DISSERTATION

Higher education – Epidemiology of cannabis use among Berlin college students

Higher education – Epidemiologie des Cannabiskonsums Berliner Studierender

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12Mp	Twelve-month-prevalence
30Dp	Thirty-day-prevalence
BAföG	Bundesausbildungsförderungsgesetz (public financial aid law for German students)
BIS	Barrett impulsivity scale (Barratt, 1959)
BtMG	Betäubungsmittelgesetz (German federal narcotics regulation)
CAGE-AID	“Cutting down, Annoyance by criticism, Guilty feeling, and Eye-opener“ Adapted to Include Drugs screening test (Brown & Rounds, 1995)
CBD	Cannabidiol
CUD	Cannabis use disorder
EMCDDA	European Monitoring Centre for Drugs and Drug Addiction
EU	European Union
GHB	γ-hydroxybutyric acid
HAPA	Health Action Process Approach
LOC	Locus of control (Rotter, 1966)
LSD	Lysergic acid diethylamide
MDMA	3,4-Methyl-enedioxy-methamphetamine
MMM	Marijuana Motives Measure (J. Simons et al., 1998)
P1	Publication 1 (Naegele et al., 2022)
P2	Publication 2 (Naegele et al., 2023)
S1, resp. S2	Survey 1, resp. survey 2; the two waves of data collection
SGIC	Self-generated identification code
THC	Tetrahydrocannabinol

Abstract

Cannabis is the most frequently used illegal substance in the world. This dissertation focuses on the cannabis use of Berlin college students, who are at particularly high risk for cannabis use disorders (CUD), due to: (a.) the high prevalence of cannabis use in his age group, (b.) the cultural context of Berlin's nightlife scene, and (c.) decreasing perceived harmfulness of cannabis in a context of legalization debates.

We collected a large data set on substance use via a web-based survey, with invitations sent out to nearly all students of Berlin's public institutions of higher education. The data was analyzed using univariate descriptive statistics and multivariate logistic regressions. For the first publication (P1; Naegele et al., 2022), a motivation scale was developed using exploratory factor analysis. For the second publication (P2; Naegele et al., 2023), we merged two survey waves and analyzed cannabis use change within individuals over two years.

The first publication P1 showed that Berlin college students endorsed coping motives for cannabis use more often than other populations in the literature. All cannabis use motives increased cannabis use frequency, but in the literature as in our data, mainly coping motives were associated with CUD.

The second publication P2 showed that cross-sectional results differed from dynamic results regarding use change in longitudinal data. The main factors for cannabis use initiation were young age, high impulsivity, tobacco and alcohol use; compared to the main factors for cannabis use reduction, which were female gender, young age, internal LOC and no tobacco use. The strong contemporary (cross-sectional) effect of perceived harm did not translate into corresponding use change, and the intention to reduce had no impact on the likelihood to reduce cannabis use.

Our results confirmed previous results of the literature. Notably, our data corroborated the well-established link between coping motives and cannabis use-related problems. Additionally, some risk factors for cannabis use initiation in adolescence (e.g. impulsivity, tobacco use) and reduction (e.g. LOC) could be confirmed in our sample of young adults.

Our results showed that Berlin college students were a particular population, who both used cannabis more frequently and were at higher risk of CUD.

Further research will be necessary to verify whether some novel results of this research hold outside the Berlin college population. In particular, factors of cannabis use change beyond adolescence have been studied very little. We found that well-established factors for use initiation in adolescence (e.g. religiosity, male gender) or use cessation (e.g. religiosity, LOC) could not be confirmed for our sample of young adults.

Zusammenfassung

Cannabis ist die weltweit am häufigsten konsumierte illegale Substanz. Diese Dissertation konzentriert sich auf den Cannabiskonsum von Berliner Studierenden, die ein besonders hohes Risiko für Cannabiskonsumstörungen (CUD) aufweisen, aufgrund (a.) der hohen Prävalenz des Cannabiskonsums in ihrer Altersgruppe, (b.) des kulturellen Hintergrunds der Berliner Clubkultur, und (c.) der abnehmenden wahrgenommenen Schädlichkeit von Cannabis im Rahmen von Legalisierungsdebatten.

