to the norms based on alcohol users in the US, the motivation to change khat use as measured by the SOCRATES was generally low. On this background, the very low Recognition score can be interpreted that subjects did not admit to having problems concerning their khat use; in this context, the low Ambivalence score means that the majority of subjects have little Ambivalence regarding their khat use because they do not see problems caused by khat use; the low scores on Taking Steps can be interpreted in a way that subjects are not already doing something to prepare a change of their khat use. The bivariate correlations revealed only weak associations between khat use variables, mental health measures, and motivation to change. In the statistical prediction of khat use, the regression models were only able to explain small percentages of the variance of the two use variables (< 6%); the strongest associations were found between khat use and motivation to change. This study substantiates the conclusion of the recently published meta-analysis (Gebrie et al., 2018) that khat use is a serious problem among Ethiopian University students; in our treatment seeking sample, we were able to recruit about 1.4% of all students at JU and found extremely high selfreports of khat use.

Our findings also correspond to the recent meta-analysis by Mekuriaw et al. (2020) who observed that students using khat are often also affected by common mental disorders; we found a similar CMD prevalence rate in our study and were able to report in more detail the quality of mental health problems. The high rate of participants screening positive for PTSD might be related to the specific population that had been exposed to violence in the context of political protests in the years before the assessment. Our data support the commonly employed method by using the SRQ-20 to detect CMD cases because almost all cases with positive PTSD screening on the PCL-5 (183 of 218, i.e., 83.9%) and with functioning problems (106 of 124, i.e., 85.5%) scored above the respective cut off (7/8). Our results add further information on the high burden of khat using university students by showing their hazardous use of alcohol and their severe functioning problems. Our data correspond to the findings of other studies, for instance, Teklie et al. (2017) who found the proportion of male khat users who used alcohol after chewing khat being more than 40% in the age group of 15-29 years and the meta-analysis of Ethiopian student samples by Gebrie et al. (2018) who found alcohol use was strongly associated with khat use. Our findings also show that the majority of these psychologically high burdened khat users do not regard khat use as their main problem, neither worrying about it nor wanting to change it. Our hypotheses can only be partially confirmed because of the smaller than expected (statistically significant but negligible) between khat use and mental health respective motivation to change that was shown in bivariate associations and multiple regression models. The most obvious question arising from our data is why do subjects with little motivation to change their khat use participate in this study? Three lines of arguments might attempt to explain our findings. First, both the SOCRATES as an assessment tool and the related transtheoretical model of change have rarely been used in the Ethiopian context. Although we developed the Amharic and Afaan Oromoo versions of the instrument with care, the English language version produced similar results, and the high intercorrelation of subscales was reproduced in the Ethiopian sample, more experience is needed to interpret the answers in

the cultural and societal context. The general societal attitude towards khat might be fundamentally different than the attitudes of Western societies towards alcohol and, thus, a country-specific norm is needed to interpret the data assessed with this instrument. Second, participants in this study might have mainly sought assistance for their comorbid mental health problems when enrolling in the study because they might have not been aware of other ways to receive assistance; Khat might in this context be a functionally used substance, for instance, to modify mood states or to self-medicate symptoms (Boys and Marsden, 2003). Third, participants might have enrolled in the study because they expected other benefits. However, this is unlikely because all participants were informed beforehand about the (small) compensation for public transport and missed meals. In sum, it is most likely that the American norms that we had used to interpret the results were not adequate, that is, have been too high. Assuming that, i.e., the direction of association is the same as in alcohol studies but the magnitude of khat-related answers in Ethiopia is lower than alcohol-related answers in the US the hierarchical regression analysis can, thus, be interpreted as it is presented below. The results of the hierarchical regression analysis revealed a low proportion of explained variance as well as small regression coefficients and bivariate correlations between previously identified predictors of khat use and quantitative measures of consumption. This is probably due to the characteristics of this study involving a more homogeneous treatment-seeking sample compared to the previously published studies with representative samples. Our statistical models revealed a positive association of motivation to change to the khat use measures when controlling for other variables. This is a typical result also found for other substances (e.g.

Klepper et al., 2016) and that is often explained in the context of health behavior theories: People practicing a risk behavior (e.g., substance abuse) evaluate their subjective risk for negative consequences higher than control subjects who do not engage in it and, in turn, are more motivated to engage in precautionary behaviors or abandoning the risk behavior (e.g.

In review Grevenstein et al., 2015). Recent studies showed that khat-using university students experience clear symptoms of an addiction syndrome (Abdeta et al., 2017) and often experience failed attempts to stop khat use (Duresso et al., 2018). Our data together with these results underscore that it is highly needed and promising to offer specialized prevention and clinical support services for students with khat-use problems. A striking finding is the low participation of female students in this voluntary convenience sample. Even though khat use is also practiced among female students in the study region (Alemseged et al., 2012: 16% of females used khat in the general population; Dires et al., 2016: 29% females among khat using high school students; Abdeta et al., 2017: 15% of female undergraduate university students), a very small proportion of female students sought assistance because of their use of this substance in this study (i.e., only 9 of the initial 717 students, 1,3%). Although the reason for this mismatch needs to be clarified in future studies, we do not think that recruitment information did not reach female students because printed flyers and announcements were publicly available. We hypothesize that the small proportion of women who volunteered for this study is related to the subjective fear of discrimination because in large parts of Ethiopia female khat use is seen as unacceptable (Mihretu et al., 2017) and has been strongly linked to female moral decay (Beckerleg, 2010). If this is true, it will need special strategies to engage female khat users in future counseling and clinical services for this substance. In this sense, Kerebih et al. (2017a) found that respondents with CMD were less frequently looking for mental health assistance when they used khat.

3.7. Strengths and limitations of the study

The study has used instruments that had been employed in different continents and cultures and for some of them, Amharic and Afaan Oromoo versions of the instruments had been developed for this study. There had been no or few prior validation studies in Ethiopia, which is why country-specific norms for interpretation of the scores are missing and there is little experience with the use of these versions of the instruments in general. While we are still confident that the Amharic and Afaan Oromoo versions of the instruments were at least as valid as English versions would have been, this should be taken into account when interpreting the results. Using electronic devices for research in Ethiopia is new and has been practiced only by a few studies (e.g. Duresso et al., 2018) so that no information is available on potential biases that are related to the use of this technique in Ethiopia. Using electronic devices to assess sensitive information without an interviewer or counselor being present has the potential to overcome answer biases (such as social desirability) and to reach larger numbers of participants but it also might create mistrust in countries where the government strongly controls the internet. The electronic assessment methods need to be tested more in the Ethiopian context. In other countries, electronic substance use assessment and intervention programs were highly accepted by students (e.g. Haug et al., 2017). We studied a treatment-seeking sample of khat users using a convenience sampling method. Preferably, treatment seekers should have been sampled using random sampling methods, because otherwise, the generalizability of the results is unclear. But the employed method allowed typical conclusions such as the difficulty to enroll females. In general, there are no studies with treatment-seeking samples of student khat users and this study can be seen as a pilot study that needs to be replicated; only one other study also using convenience sampling identified a group of khat-users among refugees in Nairobi that were equally burdened with mental health problems (Widmann et al., 2017).

3.8. Conclusion

This study highlights the challenges of and need for studying substance use and planning interventional strategies for khat as well as for comorbid mental health problems among university students in the countries of the khat belt. Instruments and national norms need to be developed to be able to effectively screen for individuals in need of professional support and to measure change. Regarding prevention and intervention, our study clearly shows how urgently adequate professional assistance services need to be strengthened at Ethiopian universities and that the to-be-built-up services need to be prepared for clients with high and complex mental health needs. The high number of participants who needed to be directly referred to clinical services shows that typical substance counseling services will largely be overburdened. We expect that khat counseling alone will not be sufficient to serve the needs of this group. Furthermore, the data suggest that there are barriers to utilization of counseling services for female khat users. Therefore, research on effective and efficient intervention and prevention strategies for this group of khat users and research on the methods of their implementation at Ethiopian universities is required.

4.Study 2

Neuropsychological and intellectual functions among khat using students at Jimma University (Ethiopia) and their association to mental health

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4.1 Abstract

The leaves of the khat shrub are the most common psychostimulant substance consumed in Ethiopia. Especially university students chew khat for neuroenhancement to cope with cognitive demands. This study aims to quantify khat use severity and executive cognitive functions among Ethiopian university students. We hypothesized that cognitive test performance is related to khat use severity and mental health variables. At Jimma University (JU), which is situated in a traditional khat producing region, 322 khat using students were recruited in a cross-sectional study (data of 286 were included into the analysis). Khat use (Timeline Follow-Back, TLFB), alcohol use (AUDIT) and mental health variables (Trauma Load, PTSD, Common Mental Disorders) were assessed by tablet computer administered self-report scales. Selected executive functions (Tower of Hanoi, ToH; Corsi block-tapping task, CBT), intelligence (RAVEN's Standard Progressive Matrices) and psychotic symptoms were assessed by trained local counselors. We used correlational and hierarchical regression analysis to detect variables related to executive functions.

The participants reported regular and heavy khat use in the 28 days before the assessment, i.e., on average 29.0 standard units ($SD = 27.9$) and 14.4 use days ($SD = 8.64$); 25% reported khat-induced psychotic symptoms. ToH and CBT measures were in a normal range and three out of nine neurocognitive variables were weakly correlated with khat use. Controlling for intelligence khat use and mental health variables did not predict a meaningful proportion of variance of executive functions.

Despite heavy khat use, executive cognitive functions seemed to be unaffected in a young sample of university students. This is most probably related to the not yet chronic use patterns. The results show that on-campus prevention and intervention measures will have a good chance to reduce the negative impact of long-term khat use. Research is urgently required to develop and evaluate targeted prevention and intervention concepts for khat using university students.

4.2 Introduction

Prolonged use of substances is typically related to neurocognitive impairments in the executive function domains of attention, inhibition, working memory and decision-making which can be explained by adaptation processes and neuro-toxic effects (Verdejo-Garcia et al., 2004; Ramey & Regier, 2019). Impaired neurocognitive functions and their changes over time play an important role in the development, maintenance and treatment of substance use disorders and are related to poorer treatment outcomes (Ekhtiari et al., 2021). Especially the chronic use of psychostimulant substances such as methamphetamine can induce functional and morphological changes in the dopamine system affecting a wide range of cognitive functions, such as cognitive flexibility, inhibitory control, sustained attention, strategic planning, decision making, memory and learning (Ersche & Sahakian, 2007).

The leaves of the khat tree (*catha edulis*) are traditionally chewed in the countries around the Horn of Africa and its use is increasing in the last century (Odenwald, Warfa, Bhui, & Elbert, 2010). Fresh khat leaves contain several psychoactive alkaloids of which the main psychoactive principle is cathinone, S(-)- α -aminopropiophenone (Kalix 1992). Cathinone acts in the central and peripheral nervous systems in a similar way to amphetamine and humans experience its effect as euphoria, making them confident, alert, and focused (Wabe 2011); that is the reason why it has been called “natural amphetamine” (Kalix 1992).

Ethiopia hosts the largest group of khat users and khat has traditionally been used to enhance work performance and concentration and fight sleep (e.g. for fieldwork, reading the Koran or long-distance drivers; Odenwald et al., 2021) and, therefore, it is highly attractive for students who use it in order to achieve better academic performance (Gebrehanna, Berhane et al. 2014, Mihretu, Teferra et al. 2017). However, empirical data from cross-sectional studies point into

the direction that students' khat use is related to worse academic performance (Ayana and Mekonen 2004, Abdeta, Tolessa et al. 2017, Kassa, Loha et al. 2017) and higher mental distress (Dires, Soboka et al. 2016, Kerebih, Ajaeb et al. 2017).

The overall khat use prevalence among Ethiopian university students reaches 23% (23% on a national level; Gebrie, Alebel et al. 2018). In single representative studies, the rate of khat consumption among students of Jimma University was found to be 26% (Abdeta, Tolessa et al. 2017) and 25% (Ayana and Mekonen 2004). In a sample of high school students in Jimma, the percentage was 16% (Dires, Soboka et al. 2016).

There is little research that studied neurocognitive impairments of khat users. Current evidence supports poorer working memory among heavy khat users compared to controls (Hoffman & al'Absi 2013; Colzato, Ruiz, van den Wildenberg, & Hommel, 2011), impaired memory functions (Ismail, El Sanosy, Rohlman, & El-Setouhy, 2014), impaired problem solving (Odenwald et al., 2012), deficits in inhibitory behavioral and cognitive control (Colzato, Ruiz, van den Wildenberg, & Hommel, 2010; Colzato, Ruiz, van den Wildenberg, & Hommel, 2012), cognitive flexibility (Colzato et al., 2011), as well as problems with perception processing and motor speed (Hoffman & al'Absi 2013; Ismail et al., 2014). In a preliminary study of the Konstanz working group, 33 khat users and 15 control subjects from Nairobi, were tested with a three-disk Tower of Hanoi and a visual spatial span test (Odenwald et al., 2012); excessive khat use was related to more moves and time to solve the ToH and to more errors in the backward spatial span (spatial working memory) of the Corsi block tapping task (CBT).

There is a high co-morbidity of mood and anxiety disorders in patients with substance use disorders (Grant et al., 2004). Different studies among khat users also identified depression, Posttraumatic Stress Disorder (PTSD) or common mental disorders (CMD) as frequent comorbid problems (e.g. Widmann, Apondi et al. 2017, Bahhawi, Albasheer et al. 2018).

Furthermore, khat use has been associated with the occurrence of psychotic symptoms and disorders (for review see Odenwald, 2007). In Ethiopian context a number of studies revealed a high prevalence of CMD and several of them reported results from the project region: 33.6% and of the general population of Jimma town (Kerebih and Soboka 2016) (Damena et al., 2011) and 35.2% among Jimma University medical students (Kerebih, Ajaeb et al. 2017). A recent meta-analysis (Mekuriaw et al., 2020) found a pooled prevalence of CMD among Ethiopian students of 37.73% (95% CI: 30.43, 45.03) which was clearly associated to khat use (*OR* 2.01; 95% CI: 1.38, 2.95).

In this study we wanted to expand our knowledge neurocognitive functions among khat users, especially on executive functions and their association to khat use among university students. In a cross-sectional study at Jimma University (JU; Ethiopia), we assessed selected executive neuropsychological functions and intelligence among khat using students and hypothesized that (1) problem-solving and working memory performance measures are related to the amount of khat and alcohol use and (2) to the severity of mental health problems (CMD, PTSD, psychotic symptoms) and trauma load after controlling for intelligence. Based on the above reported studies, we expect that especially the time to solve the ToH and errors in the CBT are related to khat use, even when controlling for other variables.

4.3. Methods

Design

This cross-sectional study was part of a larger project, a pilot RCT to reduce khat use among Jimma University (JU) students. The assessment was done from November 5, 2018 until November 23, 2018. Jimma is situated in a traditional khat producing area in Ethiopia where its use is a long-standing tradition. Here we report data from the initial screening (self-report using tablet computers to assess khat use, AUDIT, SRQ-20, LEC-5, PCL-5) and the subsequent clinical assessment by trained counselors (psychotic symptoms, neuropsychological tests, intelligence). Both assessments were made immediately or just a few days apart from each other.

Sample

Potential participants were recruited for the study, with the help of student council representatives of JU. Inclusion criteria were student status at JU, sophomore or higher, having used khat in the last month, motivation to reduce or stop khat use, language proficiency Afan Oromo, Amharic or English. Exclusion criteria were being a first year (because khat use onset is often during university education; Abdeta et al., 2017) or an extension student (night-shift) who are not living inside the campuses.

In total, 322 participants were included into the study. The average age of participants was 22.02 years ($SD = 1.53$; ranging between 17 and 28 years). The median reported study year was 6 ($M = 5.45$, $SD = 1.01$). The participants belonged to the following faculties, colleges, and departments: 209 (64.9%) participants were from the Institute of Technology, 31(9.6%) from the Faculty of Natural Sciences, 35 (10.9%) from the College of Business & Economics, 19 (5.9%) from the Faculty of Medicine and Health, and 28 (8.7%) from Law, Social Science, and

Humanities. Participants selected the following languages to fill the questionnaires: 208 (64.56%) Afaan Oromoo, 110 (34.2%) Amharic, and 4 (1.2%) English. Students described their monthly income as follows: 25 (7.8%) participants had less than 100 Ethiopian Birr, 79 (24.5%) students indicated 100–300 Birr, 90 (28.0%) of them 301–500 Birr, 56 (17.4%) indicated 501–700 Birr, 35 (10.9%) of them 701–900, and 28 (8.7) participants said they had more than 900 Birr; 9 (2.8%) participants were not willing to give information on monthly income. At the time of the study, 100 Birr was approximately \$3.50. The mean cumulative grade point average was 3.07 ($SD = 0.43$, ranging between 1.63 and 3.89).

Data assessment procedures

The screening (T0), demographic questions and psychological checklists were assessed through self-report. That was implemented with tablet computers using the assessment software Qualtrics (<https://www.qualtrics.com>). The screening was done in a classroom setting in which 10 participants were accommodated at a time. The procedure was supervised and assisted by Konstanz and JU members. All the instructions and questions were available in Amharic, Afaan Oromoo, or English; participants selected the preferred language from the given options. The assessment took, on average, 45 min. Participants were reimbursed for their public transport expenses and received a lunch voucher if they missed their university-provided lunch because of the assessment. Participants were allocated for a session with the trained counselors (T1) for the face-to-face assessment of neuropsychological functions, intelligence and psychotic symptoms. Participants' campus location, a common language for counselors and students, lecture-free time, and the counselors' availability in their office were considered before the allocation.

In preparation for the study, 18 counselors were selected and trained for 10 consecutive days for 8 hours. The training included the following parts: Assessment of psychotic symptoms by a structured clinical interview (selected items from the CIDI), conducting neuropsychological tests (Tower of Hanoi, (ToH), and The Corsi Block Tapping Task, (CBT) and administration of the RAVEN's SPM. The counselors were JU staff members from the Psychiatry Department and from the student counseling service (11 master's graduates in psychiatric nursing and 7 bachelor's degree in nursing).

Table 4-1: Data assessment of the study and number of participants

Study Time point	Instruments	Number of Participants	Means of assessment
T0	Demographics	322	Tablet computers
	Academic Performance		
	Trauma and PTSD (LEC-5 & PCL-5)		
	Anxiety and Depression (SRQ-20)		
	Khat use (TLFB)		
	Alcohol use (AUDIT)		
T1	RAVEN's SPD	276	Trained counselors
	psychotic symptoms	286	
	The Corsi Block Tapping Task (CBT)	275	
	The Tower of Hanoi (ToH)	256	

4.4. Instruments

All instruments and manuals had been made available in the two widely spoken languages in the region as well as inside the campuses (Afan Oromo and Amharic) and in English. If validated versions of the instruments had not been available, we adapted and translated them to the languages.

Neuropsychological tests

The employed tests were language free and with simple instructions. They were proven their culturally appropriateness in a prior study among Somali khat users in Kenya (Odenwald et al., 2012; Widmann et al. 2017).

The Tower of Hanoi (ToH): Also called the tower of Brahma or Lucas tower. It was invented by the French mathematician Eduard Lucas (1883). The mathematical puzzle is connected to the legendary story of the Hindu temple where the puzzle was supposedly used to increase the mental discipline of young priests. As the game is played with more and more disk patterns should be looked and connected to one of the following 3 mathematical concepts: (I) Iterative Solution: where the same sequence of instruction is repeated frequently. (II) Recursive solution: Where you use information from one step to find the next step. (III) patterns which can be used to translate in mathematical equations (De Brabandere 2017). It has been used for decades in neuropsychology as diagnostic tool in the field of planning- and problem-solving and today still plays an important role in the assessment of frontal lobe functions (Goel & Grafman, 1995; Owen, Downes, Sahakian, Polkey, & Robbins, 1990). According to Escher and Shaken (2007) better performance in the Tower of Hanoi indicated greater dissociable cognitive ability in

planning, working memory attention set shifts which are mandatory for goal direction behavior (Burgess 1995). The three-disk version of the ToH that can be solved with 7 moves was used in this study based on findings that it was sensitive to detect executive deficits in amphetamine (Ersche et al., 2006) and khat users (Odenwald et al., 2012).

Figure 4-1: The ToH wooden mathematical puzzle with three ordered stacked disks and three towers namely Source, Auxiliary and Destination (Gajera, 2017)

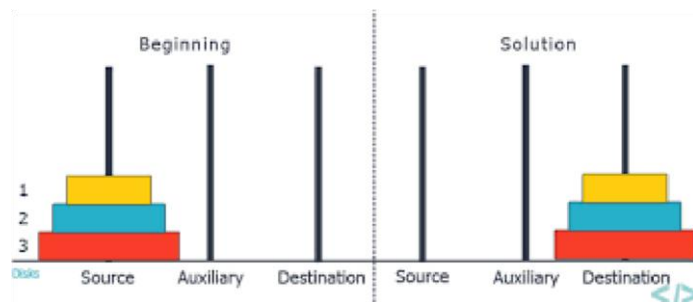
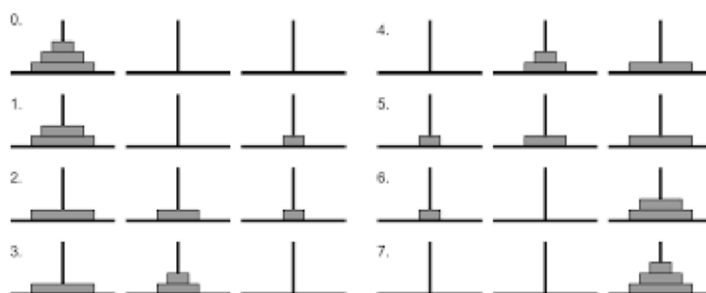
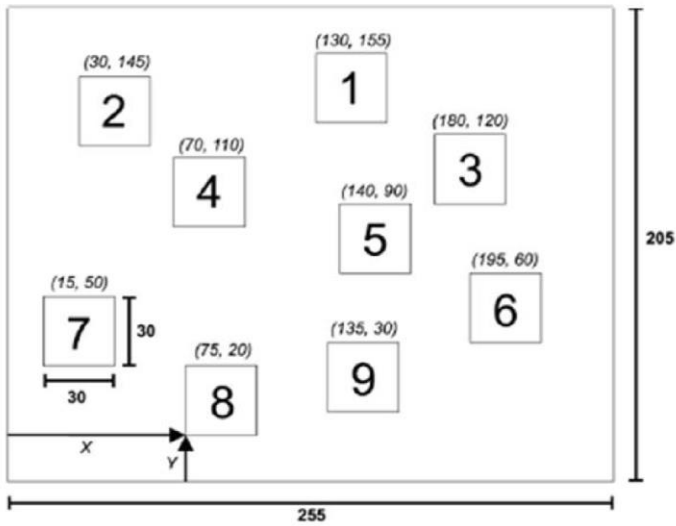


Figure 4-2: The 7 ideal moves to solve the ToH (0 Beginning and 7 Solution; Jain, 2017)



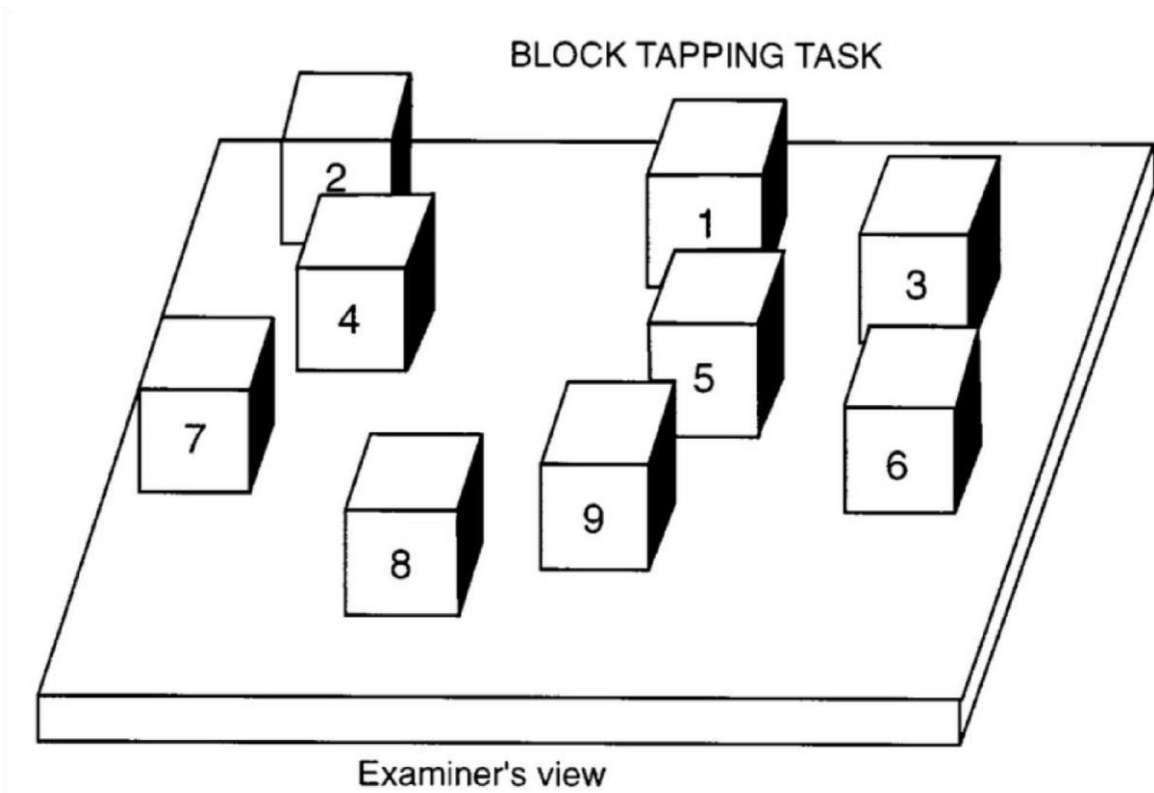
The Corsi Block Tapping Task (CBT): This test was developed as a visuospatial variation of the Digit Span Test (Corsi, 1972). It was widely used for assessments of participants visuospatial memory performance in clinical and experimental research settings today (Salame, Danion, Peretti, & Cuervo, 1998). The classic version of the CBT consists of a board with nine irregularly attached blocks. The examiner sets a specific sequence by tapping the blocks one after another and the participant's task is to repeat the given sequence in the presented or reverse order. As the length of the sequence is increasing from 2 up to 9 blocks after a correct attempt, the short-term memory's capacity becomes measurable and is further defined as the length of the last correctly repeated sequence (block span). Working memory (WM) can be assessed by the reverse mode. As soon as subjects pass a sequence, they progress to the next level, increasing in length by one box. The task is terminated when a participant is unsuccessful in all two sequences at the same level. We used this test to assess WM (reversed mode) and short-term memory capacity (spatial span) as indicated by Baddely (2003). Because there are no validated language-based versions of neuropsychological tests available in Amharic and Afan Oromo. We used the material as described by Kessels et al. (2000; see Figures 3 and 4) made of black painted wood.

Figure 4-3: CBT-Materials as described by Kessels et al. (2000)



The coordinates (in mm) are measured from the left-bottom corner of the board to the left-bottom corner of each cube. The digits 1 through 9 were visible to the examiner only.