Wir haben umfangreiche Daten zum Substanzkonsum durch eine webbasierte Umfrage erhoben, zu der alle Studierenden der öffentlichen Berliner Hochschulen eingeladen wurden. Die Daten wurden mit univariaten deskriptiven Statistiken und multivariaten logistischen Regressionen analysiert. Für die erste Publikation (P1; Naegele et al., 2022) wurde eine Motivationsskala mittels explorativer Faktorenanalyse entwickelt. Für die zweite Veröffentlichung (P2; Naegele et al., 2023) haben wir Daten von zwei Zeitpunkten zusammengeführt und die Veränderung des Cannabiskonsums innerhalb von zwei Jahren analysiert.

P1 zeigte, dass Berliner Studierende häufiger Problembewältigung als Motiv für den Cannabiskonsum angaben als andere Stichproben in der Literatur. Alle Motive des Cannabiskonsums erhöhten die Häufigkeit des Cannabiskonsums, aber in der Literatur wie in unseren Daten wurden hauptsächlich Bewältigungsmotive mit CUD in Verbindung gebracht.

P2 zeigte, dass sich die Querschnittsergebnisse von den dynamischen Ergebnissen bezüglich der Nutzungsänderung in den Längsschnittdaten unterschieden. Die Hauptfaktoren für den Beginn des Cannabiskonsums waren junges Alter, hohe Impulsivität, Tabak- und Alkoholkonsum; die Hauptfaktoren für die Reduzierung des Cannabiskonsums waren weibliches Geschlecht, junges Alter, interner LOC und kein Tabakkonsum. Der starke Effekt der wahrgenommenen Schädlichkeit im Querschnitt führte nicht zu entsprechenden Ergebnissen in der Veränderung des Cannabiskonsums, und die Absicht, den Cannabiskonsum zu reduzieren, blieb meist ohne Konsequenz.

Unsere Ergebnisse bestätigten frühere Ergebnisse der Literatur. Insbesondere bestätigten unsere Daten den bekannten Zusammenhang zwischen Bewältigungsmotiven und problematischem Cannabiskonsum. Darüber hinaus konnten einige Risikofaktoren für

den Beginn des Cannabiskonsums im Jugendalter (z. B. Impulsivität, Tabakkonsum) und die Reduzierung (z. B. LOC) in unserer Stichprobe junger Erwachsener bestätigt werden.

Unsere Ergebnisse zeigten, dass Berliner Studierende eine besondere Population waren, die sowohl häufiger Cannabis konsumierten, als auch ein höheres CUD-Risiko hatten.

Weitere Untersuchungen sind notwendig, um zu überprüfen, inwiefern einige neue Ergebnisse dieser Forschung außerhalb der Berliner Hochschulpopulation gelten. Insbesondere die Faktoren, die den Cannabiskonsum über die Pubertät hinaus verändern, wurden nur wenig untersucht. Etablierte Faktoren für den Konsumbeginn im Jugendalter oder die Konsumbeendigung konnten für unsere Stichprobe junger Erwachsener nicht bestätigt werden.

1. Introduction

1.1. Study rationale and background

1.1.1. General

In Germany (as in many countries of the world), cannabis is the most widely used illegal substance with a lifetime prevalence of 28%, twelve-month-prevalence (12Mp) of 7% and thirty-day-prevalence (30Dp) of 3% (Seitz et al., 2021), which is roughly equivalent to the average prevalence in the European Union (EMCDDA (European Monitoring Centre for Drugs and Drug Addiction), 2021). Young adults have the highest use prevalence of all age groups (Seitz et al., 2021). Even though most of the literature on initiation concentrates on adolescence (Suerken et al., 2016), cannabis use initiation often occurs during college years (Arria et al., 2008).

Berlin is internationally famous for its nightlife and techno scene (Betzler et al., 2019). There is a substantial literature showing a relationship between “club culture” and a high risk of substance use (Ding et al., 2014; Kelly et al., 2006; Palamar et al., 2015). The term “club drugs” refers mostly to speed, MDMA (ecstasy), LSD, cocaine, GHB and ketamine, but studies show that most users of club drugs additionally use cannabis (Hannemann et al., 2017). The rate of cannabis dependence and abuse (as defined in DSM-IV) is more than twice as high in Berlin than in any other region of Germany (Seitz et al., 2020).