Figure 4-4: The 3D feature of CBT(Examiners View) as described by Kessels et al. (2000)

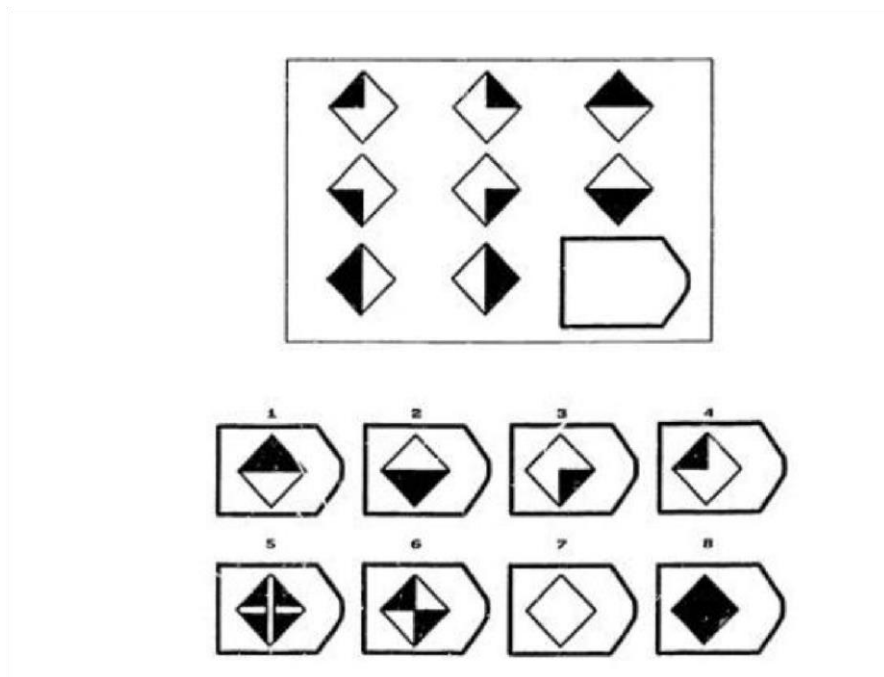


The local counselors were trained to administer the tests and record the results.

Raven Standardized Progressive Matrices (RAVEN's SPM)

A classical test that measures the general factor of intelligence established by Raven in 1936 (Raven, 1936, 1940). Since then, the test has been slightly modified and evaluated in different cultures, today parallel versions exist (Horn, 2009). The Standard Progressive Matrices (SPM) consists of five sets of graphical tasks (A to E) with 12 items each. The subject is asked to choose from a set of possible answers the correct one that fits into the gap displayed by the test item (see example in Figure 5). From A to E the degree of difficulty is increasing. The test is presented without time restriction; however, participants were asked to work swiftly. Most participants need less than 30 min. to accomplish the test. Based on the number of correct answers (maximum 60) a raw value is calculated, norms exist in different cultures for different age groups.

Figure 4-5: Example item from RAVEN's SPM (Raven, J. C. (1976))



Clinical Scales

The Timeline Follow Back (TLFB)

The *Timeline Follow Back* (TLFB) method is a well-validated and frequently employed calendar-based self-report assessment originally developed for alcohol use but appropriate for other substances, too (Robinson, Sobell et al. 2014). It has been validated in cross-cultural studies (Sobell, Agrawal et al. 2001). In previous research projects in the Jimma region, the

TLFB was adapted and used for the assessment of khat and alcohol (Adorjan, Odenwald et al. 2017). For this study, participants used the TLFB calendar to report the consumed standard bundles of khat as well as days with khat use in the last 28 days before the assessment. Standard units of different khat qualities had been determined beforehand by a local expert committee using a market survey and consensus discussions as outlined by (Widmann, Warsame et al. 2014). Respondents received descriptions and photos of the different standard units. As a common definition of problematic khat use does not yet exist (Mihretu, Teferra et al. 2017), we used the quantity of consumption as a marker for highly excessive khat consumption. In previous studies, a khat use of two or more bundles a day (Dhadphale and Omolo 1988, Odenwald, Hinkel et al. 2007) was a marker for problematic khat use.

The Alcohol Use Disorder Identification Test (AUDIT)

The Alcohol Use Disorder Identification Test (AUDIT) (Barbor, Higgins-Biddle, Saunders, & Monteiro, 2001) is a brief screening instrument with 10 items developed by the WHO to identify individuals with problematic alcohol use. A sum score of 8 and above is the recommended cut-off for hazardous and harmful alcohol use; a score of 8-15 is interpreted to represent a medium level and a score of 16 and above as a high-level alcohol problem. An Amharic version had

been developed by (Gebrehanna et al. 2014) and was tested with a sample of Ethiopian university students. We found the Cronbach's alpha for the three languages as follows Amharic ($\alpha = 0.77$), Oromo ($\alpha = 0.81$) and English ($\alpha = 0.81$)

Self-Report-Questionnaire 20 (SRQ-20):

The 20-item version of the *Self-Report Questionnaire* (SRQ-20) which was developed by WHO (Harding et al., 1983) to measure symptoms of common mental disorders (CMD). It comprises 20 simple questions that need to be answered in a yes-no format. A validated Amharic version of the instrument exists (Hanlon, Medhin et al. 2008) and an Afan Oromo version was developed in one of our previous studies (Adorjan et al., 2017). The instrument had been used to screen for CMD among JU students with the frequently used cut-off score of

7/8, identifying a proportion of 35.2% (Kerebih, Ajaeb, & Hailesilassie, 2017). The SRQ-20

Cronbach's alpha for the three languages in our study reported as follows Amharic ($\alpha = 0.90$), Oromo ($\alpha = 0.90$) and English ($\alpha = 0.71$)

Life-Event Checklist (LEC-5):

To assess traumatic experiences we used the Life-Event Checklist (LEC-5), a well-validated instrument that assesses 17 types of potentially traumatic experiences (Gray, Litz et al. 2004).

Respondents' answers whether the single items happened to them personally, whether they witnessed that it happened to somebody else, whether they learned that it happened to a close person, or whether it is part of their job. Simplified Amharic and Afan Oromo versions of the instrument, that just ask whether each event type has ever happened to the respondent personally or whether he/she has ever witnessed it happen to somebody else or whether this experience had been part of their job had been used to assess traumatic experiences in a previous study

(Adorjan, Odenwald et al. 2017). Trauma load was calculated by summing up the event types that had been experienced or witnessed or had been part of the job. The

Cronbach's alpha for the LEC-5 in the three languages were as follows Amharic ($\alpha = 0.87$), Oromo ($\alpha = 0.89$) and English ($\alpha = 0.88$)

Posttraumatic Stress Disorder (PTSD) Checklist (PCL-5):

The PTSD Checklist (PCL-5) is a well-validated self-report instrument to assess symptoms of Posttraumatic Stress Disorder that has recently been adapted to the criteria of DSM-5 (Bovin, Marx et al. 2016). The instrument asks respondents to describe their most distressing event and asks for the intensity of 21 symptoms in the last month. Amharic and Oromo versions of the instrument had been developed for this study. For screening PTSD, a cut-off score of 32/33 is recommended (Bovin et al., 2016). The Cronbach's alpha of the three language versions used in our study can be considered good to excellent ($\alpha > 0.80$). The Cronbach's alpha for the PCL5 in the three languages and in the four clusters (subscales) are as follows: Amharic: Cluster B (intrusions) $\alpha = 0.87$, Cluster C (avoidance) $\alpha = 0.83$, Cluster D (mood and cognitive alterations) $\alpha = 0.90$, and Cluster E (arousal) $\alpha = 0.89$. Afaan Oromo: Cluster B (intrusions) $\alpha = 0.91$, Cluster C (avoidance) $\alpha = 0.86$, Cluster D (mood and cognitive alterations) $\alpha = 0.91$, and Cluster E (arousal) $\alpha = 0.87$. English: Cluster B (intrusions) $\alpha = 0.89$, Cluster C (avoidance) $\alpha = 0.97$, Cluster D (mood and cognitive alterations) $\alpha = 0.96$, and Cluster E (arousal) $\alpha = 0.93$.

Rating of psychotic symptoms

An interview-based method was used to assess the current prevalence of four psychotic symptoms. Based on several prior studies with khat users in the region (Widmann et al., 2014) four items were selected and adapted from the WHO's Composite International Diagnostic

Interview (CIDI; WHO, 1999) that are frequently experienced by this group: G2 (believing people are following you), G2b (believing people are talking or laughing about you), G18 (hearing voices or things, other people cannot hear), G21 (experiencing unexplainable feelings on or under the skin). The probing and coding rules established by the WHO were applied; in addition, it was probed whether each symptom occurs during or 6 hours after khat use. A psychotic symptom was classified as khat-induced, if it only occurred during or 6 hours after khat use irrespective of the participant being able to distance from the symptom or not (according to the definition of the WHO, this definition is not necessarily psychotic). The already validated items in Amharic and Oromo versions were used. The counsellors were trained to assess the prevalence of true or khat-induced psychotic symptoms. We used a categorical information (any symptom present or absent) to report percentages of subjects with and without true psychotic symptoms and khat-induced psychotic symptoms. We used the sum scores for true and khat-induced psychotic symptoms for correlational analysis.

Ethics

The Institutional Review Boards of JU (Ethiopia) and of the University of Konstanz (Germany) approved this study. Informed consents were prepared translated and back translated in Amharic and Afan Oromo and participants were only included into the study after they had read, agreed, and signed the translated informed consent according to their language preferences. The study was part of a trial with the registry number NCT03730805.

Statistical Procedures

SPSS 26 and 27 had been used to analyze the data. We report mean and standard deviation

($M \pm SD$). For statistical testing $\alpha \leq 0.05$ was used. Because statistical pre-requirements of multiple imputation techniques were not given in all the self-report instruments. We adopted the following procedure: all participants were excluded from data analysis who had left out more than two items in the same self-report instrument; for the remaining cases, missing items were replaced by the respective scale mean. Outliers were checked using the boxplots identified by the procedure suggested by Hoaglin and Iglewicz (1987): The upper quartile plus 1.5 times the interquartile range was identified as an outlier and any score greater than the upper quartile plus 3 times the interquartile range principle (Field, 2013). Therefore, in the completion of the ToH 210 seconds or 3 minutes and 30 seconds was considered extreme due to that 13 participants results were not considered. In addition, 16 participants' result were excluded due to counselor's unclear report. From the CBT 7 participants' results were not included because counselors did not follow the correct procedure in the stopping rule. Therefore, the number of participants indicated in Table 1 are the final number of participants after extreme or incomplete cases exclusion. Because of unequal variances and sample sizes we used Wilk's ttest to compare neuropsychological test results in our sample with reports from other studies.

The bivariate associations between Khat use in the last 28 days with RAVEN's SPM, neuropsychological tests (ToH and CBT), psychopathology, trauma load and alcohol use were computed using the non-parametric Spearman rank order correlation coefficient because of deviation from normality (Kolmogorov-Smirnov and Shapiro-Wilk tests with $p < .001$).

We used linear regression to identify predictors of the two neurological tests (Tower of Hanoi and Corsi Block Taping Task). Kolmogorov-Smirnov and Shapiro-Wilk tests and inspection of QQ-plots revealed no normal distribution for Tower of Hanoi time in seconds, Corsi backward incorrect moves, Corsi forward incorrect moves, khat days, AUDIT, SRQ-20, LEC and PCL. There was no sign of multicollinearity ($VIF < 1.56$, Tolerance > 0.63). The result from Cook's distance indicated no influential cases (values range between .20 and .07). Computing the linear

regression, in the first step we entered the variable age. In the second step AUDIT and the sum score of Khat use in the last 28 days was entered. In step three we entered the sum scores of the SRQ-20, the PCL-5 and the LEC. For each step we calculated the goodness-of-fit for overall model using the Akaike information criterion (AIC). For each step we calculated R^2 and adjusted R^2 . Finally, we used an automated stepwise procedure to remove non-significant predictors from the model using the F value ($p > 0.10$).

4.5. Results

Description of psychotic symptoms, clinical scales, intelligence and neuropsychological test scores

The participants consumed an average amount of 29.04 standard khat bundles ($SD = 27.90$) in the 28 days before the assessment. In this period, khat use occurred on an average of 14.39 days in the sample ($SD = 8.64$). The average score for traumatic experience in the LEC5 was 4.71 ($SD = 3.99$). The most frequent potential traumatic experiences reported by the sample were physical assault ($N = 173$; 53.7%), sudden unexpected death ($N = 156$; 48.4%), transportation accident ($N = 154$; 47.8%), severe human suffering ($N=145$; 45.0%) and fire or explosion ($N = 128$; 39.8%). The severity of symptoms of Post-Traumatic Stress Disorder reported by the PCL-5 was on average $M = 21.98$ ($SD = 17.80$). The AUDIT (alcohol use) mean score was 4.11 ($SD = 5.88$). The mean value of the SRQ-20 sum score (Common Mental Disorders symptoms, CMD) was $M = 7.93$ ($SD = 5.05$).

The counselors' assessment of 286 participants revealed true psychotic symptoms in 24 (8.4%) subjects and khat-induced psychotic symptoms in 74 (25.9%).

From in total 60 items of the RAVEN's SPM the 276 participants correctly solved on average 36.00 ($SD = 12.25$) with a minimum score of 7 and maximum score of 57. The average time to correctly accomplish the three disks-version of the ToH ranged between a minimum of 6 seconds to a maximum of 202 seconds with an average of 69.40 ($SD = 71.84$) seconds.

Participants needed a minimum of 7 steps and a maximum of 35 steps with a mean of 9.27 ($SD = 3.64$) steps. The number of errors ranged from a minimum of 0 to a maximum of 14 with a mean of 1.2 ($SD = 2.17$). In the CBT, the following results for forward moves were achieved: The average of correct forward sequences is 8.17 ($SD = 1.66$) of incorrect forward sequences is

2.97 ($SD = 0.87$) and the mean longest forward sequence is 5.60 ($SD = 1.00$). The participants' result for the backward moves are as follows: Backward correct sequences 7.97 ($SD = 1.96$), backward incorrect moves 2.88 ($SD = 0.84$), and the mean of the longest backward sequence is 5.43 ($SD = 0.95$).

In Table 2, the current sample's results in the two neuropsychological tests and in RAVEN's SPM are compared to scores from other samples. The participants' CBT block span length (correct forward longest sequence, 5.60, $SD = 1.0$), is lower than the mean score of a healthy control group from the Netherlands (6.2, $SD = 1.3$) with an average mean age of 31.2 and equally lower than the average of a student sample from the USA (7.1, $SD = 1.0$; Pagulayan et al., 2008). However, the mean score of the study sample is greater than the one derived from patient groups with various neurological disorders (maximum mean score 5.3 ($SD = 1.4$) and minimum of 4.4 ($SD = 1.2$; Kessels, Zandvoort, Postma & Kappelle, 2000). The participants' result for ToH number of steps is not very far from the standard norm for the three disks, which is $2^n - 1 = 7$ moves, is comparable to students from the US (Emick, 2005) and clearly better than the results from a sample of khat using refugees (Odenwald et al., 2005). The study sample's average result in the RAVEN's SPM is comparable to the results of students of South Africa (Grahamstown region school, age range from 14-26) and the south African normative sample mean score of 35.1 (Vass 1992) but worse than normative results from the USA (Burke 1985).

Table 4-2: Comparison of results of the current study with other samples

Measure	Samples			Welch's t-test, p
CBT	[1] Study sample (N = 273)	[2] Kessels et al. (2000): Healthy controls in the Netherlands (N = 70)	[3] Pagulayan et al. (2008): US undergraduate sample, University of Cincinnati (N = 94)	
Block Span forward	5.6 (1.0)	6.2 (1.3)	7.1 (1.0)	[1] vs. [2]: 3.60, <0.001*** [1] vs. [3]: 12.54, <0.001***

ToH	[1] Study sample (N = 266)	[2] Odenwald et al. (2012): Somali refugees (N = 33)	[3] Emick (2005) Students at the university of Colorado (N = 47)	
Time in second	69.40(71.84)	338.10 (635.10)	-----	[1] vs. [2]: 2.43, 0.02*
Number of steps to solve the task	9.27 (3.64)	22.00 (16.50)	10.59 (4.93)	[1] vs. [2]: 4.42, <0.001*** [1] vs. [3]: 1.75, 0.09
RAVEN's SPM	[1] Study sample (N = 276)	[2] Vass (1992): South African secondary school students (N = 711)	[3] Burke (1985): USA, +12 years of education (N = 524)	
Number of correct responses	36.00 (12.25)	32.90 (9.72)	41.9 (10.90)	[1] vs. [2]: 3.74, <0.001*** [1] vs. [3]: 6.77, <0.001***

Bivariate associations between variables

Bivariate correlations between variables are reported in Table 3. The neuropsychological tests and RAVEN's SPM showed weak association with khat use days. Khat use was negatively correlated with two of the six CBT coefficients and positively correlated with one of the three ToH variables, all associations show the same direction (more khat use is related to weaker performance). Alcohol use as measured by the AUDIT was not associated to any CBT nor ToH variable. Trauma load and PTSD symptoms were weakly associated to few CBT coefficients (the higher the burden the better the performance) but not to any ToH variable. The SRQ sum score as measure for common mental disorders was not associated to any CBT and ToH variable. Furthermore, the sum of true psychotic symptoms was weakly associated with one ToH measure (more symptoms being associated with worse performance), whereas khat-induced psychotic symptoms was not correlated to any neuropsychological test variable. RAVEN's

SPM showed small positive correlations with the CBT number of correct sequences forward and backward and with the longest sequences forward and backward as well as negative correlations to two ToH variables (time to solve the ToH as well as errors), i.e., in a coherent manner the higher the intelligence test score the better the performance in the neuropsychological test.

Table 4-3. Bivariate Spearman rank-order correlations (p value; N) between neuropsychological tests, khat use days, trauma load, PCL-5 sum score, SRQ-20 sum score, AUDIT sum score, and RAVEN's SPM.

	True psychotic	Khat psychotic	LEC	PCL-5	SRQ-20	AUDIT	RAVEN's SPM	Corsi For. Corr	Corsi For. Incorr	Corsi For. Long	Corsi Back. Corr	Corsi Back. Incorr	Corsi Back. Long	ToH Time in sec.	ToH Num. of Step	ToH Num. of Errors
Days with khat use in 28 days	.075 .205 (286)	.063 .289 (286)	.072 .196 (322)	.027 .633 (322)	.044 .436 (322)	-.100 .073 (322)	-.139 .021* (276)	-.099 .050 (274)	-.096 .115 (273)	-.136 .024* (273)	.057 .348 (275)	-.121 .045* (275)	.039 .518 (275)	.022 .729 (254)	.135 .027** (267)	.108 .079 (267)
True psychotic		.329 <.001*** (286)	.124 .037 (286)	.269 <.001*** (286)	.167 .005** (286)	.160 .074 (286)	-.006 .920 (275)	.017 .781 (273)	-.026 .675 (273)	-.014 .820 (273)	.009 .877 (275)	-.069 .255 (275)	-.024 .696 (275)	.054 .392 (253)	.127 .039* (266)	.068 .269 (266)
Khat psychotic			.277 <.001*** (286)	.300 <.001*** (286)	.201 .001** (286)	.093 .115 (286)	-.066 .273 (275)	.035 .563 (273)	.036 .555 (273)	.067 .270 (273)	.116 .055 (275)	.085 .160 (275)	.102 .093 (275)	-.039 .536 (253)	.051 .406 (266)	-.036 .555 (266)
LEC				.493 <.001*** (322)	.312 <.001*** (322)	.071 .204 (322)	.144 .017* (276)	.133 .027* (274)	.092 .130 (273)	.147 .015* (273)	.107 .077 (275)	.040 .504 (275)	.068 .260 (275)	-.068 .282 (254)	.012 .847 (267)	.056 .364 (267)
PCL					.539 <.001*** (322)	.048 .393 (322)	-.004 .952 (276)	.117 .053 (274)	-.068 .264 (273)	.070 .250 (273)	.130 .031* (275)	-.098 .104 (275)	.065 .284 (275)	-.018 .780 (254)	.036 .563 (267)	-.015 .809 (267)
SRQ						.106 .057 (322)	-.019 .751 (276)	.018 .767 (274)	.009 .884 (273)	.033 .590 (273)	.057 .343 (275)	.010 .870 (275)	.063 .295 (275)	.037 .556 (254)	.060 .332 (267)	.059 .767 (267)
AUDIT							.050 .409 (276)	.114 .059 (274)	.008 .889 (273)	.076 .210 (273)	.047 .442 (275)	.115 .057 (275)	.054 .371 (275)	-.065 .305 (254)	.020 .741 (267)	-.065 .290 (267)
RAVEN's SPM								.346 <.001*** (264)	-.008 .902 (264)	.268 <.001*** (264)	.235 <.001*** (265)	.072 .246 (265)	.259 <.001*** (265)	-.202 .001** (246)	-.110 .077 (258)	-.239 <.001*** (258)

* < .05, ** p < .01, *** p < .001

Linear regression to predict neuropsychological tests

Table 4-4: Summary of the hierarchical linear regression model with the dependent variable ToH time in seconds and with the predictors khat use days, RAVEN's SPM and psychopatological measures

Predictors	Step 1				Step 2				Step 3			
	B	SE B	β	p	B	SE B	β	p	B	SE B	β	p
Constant	53.169	65.305		.416	66.581	66.581		.538	33.982	67.282		.614
Age	2.940	2.850	.063	.303	2.845	2.845	.076	.216	3.400	2.858	.073	.235
RAVEN's SPM	-1.355	.355	-.233	<.001	.356	.356	-.224	<.001	-1.350	.360	-.232	<.001
Khat use days	-	-	-	-	.323	.509	.039	.526	.212	.514	.026	.680
AUDIT	-	-	-	-	-1.799	.744	-.146	.016	-2.072	.757	-.169	.007
SRQ-20	-	-	-	-	-	-	-	-	1.646	1.003	.114	.102
PCL-5	-	-	-	-	-	-	-	-	-.191	.300	-.047	.526
LEC-5	-	-	-	-	-	-	-	-	1.058	1.222	.059	.387
F	F _{2,254} = 8.127, p < .001				F _{2,252} = 3.253, p = .040				F _{3,249} = 1.308, p = .272			
AIC	2184.759				2182.208				2184.190			
R ²	.060				.084				.098			
Adj. R ²	.053				.069				.073			

A first hierarchal regression analysis was computed to determine predictors of the time in seconds to solve the ToH (see Table 4). The control variables age and RAVEN's SPM entered in block 1 accounted for 6.0 % of the variance ($F(2, 254) = 8.127, p < .001$). Khat used in last 28 days and alcohol use (AUDIT) were entered in block 2 and accounted for additional 2.4 % of the variance ($F(2, 252) = 3.253, p = .040$). In the third block, mental health variables (PCL5, LEC and SRQ-20) were entered into the model and accounted for additional 1.4% of the variance ($F(3, 249) = 1.308, p = .272$). After backward stepwise deletion of predictors, the final model contained the predictors RAVEN's SPM ($\beta = -.232, p < .001$), AUDIT ($\beta = -.163, p = .008$), SRQ-20 ($\beta = .107, p = .081$) and explained 8.8% of the variance (overall model test: $F(3, 253) = 8.172, p < .001$).

Table 4-5: Summary of the hierarchical linear regression model with the dependent variable

CBT number of forward incorrect moves and with the predictors khat use days, RAVEN's SPM and psychopathological measures.

Predictors	Step 1				Step 2				Step 3			
	B	SE B	β	p	B	SE B	β	p	B	SE B	β	p
Constant	2.421	.789		.002	2.770	.818		.001	2.914	.821		<.001
Age	.029	.035	.052	.397	.022	.035	.039	.534	.017	.035	.030	.635
RAVEN	-.003	.004	-	.515	-.004	.004	-	.393	-.006	.004	-.078	.218
Khat use days	-	-	-	-	-.010	.006	-	.112	-.011	.006	-	.069
AUDIT	-	-	-	-	-.001	.009	-	.911	-.	.009	-	.764
SRQ-20	-	-	-	-	-	-	-	-	.014	.012	.078	.276
PCL-5	-	-	-	-	-	-	-	-	-.009	.004	-	.017
LEC-5	-	-	-	-	-	-	-	-	.030	.015	.142	.041
F	F _{2,261} = .602, p = .549				F _{2,259} = 1.273, p = .282				F _{3,256} = 2.515, p = .059			
AIC	-70.240				-68.823				-70.492			
R ²	.005				.014				.043			
Adj. R ²	-.003				-.001				.016			

A second hierarchical regression analysis was computed to determine predictors of the Corsi block-taping task coefficient forward incorrect moves (see Table 5). Predictors of block 1 (age and RAVEN's SPM) accounted for 0.5% of the variance ($F(1, 271) = .842, p = .360$). The substance use variables of block 2 (khat use days in last 28 days and AUDIT) accounted for additional 0.9% of the variance ($F(2, 259) = 1.273, p = .282$). In block 3, the mental health variables (PCL-5, LEC and SRQ-20) accounted for additional 2.9% of the variance ($F(3, 276) = 2.515, p = .059$). After backward stepwise deletion of predictors, the final model contained the predictors khat use days ($\beta = -.104, p = .090$), LEC-5 ($\beta = .134, p = .049$) and PCL-5 ($\beta = .139, p = .040$) and it explained 3.1% of the variance (overall model test: $F(3, 260) = 2.77, p = .042$).

Table 4-6: Summary of the hierarchical linear regression model with the dependent variable

CBT number of backward incorrect moves and with the predictors khat use days, RAVEN's SPM and psychopathological measures.

Predictors	Step 1				Step 2				Step 3			
	B	SE B	β	p	B	SE B	β	p	B	SE B	β	p
Constant	2.874	.760		<.001	3.345	.785		<.001	3.642	.779		<.001
Age	-.003	.033	-.005	.931	-.015	.033	-.027	.658	-.023	.033	-.042	.493
RAVEN	.002	.004	.032	.606	.001	.004	.010	.875	-.022	.004	-.023	.706
Khat use days	-	-	-	-	-.013	.006	-.138	.028	-.015	.006	-.149	.017
AUDIT	-	-	-	-	.010	.009	-.068	.271	.009	.009	-.061	.319
SRQ-20	-	-	-	-	-	-	-	-	<.001	.012	-.001	.989
PCL-5	-	-	-	-	-	-	-	-	-.010	.004	-.205	.006
LEC-5	-	-	-	-	-	-	-	-	.041	.014	.194	.005
F	F _{2,262} = .139, p = .870				F _{2,260} = 3.177, p = .043				F _{3,257} = 3.951, p = .009			
AIC	-82.690				-85.089				-91.037			
R ²	.001				.025				.068			
Adj. R ²	-.007				.010				.042			

The last hierarchical regression model was used to predict CBT backward incorrect moves (see Table 6). Variables of block 1 (age and RAVEN's SPM) could not explain any variance, $F(1, 262) = .139, p = .870$). The substance use variables of block 2 (khat use days and AUDIT) accounted for 2.4 % of the variance ($F(2, 260) = 3.177, p = .043$). In block 3, the mental health variables (PCL-5, LEC and SRQ-20) accounted for additional 4.3 % of the variance ($F(3, 257) = 3.951, p = .009$). After backward stepwise deletion of predictors, the final model contained the predictors, khat use days ($\beta = -.143, p = .018$), PCL ($\beta = -.200, p = .003$) and LEC-5 ($\beta = .192, p = .004$) explained 6.2 % of the variance (overall model test: $F(3, 261) = 5.77, p = .001$).

4.6. Discussion

In the present study, we report on executive neurocognitive functions and their associations to substance use, psychopathology and intelligence in a sample of khat using students of Jimma University in south western Ethiopia. The data on khat use shows that the study participants can be considered regular and heavy users (on average chewing every other day two standard units) and the fact that one in four experiences khat-induced psychotic symptoms is alarming. The performance in neuropsychological tasks measuring problem solving and working memory was on average normal, i.e., in general lower than in normative samples from western countries but comparable to samples from developing countries which is in line with the authoritative analysis of normative data from different cultures and decades (Raven, 2000) who found lower performance levels in Low Income Countries compared to High Income Countries.