Worldwide, the past decade has seen an unprecedented push towards legalization of cannabis, both for medical and for recreational use. This legal shift is both an expression and an accelerator of shifting social norms: perceived harmfulness decreases (Keyes et al., 2016) and social acceptability of cannabis use increases (Barbosa-Leiker et al., 2020) dramatically. Moreover, legalization increases availability, which has been shown to moderately increase cannabis use among adults without any significant effect on adolescents’ cannabis use (W. Hall & Lynskey, 2020; Laqueur et al., 2020; Smart & Pacula, 2019; Zuckermann et al., 2021).

Berlin college students are thus at risk both by their age, by their local cultural environment and by the changing zeitgeist on the perceived risk of cannabis use. The research presented in this dissertation gives an update on the epidemiology of cannabis use among Berlin college students, and its correlates.

1.1.2. High-risk population

Tucker et al. (2005) see emerging adulthood (18-23 years) as one of “two important periods of vulnerability for substance use.” They describe this phase as a “developmental period characterized by heightened exploration and change,” often involving risky behavior as these subjects start escaping parental control.

College-aged young adults (for this study defined as 18 to 25 years old) have the highest cannabis use rates in Germany (Seitz et al., 2021) and elsewhere (e.g. SAMHSA, 2021). In Germany, college students have a slightly lower cannabis use prevalence than the overall 18-25 year old population (8% 30Dp, 21% 12Mp for students (Grützmacher et al., 2018) vs. 10% 30Dp, 24% 12Mp for age group 18-25 (Seitz et al., 2021)). In a US sample, McCabe et al. (2021) found no significant difference in the cannabis use of college students and same-age subjects not enrolled in college.

Berlin is famous for its nightlife and thereby both attracts students interested in club culture (selection) and provides opportunities to join this scene (incitation). Compared to other federal states, Berlin has a much higher prevalence of cannabis use with an overall 12Mp of 17% in 2018, more than twice as high as most other federal states (national average 12Mp 7%, Seitz et al., 2020). Traditionally, federal states from West Germany had higher cannabis use rates than states from the East. In all states, the consumption rates have steeply increased since reunification and the difference between east and west has been reduced, albeit still existing (Seitz et al., 2020).

Among college students in Berlin, only the substance use of students from the Free University Berlin has been surveyed so far (Gusy et al., 2022). These college students have a 30Dp of 13%, which is moderately higher than the average rate among Berlin residents aged between 18 and 25 years (Seitz et al., 2020) and considerably higher than the prevalence of German college students elsewhere.

Given the particular context of Berlin’s nightlife reputation and the high-risk age group, Berlin college students are a risk group for high substance use and in particular high cannabis use. Before the surveys used in this dissertation, there was no recent overview of the overall epidemiology of substance use among college students of all higher education institutions in Berlin.

1.1.3. Legal context

Since early 2010s, many countries in the world have seen unprecedented shifts in the legal treatment of cannabis. At first, many countries legalized cannabis and/or drugs based on cannabis for medical purposes. Some have since proceeded to legalize cannabis fully even for recreational use; notable examples include Uruguay and Canada. Figure 1 summarizes the legal status of cannabis as of June 2022 internationally.