We found few weak bivariate associations between khat use and the executive measures, all being coherent. In contrast, no associations were found with alcohol use. Trauma load and PTSD symptoms were weakly associated to visual working memory coefficients but not to problems solving the direction being contrary to expectations. Symptoms of common mental disorders and psychotic symptoms were unrelated to executive functions (exception true psychotic symptoms with steps to solve the ToH). This is in line with the literature as most studies focusing on the association between mood disorders and neurocognitive deficits in substance abusers failed to detect a relationship (Verdejo-Garcia et al., 2004). That almost all measures of executive functions were correlated to the intelligence measure, i.e., the higher the RAVEN's SPM score the better the executive performance, is also in line with existing literature (Raven, 2000). In the hierarchical regression models for the three variables of interest (time to solve the 3-disk version of the ToH; incorrect moves forward and backward of the CBT), a small part of the variance could be explained. The best model fit was achieved for the time to solve the ToH, with intelligence as strongest predictor and alcohol use being associated

in an incoherent manner (higher alcohol-related problems were associated with better performance). Khat use and PTSD symptom severity were predictors for the CBT backward incorrect moves, but both were negatively associated, i.e., higher problem score was related to better CBT performance. In sum, the regression models produced results that can hardly be interpreted at all. Our hypotheses, that Working Memory and problem solving are related to khat use and the severity of mental health problems cannot be confirmed by the study data. Intelligence seemed to be the clearest predictor of the executive functions we measured, but with a weak contribution.

Looking for explanations why we did not find the hypothesized associations between khat use and executive functions, we first consider the design. In contrast to most previous studies (e.g. Colzato et al., 2010, Ismail et al., 2014), we did not include a non-khat-using comparison sample. The variance of khat use in our sample was large but, in sum, our sample was very homogeneous, i.e., young male university students in their twenties with a few years of khat use and with a high mental health burden. Thus, it was difficult to detect the associations we had expected. Furthermore, in our design, we did not employ a washing-out phase before the neuropsychological assessment and have to expect that a large number of study participants were still under the influence of khat alkaloids during study participation; it is well known that acute administrations of central stimulants cause an increase of working memory performance (De Jongh et al., 2008) – that’s a main motivation for students to use khat (Mihretu et al., 2017). A second consideration to explain our results is related to the specific sample of our study. A study by (Odenwald et al., 2013) among Somalian refugees in Kenya reported a relationship between the performance of the ToH and khat use (non-khat users, moderate khat users, and binge users): The non-users had the best and the binge khat users the poorest outcomes. In our study, the khat users had in general results comparable to the non-khat using sample from Odenwald et al. (2013). Potential reasons for the difference in comparison with the Somali

sample in Nairobi could be related to the chronicity and amount of khat use, education, age, malnutrition, somatic and mental health. The following examples illustrate the large difference between the samples: Whereas the refugee sample from Nairobi used in one week on average 16 standard units of khat ($SD = 10$) and used it on 5 days/week in the 28 days before the assessment (Widmann et al., 2014), the JU sample chewed on average 29 bundles in the 28 days before the assessment with on 14 use days in this period. At the same time, the Nairobi sample's (Widmann et al., 2014) mental health was much more burdened as indicated by the percentage of psychotic symptoms: In the Nairobi sample 17% and 52% had true and khat-induced psychotic symptoms, whereas in the JU sample this was 8% and 26%. Reason why khat using students from JU achieved similar results in the ToH compared to other student samples might be the not yet chronic use of khat and the fact that substance use is common among students in all countries (Helmer et al., 2014). This is supported by the study of Ismail et al. (2014) who found a difference in executive functions when comparing non-users to chronic khat users. A third line of thought to explain the current results focusses on the measures of executive functions that we had selected: In a study with African descendants in south Holland the Stop Signal Task was compared between khat users and non-users (Colzato et al., 2010). The khat users needed more time to inhibit a behavioral response. Another study from Jazan, southwest of Saudi Arabia, assessed neuropsychological performance among chronic khat chewers and non-chewers (Ismail et al., 2014). The assessment included measures of learning, episodic and working memory and revealed that chronic khat chewers performed significantly worse in 3 out of 14 tests.

Concerning the associations between trauma load and PTSD and executive functions, several studies from Africa showed an association between PTSD and executive functions: A study among 323 Congolese refugees in Uganda revealed a negative association between scores of PTSD symptoms severity and working memory capacity assessed by the CBT (Ainamani et al., 2017). In another study among 232 children and adolescents in Uganda (age range 8-18) a

significant relationship between child maltreatment, working memory (assessed by the CBT) and executive functioning (assessed by the Tower of London) was found, but PTSD did not mediate this relationship (Ainamani et al., 2020). In our study, trauma load and PTSD were the only psychopathology variables that showed some bivariate associations (and some associations in the in general poor regression models) with CBT, however, in the opposite direction as reported by Ainamani et al. (2017, 2020). Our result is difficult to interpret, especially as the Ugandan and Congolese samples were deprived and much more burdened by trauma and mental health problems and had lower levels of education. However, we also need to consider the possibility that the acute neuro-enhancing effects of central stimulants might have overwritten the negative association between trauma variables and executive functions (De Jongh et al., 2008).

Whereas our data could not confirm the expected associations between executive functions, khat and alcohol use, trauma and mental health variables, our findings on the association between the RAVEN's SPM and the neuropsychological tests is confirmed by other studies. For example, a study by Carpenter, Just & Shell (1990) found that the overall performance in both tests, i.e., the correct moves to finish the ToH and the number correct items in RAVEN's SPM, were highly correlated; they concluded that the main distinction between the higher and lower scoring subjects in RAVEN's SPM and ToH is the ability to include abstract relations and dynamically manage a large set of problem-solving towards the desired goals in the working memory.

In sum, the studied executive functions appeared largely normal and unaffected in our sample of JU student with heavy khat use. This is a good result as it shows that young and intelligent men in this stage of life seem to be able to compensate the negative effects of substance use on cognition. However, being aware that chronic use might have a severe impact on neuropsychological performance, the same study design with a sample of more chronic khat users, i.e. some years later in life, might have revealed the hypothesized effects. Our results that

the students at their young age were not yet affected by the consequences of khat use encourage prevention and intervention services offered to students that will have a high chance to prevent further severe consequences such as declined cognitive functions. The largely positive response to our khat counseling offers further supports that prevention and treatment services will be accepted, utilized and sought after by student khat users.

Future research will need to address questions that were raised with this study. In order to be able to quantify the effect of chronic khat use on mental health and cognitive functions, longitudinal research is required that starts at young adulthood, spans over the entire study period and also controls for the possibility of bidirectional causality. In a prospective study by Khurana et al. (2017) scoring high in act without thinking (AWT) and a weak working memory, assessed by the CBT, at the baseline were significant predictors of substance use disorders (SUD) at the final follow upstage. The study concludes that adolescents with weak working memory have less control over sudden rush, leading to substance use disorder in later years. In order to be able to implement such study designs, Ethiopian normative data for intelligence and neuropsychological test data will be required in order to be able to identify and classify individuals and groups of participants with respect to their intellectual and cognitive functions. In order to complement test scores, future studies should also assess real-life indicators of neuropsychological functions, i.e., personal and social dysfunction that can include increased traffic accidents (Colzato et al., 2010). Future research will need to focus on the development of evidence-based prevention and intervention tools for khat use. Especially college and university students for whom the stimulating and neuro-enhancing effects of khat are attractive to cope with cognitive demands and at the same time they are for the first time in their lives free to decide on their matters are at risk to develop a problematic use pattern and khat-use disorders; thus, on-campus prevention services highly demanded for them.

4.7. Strengths and limitations of the study

The strengths of this study were the assessment methods: The local team of interviewers had an intensive two-weeks training in the administration of the application of neuropsychological tests and the assessment instruments for psychotic symptoms. It demanded effective management and planning to allocate students to trained counselors who made face-to-face assessments because students and counselors needed to match in terms of preferred language and free time slots in a very structured class schedule. Several instruments were used for the first time in the respective Ethiopian languages. The three language versions (Afan Oromoo, Amharic and English) of the psychodiagnostics instruments used in this study (AUDIT, SRQ20, PCL-5 and LEC-5) had been translated and culturally adapted according to the state of the art and their application revealed acceptable to good internal consistency with ranges from acceptable ($\alpha = 0.71$) to excellent ($\alpha = 0.93$). Finally, the anonymous self-report of sensitive data (khat use, alcohol use, etc.) via tablet computer without asking the participants' names had the advantage of avoiding social desirability effects; the experience during the assessment revealed that the study participants were experienced with the use of touch screens and had no problem with the use of the devices.

The study had some limitations that are related to the fact that the treatment study in which this assessment of executive functions took place focused exclusively on khat-using students. As a consequence, a non-khat using control group was missing in this study. Furthermore, the assessment of recent khat use and khat alkaloid screening (e.g. in urine) was not part of the study. This means that we cannot control for the effects of acute khat use, e.g., on test performance and mental health symptom presentation. In this study we decided for a low threshold for participation – repeated urine sampling would have been an obstacle for potential participants and it would have increased the demand for resources. In future studies, urine screening should be routinely applied to be able to control for acute khat effects. The

comparison of neuropsychological and intelligence test results with data from other countries can be criticized but it revealed an overall agreement with the authoritative review by Raven (2000); however, currently, there are no comparison or normative data from Ethiopia available.

Despite the care with instrument translation and cultural adaptation to Amharic and Oromo, the finding of the exact terms and concepts without deviation from the original English term's is a huge challenge that would require a study on its own; the instruments need further evaluation in the Ethiopian languages and their interpretation needs to be treated with caution until their validity has been shown by independent studies. On the practical side, there was a challenge to implement supervision session during the data assessment phase due to the counselors workload and the fact that their offices were located in different campuses. However, regular contact was maintained via telephone and email, occurring problems were dealt by this was and feedback from the counselors revealed no major difficulties.

4.8. Conclusion

In this uncontrolled correlational study executive cognitive functions among heavily khat chewing university students were only weakly related to khat use severity and not associated to alcohol use severity, trauma load and quantitative mental health variables. The overall performance in neurocognitive and intelligence tests was in the normal range, which is probably related to the fact that this young and homogeneous sample has not yet developed chronic substance use patterns. We conclude that prevention and intervention measures should be ideally situated at university campuses because students show a heavy use pattern, are motivated to utilize such assistance services and prevention at this point of lifetime when cognitive functions are still largely unaffected will have a positive effect. A strong applied research agenda is required to develop concepts and build up capacities to implement targeted prevention and intervention programs for university students.

5. Summary of Results

Study 1 investigated the relationship between khat use with comorbid mental health problems, alcohol use, trauma load and motivation to change. The results from study 1 confirmed the highly problematic khat use habit of the participants. The study sample was significantly burdened with comorbid psychiatric problems, higher trauma load and mental health burdens. More than half i.e., 60.2% of the participants screened positive for CMD and 37.9% positive for PTSD, 47.1% screened for hazardous alcohol use, and 21.6% severe functioning problems due to mental and neurological disorders. Results from the regression model indicated a small association between khat use and motivation to change. The bivariate correlation regarding the khat use variables showed weak to medium association to measures of trauma and psychopathology and small association with the motivation to change. Findings from the khat-adopted version of SOCRATES indicated low magnitude of components for the three subscales. Lower Recognition showed the participants' denial of khat consumption. Lower Ambivalence and Taking Steps can be interpreted as non-consideration of khat use as a problem and non-action stage. The interpretation of the Ambivalence score is only possible in relation to Recognition, in total 302 participants score low in both subscales. The instruments were widely used in different parts of the world. The translated versions of the instruments in the two dominantly spoken Ethiopian languages (Amharic and Afan Oromoo) achieved good to excellent internal consistencies. The existed valid versions of the instruments were few to non in Ethiopia, an overall and more evaluative assessment in psychometrics is mandatory. The study contributes to the understanding of khat and alcohol use, psychotic symptoms among university students. With this basic understanding addressing the problem with interventional strategies could be the next step.

Study 2 evaluated neuropsychological functions, intelligence, mental health problems (CMD, PTSD), trauma load, and psychotic symptoms with khat and alcohol use among khatchewing students of Jimma university. The following diagnostic tools were selected for assessing the neuropsychological executive functions: Tower of Hanoi (ToH) and Corsi blocktapping task (CBT). The score for intelligence was assessed by Raven's SPM. Moreover, AUDIT, LEC-5, PCL-5 and SRQ-20 were the psychometric instruments used to assess clinical information. Selected questions from Composite International Diagnostic Interview (CIDI) were used to diagnose psychotic symptoms. Results indicated no significant relationship of neuropsychological tests, mental health variables and intelligence with the participants' khat use and alcohol use. The counselors' reports regarding the CIDI in terms of khat-related psychotic symptoms revealed 25% of the participants reported khat-induced psychotic symptoms. The results of the ToH, CBT and Raven's SPM were in a normal range. Trauma load and PTSD symptoms were weakly associated with two CBT coefficients but not with the ToH coefficients. The ToH time in seconds result from this study was less than from khat users and non-users among Somalian refugees in Kenya (Widman et al., 2017). The executive test results had significant but low positive relationships with Raven's SPM, which is supported by other research findings (Carpenter, Just & Shell 1990). The mean score for the correct forward attempts in the Corsi block-tapping task from this study was higher than the score achieved by neurological patients but lower than the one from healthy controls in the Netherlands (Kessels, Zandvoort, Postma & Kappelle, 2000).

The second study also indicated a weak association between the participants' neuropsychological and intelligence performance with khat use. Executive cognitive functions were normal despite heavy khat use. The result could be related to the not yet chronic use patterns among the young homogeneous participants. The results show that practical on-campus prevention and intervention measures might have a successful chance of reducing the negative consequences of khat use in the long term. This study results indicated a high burden

in substance use, trauma exposure, and psychological disorders. The challenges faced to include female participants need further investigation and other strategies. In a nutshell, strategic plans to develop specific research instruments and screening methods that are compulsory. The neuropsychological and intelligence test findings were among the first studies using this kind of diagnostic tools with Ethiopian students, requiring comparative research.

The following results from other samples indicated mental health as a common challenge among university students. A study among 4330 students at Onsekiz Mart University in Turkey (Oyekcin, Sahin & Aldemir 2017) revealed that 15.1% of the students reported suicidal thoughts at least once in their lifetime, 28.2% ever had depression, 33.1% screened positive for anxiety disorder. A prevalence study among 5000 Australian university students (Larcombe et al., 2016) regarding psychological distress revealed 13% of respondents reported severe or extremely severe levels of depressive symptoms, 22% were experiencing moderate symptoms of psychological distress and over half the sample was in the normal or mild range. A webbased survey from the University of Michigan at Midwestern University (N=2843) with a response rate of 56.6% indicated the estimated prevalence of any depressive or anxiety disorders was 15.6% for undergraduates and 13.0% for graduate students (Dzierzewski et al.,2020).

6. General Discussion

The results from our studies on khat use patterns and associated features and on neuropsychological executive functions revealed the necessity for preventive, interventional and integrated treatment strategies for khat and other substance misuse for students during their time at the university. In this period of lifetime, khat use has not yet reached chronicity, intellectual functions are unaffected and, thus, prevention and treatment can be taken up and have a good chance to avoid development of problems or restore functioning without lasting deficits; furthermore, students can be reached much easier by prevention campaigns and they themselves can reach treatment much easier than later in their lives because they are concentrated around a campus where the respective services are located.

6.1 Conclusions and Recommendations

As our study confirmed and Ethiopia's federal government recognized it, khat is a substance of concern among students (the Federal Democratic Republic of Ethiopia, Ministry of Education, 2010; (Gebrehanna, Berhane, & Worku, 2014). According to (Geberie, Alebel, Zegeye & Tesfaye 2018) the khat chewing prevalence among Ethiopian university students was slightly more than 1 in 5. Another study among 651 medical students from Jimma university indicated that lifetime and current prevalence of khat use were 26.3% and 23.9% (Abedeta et al., 2017). Peer influence is one factor for khat use among university students (Astatkie et al., 2015). The above studies highlighted the widespread use of khat among Ethiopian university students. Our data from a khat counseling-seeking student sample added information on the excessiveness of use patterns and on the prevalence of comorbid mental health problems. The prevalence of CMD found in our sample exceeded the reported results of most other studies: In a study that involved 290 Jimma university medical students, the prevalence rate of CMD was 35.2% (Kerebihe et al., 2017). A cross-sectional study among 422 students at Debre Berhan University students revealed three out of five students suffered from CMD, the prevalence rate of CMD among Ethiopian university students was 37.7% (Mekuriaw et al. 2020). The studies further recommended the importance of interventional and stress coping techniques. A comprehensive and prevention approach involving various stakeholders that incorporate students, the university officials, and the surrounding community are mandatory (Astatkie et al., 2015).

A study on neuropsychological functioning, which was assessed using the Behavioral Assessment and Research System (BARS) among khat chewers and non-khat chewers in the Jazan region of Saudi Arabia result indicated khat chewers performed significantly flawed in neuropsychological tests that included motor speed, set shifting/response inhibition function

(Ismail et.al, 2014). The performance in the Corsi block-tapping task of the university students in this study was worse than those of healthy controls from a study in the Netherlands (Kessels, Zandvoort, Postma & Kappelle, 2000) and of healthy US students from Cincinnati University (Pagulayan, Busch, L. Medina & John A, 2003). In the Tower of Hanoi, our Ethiopian university student sample scored better than Somali refugees with and without khat use in Nairobi (Odenwald et al., 2012) but in the same range as a sample of US students from the University of Colorado (Emick, 2005). For making the comparison with the western setting studies, culture and norm should be taken into consideration. According to (Rosselli & Ardila 2003), neuropsychological tests are not universal. They pointed out in relation to timed nonverbal tests that measuring speed performance might be affected by the participants' perception of time restrictions in the culture. Therefore, speed performance tests might be culturally biased.

The following three recommended approaches are considered practical for the treatment of substance use in Ethiopia. Community Reinforcement Approach (CRA), Motivational Interviewing (MI) and Relapse Prevention (RP). These recommended evidence-based treatment approaches will be discussed in brief.

The Community Reinforcement Approach is a comprehensive cognitive-behavioral intervention manual in which the environment is considered a significant change agent to continue or stop substance use (i.e., familial, social, recreational, and occupational). CRA has shown its effectiveness in several meta-analytical reviews of treatments for alcoholism, and it ranked among the best five interventional programs. (Meyers, Roozen & Smith, 2011). CRA is stated as suitable for diverse clients ranging from mild to severe alcohol problems, and its goal is to reduce or stop drinking. It is also found to be effective in treating both inpatients and outpatients in rural and urban settings. Moreover, the program is flexible, and it contained quite

a variety of tools, e.g. specific skill training or couple's therapy which might be effective for students with diverse socioeconomic status and ethnic background. The manual and its specific tools need to be adapted to the Ethiopian culture and to khat as the main target. CRA is especially appropriate for addressing khat misuse because the behavioral skill training includes new and practical coping skills including healthy and assertive communication skills, structured problem solving and drug(khat) and drink refusal that entails role plays that might be interesting for the university students.

Motivational Interviewing (MI) is the second suggested strategy. It is a general psychotherapeutic approach to prepare, support, and strengthen a client's attempts to change a problematic behavior not requiring any motivation as pre-requirement. This approach appeared for the first time in 1982 in Norway. In 1991, the first Motivational Interviewing book was published, which targeted addiction (Miller & Rollnick 2013). Since then, numerous books and articles from different authors were published, applying MI to a range of different problem behaviors, such as alcohol and illicit substance use, cigarette smoking, inactivity, unhealthy diet, and suicidality. There are four significant steps in MI, according to (Miller & Rollnick 2013). The first step is called engaging. It is the process of developing a helpful connection and working relationship. The authors explained engaging as the most essential and fundamental practice during MI. The first process, which is engaging, cleans the pavement for the second process which is focusing. The core of focusing is finding specific goals or planned outcomes that direct the process of the therapy. The focus not only arises from the client but also from the context of the therapist. Moreover, the general principles of counseling can also include directing, guiding, and following. The third process, which is known as evoking, involves various procedures or strategies that can be used to elicit motivation and commitment for a change. When a client shows change talk, the therapist should recognize and strengthen it by asking for elaboration, by affirmation, reflection, and summarization. The last process in MI is planning, which is a approach to move the client's change forward. The ultimate movement

from evoking to planning could be guided by the degree of readiness of the client. It might be inappropriate and unwise to do the planning before the client has developed readiness to change, Asking the client key questions and recapitulations are main indicators of whether it is the right time for planning or whether it is still premature. Developing a change plan is a process of moving from a general intention to a specific implementation plan. MI has been used in different cultures and makes use of general psychological processes that apply for a wide range of behaviors. It seems especially appropriate for khat users because it increases the individual motivation for change in an environment in which chewing is normal and does not require high resources. MI is also adaptable and can be integrated with other treatment interventions for instance it was used with ASSIST among Khat using Somalian refugees living in Kenya (Widman 2017).

Relapse Prevention (Marlatt and Donovan 2008) is based on the cognitive-behavioral framework and its primary goals are to identify the significant challenges of people who already stopped their substance use and to develop techniques for preventing or managing its reoccurrence. RP searches and identifies high-risk factors in which the client is vulnerable to relapse. RP integrates theoretic models of relapse and plenty of specific and general intervention techniques that permit the therapist and the client to address each step in the relapse process. The specific intervention incorporates identifying specific high-risk situations for each client and enhancing the client's ability to cope with these situations. RP emphasizes the workingalliance between therapist and client, improvement of self-efficacy, changing wrong perceptions regarding alcohol effects, managing lapses and restructuring the client's view of the relapse process. RP need to be modified for khat use and it can also be applied for the comorbid alcohol and other substances use. RP contains self-help interventions which is commonly utilized in smoking that can be appropriate and practical to khat using university students. RP together with the mindfulness-based treatments hold promise for prevention of relapse that can be adoptable to different cultures (Brandon, Vidrine & Litvin 2007).

Our data highlight the need for the assessment, interventional and integrated treatments for khat, alcohol and substance use and comorbid mental health problems. With basic treatment training for university counselors and health care professionals who are directly working with students on complex mental health problems, the approaches mentioned above are considered practical for the highly burdened university students with diverse backgrounds.

Author contribution

The present dissertation consists of an abstract, a preface, a theoretical background discussion, conclusion and recommendation together with two research studies. I am responsible for conception, design, data acquisition and analysis, interpretation and writing the dissertation.

Study 1: Khat use patterns, associated features, and psychological Problems in a counseling-seeking student sample in Ethiopia

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Contribution: I contributed to study design and data assessment; I carried out statistical analysis and drafted the manuscript together with Dr Michael Odenwald.

Status: in preparation.

Study 2: Neuropsychological and intellectual functions among khat using students at Jimma University (Ethiopia) and their association to mental health

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Contribution: I contributed to study design and data assessment; I carried out statistical analysis and drafted the manuscript together with Dr Michael Odenwald. *Status:* in preparation.

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Abbreviation

ANOVA	–	Analysis of Variance
AUDIT	–	Alcohol Use Disorders Identification Test
CBT	–	Corsi Block Tapping Task
CGPA	–	Cumulative Grade Point
CIDI	–	Composite International Diagnostic Interview
CMD	–	Common Mental Disorders
CRA	–	Community Reinforcement Approach
JU	–	Jimma University
LEC-5	–	Life Events Checklist for DSM-5
MI	–	Motivational Interviewing
PCL-5	–	Posttraumatic Stress Disorder Checklist for DSM-5
PTSD	–	Posttraumatic Stress Disorder
Raven SPM's	–	Raven standardized Progressive Matrices
RCT	–	Randomized Controlled Trail
RP	–	Relapse Prevention
SOCRATES	–	Stages of Change Readiness and Treatment Eagerness Scale
SPSS	–	Statistical Package for Social Science
SRQ-20	–	Self Report Questionnaire 20 items
TLFB	–	Timeline Follow Back
ToH	–	Tower of Hanoi
WHO	–	World Health Organization

Literature

- Abdeta, T., Tolessa, D., Adorjan, K., and Abera, M. (2017). Prevalence, withdrawal symptoms and associated factors of khat chewing among students at Jimma University in Ethiopia. *BMC Psychiatry* 17(1), 142. doi: 10.1186/s12888-017-1284-4.
- Adorjan, K., Odenwald, M., Widmann, M., Tesfaye, M., Tessema, F., Toennes, S., et al. (2017). Khat use and occurrence of psychotic symptoms in the general male population in Southwestern Ethiopia: evidence for sensitization by traumatic experiences. *World Psychiatry* 16(3), 323. doi: 10.1002/wps.20470.
- Ahmed A., Ismail, Rashad M., El Sanosy, Diane S., Rohlman & Maged ElSetouhy. (2014). Neuropsychological Functioning Among Chronic Khat Users in Jazan Region, Saudi Arabia, *Substance Abuse*, 35:3, 235-244, doi: [10.1080/08897077.2013.832469](https://doi.org/10.1080/08897077.2013.832469)
- Ainamani ,H.E., Mbarara,G.Z., & Hecker, T. (2020). Child maltreatment, cognitive functions and the mediating role of mental health problems among maltreated children and adolescents in Uganda. *Research Square* ,DOI: <https://doi.org/10.21203/rs.3.rs-75462/v1>
- Ainamani,H.E, Elbert, T., Olema ,D.K, & Hecker.T, (2017). PTSD symptom severity relates to cognitive and psycho-social dysfunction a study with Congolese refugees in Uganda. *European Journal of Psychotraumatology*, 8:1, DOI: [10.1080/20008198.2017.1283086](https://doi.org/10.1080/20008198.2017.1283086)
- Alemseged, F., Haileamlak, A., Tegegn, A., Tessema, F., Woldemichael, K., Asefa, M., et al. (2012). Risk factors for chronic non-communicable diseases at gilgel gibe field research center, southwest Ethiopia: population based study. *Ethiopian journal of health sciences* 22(S), 19-28.
- Ali, A.D., Al-Adhroey, A.H., Al-Shammakh, A.A., Mehrass, A.A.O., Jaber,H.Y., Mujlli,H.M. A Pilot Community-Based Study on Association of Khat (*Catha edulis*) Chewing Practice with Psychosis in Yemen. *American Journal of Health Research*. Vol. 3, No. 2, 2015, pp. 91-96. doi: 10.11648/j.ajhr.20150302.16
- Al-Sanosy, M. (2009) Pattern of Khat abuse and academic performance among secondary school and college students in Jazan region, kingdom of Saudi Arabia (KSA) *Journal Family Community Medical*; 16(3): 89–95 PMID: PMC3377048
- Astatkie, A., Demissie, M., Berhane, Y., & Worku, A. (2015b). Prevalence of and factors associated with regular khat chewing among university students in Ethiopia. *Substance Abuse Rehabil*, 6, 41-50. doi:10.2147/SAR.S78773