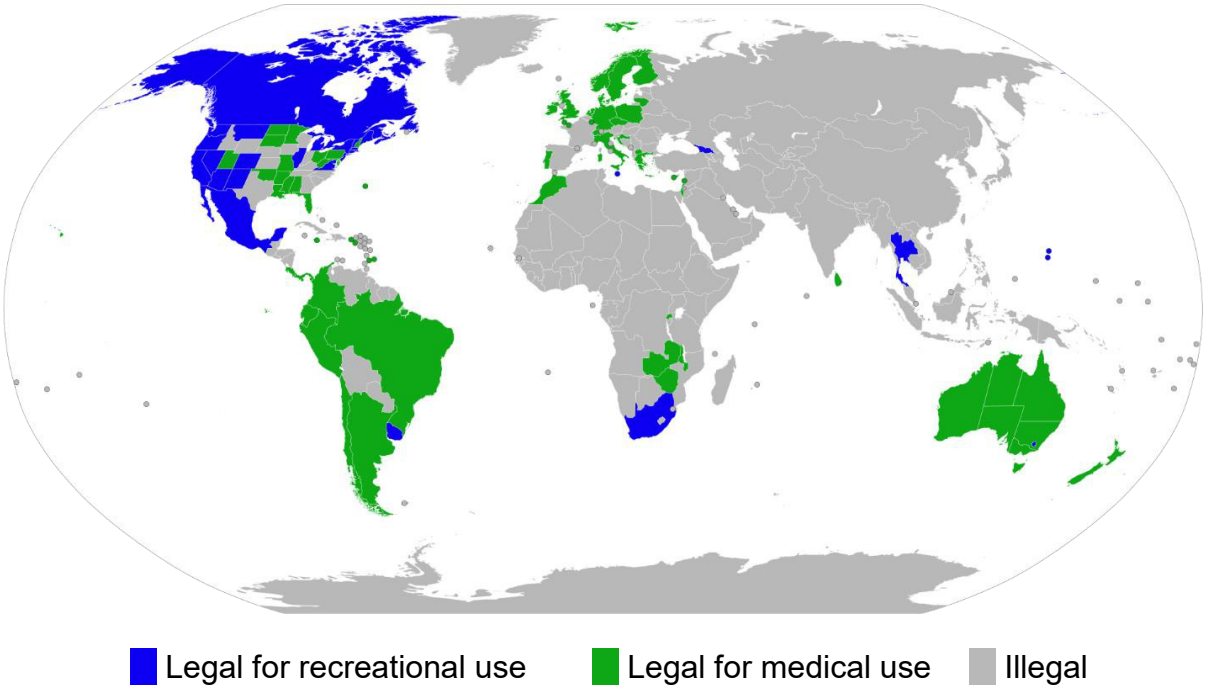

Figure 1. Legal status of cannabis for medical use (status as of June 2022)

Data from Wikipedia: Legality of cannabis. Map does not reflect countries that have approved use of isolated cannabinoid drugs, such as Sativex or Marinol. Figure from Wikimedia Commons, constantly updated version is accessible under: https://commons.wikimedia.org/wiki/File:Map-of-world-medical-cannabis-laws.svg, consulted on 15/08/2022. Creative commons license BY-SA 4.0.

In Germany, medical products based on cannabis are legal on prescription since May 2010 (Annex III Betäubungsmittelgesetz (BtMG, German federal narcotics regulation)) and cannabis can be prescribed directly since March 2017 (Annex III BtMG; Schürenkamp, 2022).

For recreational use, cannabis and products containing relevant amounts of tetrahydrocannabinol (THC) are not legalized. Their cultivation, production, import, export, sale, distribution and ownership remain illegal in Germany (§§ 29 BtMG onwards; Anenx I BtMG). Small amounts, considered to cover only personal consumption, can remain exempt from

punishment (§ 31a BtMG) and the percentage of suspended procedures falling under this exemption has increased in recent years (Hofmann, 2022). The consumption of cannabis itself is not judicially indictable, as it is considered a self-inflicted risky behavior ("eigenverantwortliche Selbstschädigung", Graebsch, 2019). Cannabidiol (CBD) is classified a "non-psychotropic" cannabinoid and therefore is not subject to narcotics regulation (Schürenkamp, 2022). Nevertheless, life-style products based on CBD have to be authorized individually under the regulation of novel foods (NFR, EU regulation 2015/2283 of the European Parliament).

In 2021, the newly elected federal government of Germany included the legalization of recreational cannabis use in their coalition agreement (SPD, B90/Grüne, FDP, 2021). It is not yet clear how this legalization will be realized within a prohibitive Europe and international legal framework (Hofmann, 2022).

The impact of recreational cannabis legalization on cannabis use is so far not clearly established in the literature (Smart & Pacula, 2019). In Canada, Turna et al. (2021) found a significant increase of cannabis use (frequency and quantity), especially among those adults not using cannabis pre-legalization. In the United States, some researchers find that legalization had no effect on cannabis use (Smart & Pacula, 2019), while some find that recreational cannabis legalization increased use (Kerr et al., 2017, on a sample of college students) and some find it decreased use (Anderson et al., 2021, on a sample of adolescents).

Beyond the increased availability of cannabis, recreational cannabis legalization also correlates with a reduced risk perception associated with cannabis use (Keyes et al., 2016). Within a context of discussed legalization of recreational cannabis use in Germany and elsewhere, it appears essential to provide detailed research on the epidemiology and characteristics of cannabis use.

The scientific work at hand examines recreational cannabis use in Berlin, which remains illegal. Data on such illegal practices is scarce and data collection potentially subject to biases. In order to address this problem, we emphasized anonymity of respondents.

1.2. State of the literature

1.2.1. Socio-demographic correlates of cannabis use

The literature has firmly established that **male** subjects use cannabis more often and are about twice as likely to experience CUD (Gusy et al., 2022; Hayatbakhsh et al., 2009). Surveying a large body of literature, Hemsing & Greaves (2020) find that men/boys use cannabis more, but that this gender gap is narrowing as gender roles become more permissive. The authors associate cannabis use with male typicality and male gender roles, so that they call for gender transformative principles in cannabis use prevention campaigns.

Similarly, **religiosity** has been shown repeatedly to reduce the likelihood of cannabis use and CUD (Mader et al., 2019; McCabe et al., 2021; White et al., 2006). There seems to exist a complex relationship between individual religiosity and contextual (e.g. school-level) religiosity, where both levels reinforce the protective effect of the other (Wallace et al., 2007).

Socio-economic status is a wider construct, which results of an interaction of education (own and those of parents), income (own and living environment average) and occupation. In Chan et al. (2018), all three levels are shown to correlate with the frequency of cannabis use. However, in other studies parent's education (Mader et al., 2019; Suerken et al., 2014; Sussman & Dent, 2004) and disposable income (Suerken et al., 2014) do not correlate with cannabis use, whereas family-level and neighborhood-level income influence cannabis use trajectory (Arria et al., 2016; Caldeira et al., 2012; Vijapur et al., 2021). Socio-economic status as measured by occupation correlates with cannabis use (Redonnet et al., 2012), but the direction of causality is not clear.

In US American studies, **race/ethnicity** is a standard covariate of substance use studies: white and Hispanic students use cannabis most, followed closely by African Americans, and Asian college students use cannabis the least (McCabe et al., 2007). Except for the difference with Asian students, the differences are not large in magnitude and the difference between black and white youth has decreased over the past years, as blacks increased and whites decreased their cannabis use (Johnston et al., 2019). In European contexts, much less is known about the impact of race/ethnicity on substance use. In Germany, it is generally not possible to collect data on race/ethnicity:

> *"The colour-blind approach [in] some countries (e.g. France, Denmark, Germany and Sweden) prohibits the collection of ethnic and racial data"* (Balestra & Fleischer, 2018).

Our questionnaire (and data set) thus did not include any information on race/ethnicity.

1.2.2. Personality

Beyond sociodemographic variables, personality traits have been used to explain substance use.

Internal/external locus of control (Rotter, 1966) describes whether an individual believes that the control over their life outcomes lies within or outside of themselves. External **locus of control** (LOC) is associated with tobacco and alcohol consumption (Lassi et al., 2019). Overall, however, "although locus of control is one of the most extensively investigated constructs in psychological and social science literature […], its use by substance abuse researchers has been limited" (E. A. Hall, 2001), but there is some evidence that external LOC correlates with lifetime cannabis use (Ernst-Linke et al., 2022; Helmer et al., 2012; Mendolia & Walker, 2014).

Impulsivity has been described as a "temperamental vulnerability factor for substance use" (Acton, 2003) and is an established risk factor for cannabis use intensity and use-related problems (Ernst-Linke et al., 2022; Kearns et al., 2022). However, some studies show that despite higher use rates, impulsivity may not increase the risk of cannabis dependence (Conrod et al., 2000). More specifically, impulsivity is associated with cannabis use for coping motive, which is associated to more cannabis-related problems than cannabis use for other motives (Hecimovic et al., 2014).