- Ayana, A.M., and Mekonen, Z. (2004). Khat (*Catha edulis* Forsk) chewing, sociodemographic description and its effect on academic performance, Jimma University students 2002. *Ethiopian Medical Journal* 42(2), 125-136.
- Baddeley, B., (2003) Working Memory: Looking Back and Looking Forward: *Nature Reviews Neuroscience*, 829:837 doi:10.1038/nrn1201
- Bahhawi, T.A., Albasheer, O.B., Makeen, A.M., Arishi, A.M., Hakami, O.M., Maashi, S.M., et al. (2018). Depression, anxiety, and stress and their association with khat use: a cross-sectional study among Jazan University students, Saudi Arabia. *Neuropsychiatr Dis Treat* 14, 2755-2761. doi: 10.2147/NDT.S182744.
- Balint, G. A., Ghebekidan, H., & Balint, E. E. (1991). *Catha edulis*, an international socio-medical problem with considerable pharmacological implications. *East African medical journal*, 68(7), 555–561
- Barbor, T.F., Higgins-Biddle, J.C., Saunders, J.B., and 614 Monteiro, M.G. (2001). The Alcohol Use Disorders Identification Test: Guidelines for Use in Primary Care, Second Edition. (Geneve: World Health Organization)
- Beckerleg, S. (2010). East African discourses on khat and sex. *Journal Ethnopharmacol*.
- Bhui, K., Craig, T., Mohamud, S., Warfa, N., Stansfeld, S. A., Thornicroft, G., . . . McCrone, P. (2006). Mental disorders among Somali refugees: Developing culturally appropriate measures and assessing socio-cultural risk factors. *Social Psychiatry and Psychiatric Epidemiology*, 41(5), 400–408. <https://doi.org/10.1007/s00127-006-0043-5>
- Bovin, M.J., Marx, B.P., Weathers, F.W., Gallagher, M.W., Rodriguez, P., Schnurr, P.P., et al. (2016). Psychometric properties of the PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (PCL-5) in veterans. *Psychological Assessment* 28(11), 1379-1391. doi: 10.1037/pas0000254.
- Boys, A., and Marsden, J. (2003). Perceived functions predict intensity of use and problems in young polysubstance users. *Addiction* 98(7), 951-963.
- Brandon, H.T., Vidrine, I.J., Litvin, B.E. (2007) Relapse and Relapse Prevention Annual Review of Clinical Psychology 3:1, 257-284
- Burgess, p., Duncan, J., Emslie, H. (1995) Fluid intelligence after frontal lobe lesions *Neuropsychologia*, 33,(3)261-268 ISSN 0028-3932, [https://doi.org/10.1016/00283932\(94\)00124-8](https://doi.org/10.1016/00283932(94)00124-8).
- Burke, R.H. (1985) RAVEN'S Progressive Matrices (1938): More on Norms, Reliability, and Validity. *Journal of Clinical Psychology* Vol 4, No2
- Carpenter, P.A., Just, M.A., and Shell, P. (1990) What One Intelligence Test Measures: A Theoretical Account of the Processing in the Raven Progressive Matrices Test. *The American Psychological Association, Inc.* 0033-295X/90/S00.75

- Colzato L.S., Ruiz MJ., van den Wildenberg WPM, Bajo M.,T &Hommel B.(2010). Long-term effects of chronic khat use: impaired inhibitory control. *Frontiers in Psychology* 1(219) doi: 10.3389/fpsyg.2010.00219
- Colzato L.S., Ruiz MJ., Wery P.M., van den Wildenberg & Hommel B.(2012). Khat use is associated with increased response conflict in humans *PLoS ONE*, DOI: 10.1002/hup.2229
- Colzato LS, Ruiz MJ, van den Wildenberg WPM, Hommel B (2011) Khat Use Is Associated with Impaired Working Memory and Cognitive Flexibility. *PLoS ONE* 6(6): e20602. <https://doi.org/10.1371/journal.pone.0020602>
- Corsi, P. M.(1972).Human memory and the medial temporal region of the brain. *Dissertation Abstracts International*, 34, 819B.
- Cox, G., & Rampes, H. (2003). Adverse effects of khat: a review. *Advances in Psychiatric Treatment*, 9(6), 456–463. <https://doi.org/10.1192/apt.9.6.456>
- Damena, T., Mossie, A., and Tesfaye, M. (2011). Khat chewing and mental distress: a communitybased study, in Jimma city, southwestern Ethiopia. *Ethiopian Journal Health Sci* 21(1), 37-45.
- De Braabandere, B., Neven,D ., Gool L.V., (2017). Semantic Instance Segmentation with a Discriminative Loss Function: *Deep Learning for Robotic Vision, workshop at CVPR* <https://arxiv.org/abs/1708.02551>
- Dessie, G. (2016). "Land and Water for Drugs, Cash for Food: Khat Production and Food Security in Ethiopia," in *A History of Water. Volume 3: Water and food from hunter gatherers to global production in Africa*, eds. T. Tvedt & T. Oestigaard. (London, New York:I.B.Tauris), 482-501.
- Dhadphale, M., and Omolo, O.E. (1988). Psychiatric morbidity among khat chewers. *East Africa Medical Journal* 65(6), 355-359.
- Dires, E., Soboka, M., Kerebih, H., and Feyissa, G.T. (2016). Factors Associated with Khat Chewing among High School Students in Jimma Town Southwest Ethiopia. *Journal of Psychiatry* 19:4(372), 1-5. doi: 10.4172/2378-5756.1000372.
- Duresso, S. W., Bruno, R., Matthews, A. J., & Ferguson, S. G. (2018). Stopping khat use: Predictors of success in an unaided quit attempt. *Drug and alcohol review*, 37 Suppl 1, S235-S239. doi:10.1111/dar.12622
- Dzierzewski, J.M, Ravyts, S.J, Dautovich,N.D, Perez,E., Schreiber, D.,Rybarczyk,B.D. (2020). Mental health and sleep disparities in an urban college sample: A longitudinal examination of White and Black students, *Journal of Clinical Psychology*, 10.1002/jclp.22974, 76, 10, (1972-1983), [.Wiley Online Library](https://doi.org/10.1002/jclp.22974)
- Ekhtiari,H., Zare-Bidoky,M. & Verdejo-Garcia, A. (2021) Neurocognitive Disorders in Substance Use DisordersSpringer Nature Switzerland AG 115 N. el-Guebaly et al. (eds.), *Textbook of Addiction Treatment*, https://doi.org/10.1007/978-3-030-36391-8_81

- Emick, J., Welsh, M. (2005) Association between formal operational thought and executive function as measured by the Tower of Hanoi-Revised, *Learning and Individual Differences* Volume 15 ,*Elsevier*
- Ersche, K.D., Sahakian, B.J. (2007)The Neuropsychology of Amphetamine and Opiate Dependence: Implications for Treatment. *Neuropsychol Rev* **17**, 317–336. <https://doi.org/10.1007/s11065007-9033-y>
- Ethiopian College Students (2020): A Systematic Review and Meta-Analysis. *Psychiatry Journal*, 1462141. doi: 10.1155/2020/1462141.
- Federal Democratic Republic of Ethiopia, Ministry of Education. (2010). *Education Sector Development Program IV (ESDP IV)* . Addis Ababa. Retrieved from
- Fekadu, A., Desta, M., Alem, A., and Prince, M. (2007). A descriptive analysis of admissions to Amanuel Psychiatric Hospital in Ethiopia. *Ethiopian Journal Health Dev* 21(2), 1-6.
- Field, A. (2013). *Discovering statistics using IBM SPSS*. London: Sage.
- Field, A. (2013). *Discovering statistics using IBM SPSS*. London: Sage.
- Gajera C. (2017.) Tower of Hanoi Algorithm. *Code Nuclear a source of Knowledge*.
- Gebissa, E. (2008). Scourge of Life or an Economic Lifeline? Public Discourses on Khat (*Catha edulis*) in Ethiopia *Substance Use & Misuse* 43:784–802
- Gebissa, E.(2004). Leaf of Allah: Khat & Agricultural Transformation in Harerge, Ethiopia 18751991 James Currey **ISBN:085255480X** *Ohio university Press* 88-109
- Gebrehanna, E., Berhane, Y., & Worku, A. (2014). Khat chewing among Ethiopian University Students--a growing concern. *BMC Public Health*, 14, 1198. doi:10.1186/1471-2458-14-1198
- Gebrehanna, E., Berhane, Y., & Worku, A. (2014a). Khat chewing among Ethiopian University Students--a growing concern. *BMC Public Health*, 14, 1198. doi:10.1186/1471-2458-14-1198
- Gebrehanna, E., Berhane, Y., and Worku, A. (2014). Prevalence and predictors of harmful khat use among university students in Ethiopia. *Substance Abuse* 8, 45-51. doi: 10.4137/SART.S14413.
- Gebreslassie, M., Feleke, A. & Melese, T. (2013). Psychoactive substances use and associated factors among Axum university students, Axum Town, North Ethiopia. *BMC Public Health* **13**, 693. <https://doi.org/10.1186/1471-2458-13-693>
- Gebrie, A., Alebel, A., Zegeye, A., and Tesfaye, B. (2018). Prevalence and predictors of khat chewing among Ethiopian university students: A systematic review and meta-analysis. *PLoS One* 13(4), e0195718. doi: 10.1371/journal.pone.0195718.
- Girma, E., Assefa, T., and Deribew, A. (2010). Cigarette smokers' intention to quit smoking in Dire Dawa town Ethiopia: an assessment using the Transtheoretical Model. *BMC Public Health* 10, 320. doi: 10.1186/1471-2458-10-320.

- Goel, V., & Grafman, J. (1995) Are the frontal lobes implicated in "planning" functions? Interpreting data from the Tower of Hanoi: *Neuropsychologia*, .33(5), 623-642.
- Grant B.F., Stinson F.S., Dawson D.A., et al. (2004) Prevalence and Co-occurrence of Substance Use Disorders and Independent Mood and Anxiety Disorders: Results from the National Epidemiologic survey on Alcohol and Related Conditions. *Arch Gen Psychiatry*. 2004;61(8):807–816. doi:10.1001/archpsyc.61.8.807
- Gray, M.J., Litz, B.T., Hsu, J.L., and Lombardo, T.W. (2004). Psychometric properties of the life events checklist. *Assessment* 11(4), 330-341.
- Grevenstein, D., Nagy, E., and Kroeninger-Jungaberle, H. (2015). Development of risk perception and substance use of tobacco, alcohol and cannabis among adolescents and emerging adults: evidence of directional influences. *Subst Use Mis use* 50(3), 376-386. doi: 10.3109/10826084.2014.984847.
- Gulec, D.O, Sahin, E.M ., Aldemir,E. (2017). Mental health, suicidality and hopelessness among university students in Turkey *Asian Journal of Psychiatry*, 185-189
- Haile, D., and Lakew, Y. (2015). Khat Chewing Practice and Associated Factors among Adults in Ethiopia: Further Analysis Using the 2011 Demographic and Health Survey. *PLoS One* 10(6), e0130460. doi: 10.1371/journal.pone.0130460
- Hanlon, C., Medhin, G., Alem, A., Araya, M., Abdulahi, A., Hughes, M., et al. (2008). Detecting perinatal common mental disorders in Ethiopia: validation of the self reporting questionnaire and Edinburgh Postnatal Depression Scale. *J Affect Disord* 108(3), 251-262. doi: 10.1016/j.jad.2007.10.023.
- Harding, T.W., Climent, C.E., Diop, M., Giel, R., Ibrahim, H.H., Murthy, R.S., et al. (1983). The WHO collaborative study on strategies for extending mental health care, II: The development of new research methods. *The American journal of psychiatry* 140(11), 1474-1480.
- Haug, S., Paz Castro, R., Kowatsch, T., Filler, A., and Schaub, M.P. (2017). Efficacy of a technology-based, integrated smoking cessation and alcohol intervention for smoking cessation in adolescents: Results of a cluster-randomised controlled trial. *J Subst Abuse Treat* 82, 55-66. doi: 10.1016/j.jsat.2017.09.008.
- Helmer, S.M, Mikolajczyk, R.T, McAlaney ,J., Vriesacker ,B., Van Hal, G., Akvardar, Y. GuillenGrima, F., Salonna, F., Stock, C ., Dempsey, R.C ., Bewick, B.M Zeeb. H. Illicit (2014) substance use among university students from seven European countries: A comparison of personal and perceived peer use and attitudes towards illicit substance use, *Preventive Medicine: Science Direct* ,<https://doi.org/10.1016/j.yjmed.2014.07.039>. Hoaglin, D.C., and Iglewicz, B. (1987). Fine-tuning some Resistant Rules for Outlier Labeling. *Journal of the American Statistical Association* 82(400), 1147-1149.

- Hoaglin, D.C., and Iglewicz, B. (1987). Fine-tuning some resistant rules for outlier labeling. *Journal of the American Statistical Association* 82(400), 1147-1149.
- Kalix, P. (1992). Cathinone, a natural amphetamine. *Pharmacol Toxicol* 70(2), 77-86.
- Hoffman R., al' Absi M.,(2013) Working Memory and Speed of Information Processing in Chronic Khat Users: Preliminary Findings: *Eur Addict Res* 19 (1-6). doi: 10.1159/000338285
- Horn, R. *Raven's Standard Progressive Matrices*.(2009) *Classic, Parallel, Plus*. (2nd ed.), Frankfurt: Pearson
- Ismail, A.A, El Sanosy ,R.M, . Rohlman, D.S,& El-Setouhy,M. (2014) Neuropsychological Functioning Among Chronic Khat Users in Jazan Region, Saudi Arabia, *Substance Abuse*, 35:3, 235-244, DOI:
- Jain, A. (2017) The power of Hanoi using recursion (C++ Program) *Include help.com* Inhanced by Google
- Kalix, P. (1990). Pharmacological properties of the stimulant khat. *Pharmacology & therapeutics*, 48(3), 397–416. [https://doi.org/10.1016/0163-7258\(90\)90057-9](https://doi.org/10.1016/0163-7258(90)90057-9)
- Kalix, P. (1992). Cathinone, a natural amphetamine. *Pharmacology & toxicology*, 70(2), 77–86. <https://doi.org/10.1111/j.1600-0773.1992.tb00434.x>
- Kassa, A., Loha, E., and Esaiyas, A. (2017). Prevalence of khat chewing and its effect on academic performance in Sidama zone, Southern Ethiopia. *Africa Health Science* 17(1), 175-185. doi: 10.4314/ahs.v17i1.22.
- Kerebih, H., Abera, M., and Soboka, M. (2017a). Pattern of Help Seeking Behavior for Common Mental Disorders among Urban Residents in Southwest Ethiopia. *Quality in Primary Care* 25(4), 208-2016.
- Kerebih, H., Ajaeb, M., and Hailesilassie, H. (2017b). Common mental disorders among medical students in Jimma University, SouthWest Ethiopia. *Africa Health Science* 17(3), 844-851. doi: 10.4314/ahs.v17i3.27.
- Kerebih, H., and Soboka, M. (2016). Prevalence of Common Mental Disorders and Associated Factors among Residents of Jimma Town, Southwest Ethiopia. *Journal of Psychiatry* 19(4), 373. doi: 10.4172/2378-5756.1000373.
- Kessels, R.P.C., Zandvoort, M. J. E., Postma, A., Kappelle L.J.(2000)The Corsi Block-Tapping Task: Standardization and Normative: *Applied Neuropsychology*, 4:252–258
- Khurana, A.,Romer,D., Betancourt .L.M., Hurt,H.(2017) Working memory ability and early drug use progression as predictors of adolescent substance use disorders; *Society for the Substance Addiction* <https://doi.org/10.1111/add.13792>