Within the **Five Factor Model** (McCrae & Costa, 1987), most literature finds openness and neuroticism are positively and conscientiousness negatively related to cannabis use; overall, effect sizes are usually small and the effects of extraversion and agreeableness are unclear (Ernst-Linke et al., 2022; Fridberg et al., 2011; Terracciano et al., 2008). The fact that the literature has struggled to establish a clear personality structure of cannabis users may be explained by the fact that cannabis is used for more diverse motivations than e.g. cocaine (Hecimovic et al., 2014).

Strong associations have been found between cannabis use and **psychiatric disorders**, in particular alcohol and nicotine use disorders, mood disorders, anxiety disorders, personality disorders, and posttraumatic stress disorder (Caldeira et al., 2008; Hasin, 2018). The most frequently associated diagnosis are depression, schizophrenia and psychotic disorders. However, the causal links are not always clear: cannabis and psychiatric disorders might cause one another, or share an external common etiology.

In particular, cannabis use has been associated with schizophrenia and psychosis (W. Hall & Degenhardt, 2009; Marconi et al., 2016), and even healthy cannabis users show more **schizotypical traits**, defined as traits reflecting "psychosis proneness," than non-users (Dumas et al., 2002; Fridberg et al., 2011; González et al., 2000), suggesting a common etiology hypothesis. Structural equation modelling suggests that cannabis use increases psychosis risk, with increasing levels of use leading to increased risk (Fergusson et al., 2005; National Academies of Sciences, Engineering, and Medicine, 2017). Reviewing experimental literature, Hindley et al. (2020) provides evidence of *acute* psychotic symptoms caused by THC exposure to healthy subjects; however, the persistence of these symptoms beyond the acute effect time span of the drug is not examined.

1.2.3. Beliefs

Subjective norms, i.e. the perceived social pressure, and perceived harm have been discussed as useful targets for cannabis use prevention interventions (Blevins et al., 2018).

Studies show that a long-term trend of students increasingly viewing cannabis consumption as harmless (Hasin, 2018; Johnston et al., 2019; Meier et al., 2012). The literature has established a solid inverse relationship between **perceived risk/harmfulness** and cannabis use frequency/intensity (Bachman et al., 1988; Johnston et al., 2019; Mader et al., 2019; Neighbors et al., 2008; Pacek et al., 2015; Piontek et al., 2013).

"**Injunctive norms**", i.e. others' approval of use, is shown to predict cannabis use frequency if they come from friends but not from parents (Buckner, 2013).

Adolescents and young adults have been shown to dramatically over-estimate peer substance use, ("**descriptive norm**"; Sanders et al., 2013; Dempsey et al., 2016; Blevins et al., 2018; Buckner, 2013). In an international study, high school students are over-estimating their peer's cannabis use in 25 out of 35 European countries (Piontek et al., 2013). Assuming that cannabis use among their peers is frequent is associated with more frequent own cannabis consumption (Buckner, 2013; Dempsey et al., 2016; Neighbors et

al., 2008; Piontek et al., 2013). This misperception holds mostly for general peer usage, while close friends' cannabis consumption is accurately estimated (Mason et al., 2019). Moreover, having friends with higher drug consumption is associated with higher own consumption (Hernández-Serrano et al., 2015).

1.2.4. Risk-taking behavior

Cannabis use has been shown to correlate with other risky behavior, in particular use of other substances.

Compared to subjects using only cannabis, those using both cannabis and **tobacco** present higher cannabis use rates and more use-related problems (Peters et al., 2012). Moreover, co-users have a harder time quitting cannabis use (Masters et al., 2018; Zuckermann et al., 2019). Similarly, the severity of alcohol use predicts cannabis use severity (Mader et al., 2019).

In particular for women, cannabis use is associated with a higher risk to engage in **unprotected sexual intercourse** (Moure-Rodriguez et al., 2016). The personality traits underlying cannabis use, such as external LOC and low self-esteem, also correlate with early and unprotected sexual activity (Mendolia & Walker, 2014). Supporting the idea of common etiology rather than direct causality, Buckner et al. (2018) find that the low condom use of cannabis users may be explained by fewer condom-related protective behavior strategies (e.g. keeping condoms handy). Cannabis use is also associated with having more different sexual partners (Castilla et al., 1999).