- Klein, A. (2014). "Framing the chew: Narratives of development, drugs and danger with regard to khat (catha edulis)," in *Prohibition, Religious Freedom, and Human Rights: Regulating Traditional Drug Use*, eds. B.C. Labate & C. Cavnar. (Berlin: Springer).
- Klepper, S., Odenwald, M., and Rockstroh, B. (2016). Risikowahrnehmung und Alkoholabhängigkeit. *Sucht* 62(6), 374-382.
- Kolb, B., Wishaw, I.Q. (2009). *Fundamentals of Human Neuropsychology*.
- Krikorian, A.D. (1984). Kat and its use: an historical perspective. *Journal of Ethnopharmacology* 12, 115-178. [https://doi.org/10.1016/0378-8741\(84\)90047-3](https://doi.org/10.1016/0378-8741(84)90047-3)
- Larcombe, W., Finch, S., Sore, R., Murray, C.M., Kentish, S., Mulder, R.A., Lee-Stecum, P., Baik, C., Tokatlidis, O., Williams, D.A. (2016) Prevalence and socio-demographic correlates of psychological distress among students at an Australian Studies in Higher Education, 41:6, 1074-1091, DOI: [10.1080/03075079.2014.966072](https://doi.org/10.1080/03075079.2014.966072)
- Lemma, S., Berhane, Y., Worku, A., Gelaye, B., Williams, M.A. (2014) Good quality sleep is associated with better academic performance among university students in Ethiopia. *Sleep Breath* 18, 257–263. <https://doi.org/10.1007/s11325-013-0874-8>
- Lucas, É. (2012). In Wikipedia, The Free Encyclopedia. Retrieved from http://en.wikipedia.org/wiki/%C3%89douard_Lucas
- Marlatt, G. & Donovan, M.D. (2008). Relapse Prevention Maintenance strategies in the Treatment of Addictive Behavior. *Division of Guilford*.
- Mekuriaw, B., Zegeye, A., Molla, A., Hussen, R., Yimer, S., and Belayneh, Z. (2020). Prevalence of Common Mental Disorder and Its Association with Khat Chewing among Ethiopian College Students: A Systematic Review and Meta-Analysis. *Psychiatry Journal*:1462141.
- Meyers, R.J., Roozen, H.G., & Smith, J.E. (2011) The Community Reinforcement Approach An Update of the Evidence <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3860533>, (4):380-388
- Mihretu, A., Teferra, S., and Fekadu, A. (2017). What constitutes problematic khat use? An exploratory mixed methods study in Ethiopia. *Substance Abuse Treat Prevention Policy* 12(1), 17. doi: 10.1186/s13011-017-0100-
- Miller, W. R., & Rollnick, S. (2012). *Motivational interviewing: preparing people to change addict behavior*. New York: Guilford Press.
- Miller, W.R., and Tonigan, J.S. (1996). Assessing drinker's motivation to change: The Stages of Change Readiness and Treatment Eagerness Scale (SOCRATES). *Psychology of Addictive Behaviors* 10(2), 81-89.
- Odenwald M., Klein A., Warfa N. (2021) Khat Addiction. In: el-Guebaly N., Carrà G., Galanter M., Baldacchino A.M. (eds) *Textbook of Addiction Treatment*. Springer, Cham. https://doi.org/10.1007/978-3-030-36391-8_17

- Odenwald, M. (2007). Chronic khat use and psychotic disorders: a review of the literature and future prospects. *Sucht* 53(1), 9-22.
- Odenwald, M., and Al'Absi, M. (2017). Khat use and related addiction, mental health and physical disorders: the need to address a growing risk. *Eastern Mediterranean Health Journal* 23(3), 236-244.
- Odenwald, M., and Al'Absi, M. (2017). Khat use and related addiction, mental health and physical disorders: the need to address a growing risk. *Eastern Mediterranean Health Journal* 23(3), 236-244.
- Odenwald, M., Hinkel, H., Schauer, E., Neuner, F., Schauer, M., Elbert, T.R., et al. (2007). The consumption of khat and other drugs in Somali combatants: a cross-sectional study. *PLOS Medicine* 4(12), e341. doi: 10.1371/journal.pmed.0040341.
- Odenwald, M., Klein, A., & Warfa, N. (2015). Khat Addiction. In N. el-Guebaly, G. Carrà, & M. Galanter (Eds.), *Textbook of Addiction Treatment: International Perspectives* (pp. 455–466). Milano: Springer Milan. https://doi.org/10.1007/978-88-470-5322-9_19
- Odenwald, M., Klein, A., and Warfa, N. (2020). "Khat Addiction," in *Textbook of Addiction Treatment: International Perspectives*, eds. N. El-Guebaly, G. Carra & M. Galanter. 2nd Edition ed (New York: Springer).
- Odenwald, M., Lingenfelder, B., Peschel, W., Haibe, F. A., Warsame, A. M. [Abdirisak Mo-hamed], Omer, A., Elbert, T. (2012). A pilot study on community-based outpatient treatment for patients with chronic psychotic disorders in Somalia: Change in symptoms, functioning and co-morbid khat use. *International Journal of Mental Health Systems*, 6(1), 8. <https://doi.org/10.1186/17524458-6-8>
- Odenwald, M., Mikulica, J., von Beust, J., Widmann, M., Ndetei, D., al'Absi, M. (2012). Severe khat abuse is related to executive dysfunctions: A pilot study among Somali refugees in Kenya. Poster presentation. 14th Annual Meeting of the International Society of Addiction Medicine, Geneva, Switzerland, 14.-18.10.2012.
- Odenwald, M., Neuner, F., Schauer, M., Elbert, T.R., Catani, C., Lingenfelder, B., et al. (2005). Khat use as risk factor for psychotic disorders: A cross-sectional and case-control study in Somalia. *BMC Med* 3(1), 5.
- Odenwald, M., Warfa, N., Bhui, K., and Elbert, T. (2010). The stimulant khat-Another door in the wall? A call for overcoming the barriers. *Journal of Ethnopharmacology*. <https://www.sciencedirect.com/science/article/pii/S0378874109007004>
- Owen, A. M., Downes, J. J., Sahakian, B. J., Polkey, C. E., & Robbins, T.W. (1990) Planning and spatial working memory following frontal lobelesions in man: *Neuropsychologia*, 28(10), 1021-1034.
- Oyekcin,D.g., Sahin, E.M., Aldemir,E. (2017). Mental health, suicidality and hopelessness among university students in Turkey *Asian Journal of Psychiatry*, 185-189 of Psychiatry, Volume 29, ISSN1872018, <https://doi.org/10.1016/j.ajp.2017.06.007>. (<https://www.sciencedirect.com/science/article/pii/S1876201816305226>)

- Pagulayan, K.F., Busch, R.M., Medina, K.L., Bartok, J.A. & Krikorian, R. (2006) Developmental Normative Data for the Corsi Block-Tapping Task, *Journal of Clinical and Experimental Neuropsychology*, 28:6, 1043-1052, DOI:10.1080/13803390500350977
- Prochaska, J.O., and Velicer, W.F. (1997). The transtheoretical model of health behavior change. *American Journal Health Promotion* 12(1), 38-48. doi: 10.4278/0890-1171-12.1.38.
- Ramey, T., & Regier, P. (2019). Cognitive impairment in substance use disorders. *CNS Spectrums*, 24(1), 102-113. doi:10.1017/S1092852918001426
- Raven, J. C. (1976). Standard Progressive Matrices, Sets A, B, C, D & E. Prepared by J.C. Raven. Oxford: *Oxford Psychologists Press*.
- Raven, J., C. (1936). Mental tests used in genetic studies: The performance of related individuals on tests mainly educative and mainly reproductive. (*MSc Thesis*), University of London,
- Raven, J., C. (1940). Matrix Tests. *Mental Health (London)*, 1(1), 10-18.
- Raven, J.C. (2000) The Raven's Progressive Matrices: Change and Stability over Culture and Time: *Great King Street, Edinburgh EH3 6QH, Scotland* <http://www.idealibrary.com> on
- Reda, A. A., Moges, S., Biadgilign and B. Y. Wondmagegn (2012). "Prevalence and determinants of khat (*Catha edulis*) chewing among high school students in eastern Ethiopia: a cross-sectional study." *PLoS ONE* 7(3): e33946.
- Robinson, S.M., Sobell, L.C., Sobell, M.B., and Leo, G.I. (2014). Reliability of the Timeline Followback for cocaine, cannabis, and cigarette use *Psychology of Addictive Behaviors* 28(1), 154-162. doi: 10.1037/a0030992.
- Rosselli, R., & Ardila, A. (2003) The impact of culture and education on non-verbal neuropsychological measurements: A critical review, *Brain and Cognition*, Volume 52, 3
- Salame, P., Danion, J. M., Peretti, S., & Cuervo, C. (1998) The state of functioning of working memory in schizophrenia. *Schizophr Res.*, 30 (1), 11-29.
- Scholte, W.F., Verduin, F., van Lammeren, A. *et al.* Psychometric properties and longitudinal validation of the self-reporting questionnaire (SRQ-20) in a Rwandan community setting: a validation study. *BMC Medical Research Methodology* 11, 116 (2011). <https://doi.org/10.1186/1471-2288-11-116>
- Siddi, S., Preti, A., Lara, E., Brébion, G., Vila, R., Iglesias, M., Cuevas-Esteban, J., López-Carrilero, R., Butjosa, A. & Haro, J.M. (2020) Comparison of the touch-screen and traditional versions of the Corsi block-tapping test in patients with psychosis and healthy controls. *BMC Psychiatry* 20, 329 (2020). <https://doi.org/10.1186/s12888-020-02716-8>
- Sobell, L.C., Agrawal, S., Annis, H., Ayala-Velazquez, H., Echeverria, L., Leo, G.I., et al. (2001). Cross-cultural evaluation of two drinking assessment instruments: alcohol timeline followback and inventory of drinking situations. *Substance Use and Misuse* 36(3), 313-331. doi: 10.1081/ja-100102628

- Teklie, H., Gonfa, G., Getachew, T., Defar, A., Bekele, A., Bekele, A., et al. (2017). Prevalence of Khat chewing and associated factors in Ethiopia: Findings from the 2015 national Noncommunicable diseases STEPS survey. *Ethiopian Journal of Health Development* 31, 320-330
- Valente, M.J., Guedes de Pinho, P., de Lourdes Bastos, M. et al. Khat and synthetic cathinones: a review. *Archives of Toxicology* 88, 15–45 (2014). <https://doi.org/10.1007/s00204-013-1163-9>
- Van de Vijver, F.J.R., and Tanzer, N.K. (1997). Bias and equivalence in cross-cultural assessment: An overview. *European Review of Applied Psychology* 47(4), 263-280.
- Vass, V.A. (1992). *Standardization of Ravens standard progressive matrices for secondary school African pupils in Grahamstown region* (Master's thesis) Arts of Rhodes University, South Africa.
- Verdejo-García, A., López-Torrecillas, F., Giménez, C.O. et al. ((2004). Clinical Implications and Methodological Challenges in the Study of the Neuropsychological Correlates of Cannabis, Stimulant, and Opioid Abuse. *Neuropsychol Rev* 14, 1–41 <https://doi.org/10.1023/B:NERV.0000026647.71528.83>
- Wabe, N.T. (2011). Chemistry, pharmacology, and toxicology of khat (*catha edulis forsk*): a review. *Addict Health* 3(3-4), 137-149.
- Warfa, N., Klein, A., Bhui, K., Leavey, G., Craig, T., & Alfred Stansfeld, S. (2007). Khat use and mental illness: A critical review. *Social Science & Medicine* (1982), 65(2), 309–318. <https://doi.org/10.1016/j.socscimed.2007.04.038>
- Widmann, M., Apondi, B., Musau, A., Warsame, A.H., Isse, M., Mutiso, V., et al. (2017). Comorbid psychopathology and everyday functioning in a brief intervention study to reduce khat use among Somalis living in Kenya: description of baseline multimorbidity, its effects of intervention and its moderation effects on substance use. *Soc Psychiatry Psychiatr Epidemiol*. doi: 10.1007/s00127-017-1368-y.
- Widmann, M., Warsame, A.H., Mikulica, J., von Beust, J., Isse, M.M., Ndeti, D., et al. (2014). Khat Use, PTSD and Psychotic Symptoms among Somali Refugees in Nairobi - A Pilot Study. *Frontiers Public Health* 2, 71. doi: 10.3389/fpubh.2014.00071.
- Yitayih, Y., Abera, M., Tesfaye, E., Mamaru, A., Soboka, M., and Adorjan, K. (2018). Substance use disorder and associated factors among prisoners in a correctional institution in Jimma, Southwest Ethiopia: a cross-sectional study. *BMC Psychiatry* 18(1), 314. doi: 10.1186/s12888018-1901-x.
- Yitayih, Y., Soboka, M., Tesfaye, E., Abera, M., Mamaru, A., and Adorjan, K. (2019). Trauma exposure and alcohol use disorder among prisoners in Jimma Zone correctional institution, Southwest Ethiopia: a cross-sectional study. *BMC Res Notes* 12(1),. doi:10.1186/s13104-0194796-9.

Zelger, J. L., Schorno, H. X., & Carlini, E. A. (1980). Behavioral effects of cathinone, an amine obtained from *Catha edulis* Forsk.: comparisons with amphetamine, norpseudoephedrine, apomorphine and nomifensine. *Bull Narc*, 32(3), 67–81.