Cannabis use is associated with **poor educational outcomes**, such as higher drop-out rates from college and lower average grades (Arria et al., 2016; Horwood et al., 2003; Lynskey & Hall, 2000; Suerken et al., 2016). Causality is not clear in the literature. Some longitudinal studies suggest that early cannabis use increases the risk for poor educational outcomes, mediated mostly through social context and the adoption of an "anti-conventional lifestyle" (Lynskey & Hall, 2000).

1.2.5. Motives

Cannabis use motives have been studied using a variety of measurement tools. The Marijuana Motives Measure (MMM) (J. Simons et al., 1998) distinguishes five use motives: coping, enhancement, social, conformity and expansion motives. Many researchers rely on the MMM (e.g. Benschop et al., 2015; Bujarski et al., 2012; Van Der Pol et al., 2013).

However, this is not the only established measurement tool: some authors include additional motives to the MMM (Benschop et al., 2015), while others have created distinct questionnaires, such as the Comprehensive Marijuana Motives Questionnaire with twelve distinct motives (Blevins et al., 2016; Lee et al., 2009) or the substance use functions questionnaire by Boys et al. (2001).

Research usually finds that cannabis use intensity/frequency correlates positively with agreement to *all* motives (Blevins et al., 2016; Bonar et al., 2017; Patterson et al., 2020; J. S. Simons et al., 2005).

Coping motives have been studied more in detail, because of the solidly established link between coping motives and negative outcomes (CUD and use-related problems), even when controlling for frequency of use (Blevins et al., 2016; Brodbeck et al., 2007; Buckner et al., 2014; Fox et al., 2011; Mader et al., 2019; Schultz et al., 2019; J. S. Simons et al., 2005; Van Der Pol et al., 2013).

Generally, the authors see coping mechanism as a channel leading from personal characteristics, such as social anxiety (Buckner et al., 2014; Johnson et al., 2010) or lack of distress tolerance (Bujarski et al., 2012), to problematic use. Glodosky & Cuttler (2020) explain a vicious cycle dynamic, where cannabis is used to cope with negative affect (stress, depression, anxiety), but itself reinforces negative affect. Thus, cannabis use appears a dysfunctional coping mechanism.

Occasionally, some authors fail to find the link between CUD and coping motives (Buckner et al., 2019; Chabrol et al., 2005; Patterson et al., 2020) and rather find associations with other motives, e.g. expansion motives (Patterson et al., 2020).

Hecimovic et al. (2014) describes the “heterogeneity in cannabis use motives” as depending on personality traits: in her study, “anxiety sensitivity was associated with cannabis use for conformity”, introversion/hopelessness with coping, sensation seeking with expansion.

Although coping motives are the most clearly identified problematic cannabis use motive, they are rather rare. In most samples of the literature, enhancement, social and expansion motives (from the MMM) are more common than coping and only conformity is less common (Bujarski et al., 2012; Johnson et al., 2010; J. Simons et al., 1998; van der Pol et al., 2013).

1.2.6. Use setting (location)

Alternatively to use motives, the literature has studied cannabis use contexts as defined by location or setting.

Adapted from the literature on alcohol consumption (Gonzalez & Skewes, 2013), the literature on cannabis use settings has focused on the distinction between social and solitary use (Buckner et al., 2016; Guo et al., 2021; Noack et al., 2011; Tucker et al., 2006). Solitary cannabis use has been associated with problematic outcomes (Guo et al., 2021; Noack et al., 2011; Tucker et al., 2006).

Occasionally, use settings have been studied more in detail in the alcohol literature, for example distinguishing restaurant, bar, home, park, party (Nyaronga et al., 2009). Regarding cannabis use, Looby et al. (2021) is the only article so far examining use locations ("at their home, at a friend's home, at a stranger's home, outside, in a car, at a party, other") and their link to simultaneous alcohol and cannabis use. Espinosa et al. (2022) distinguish many different social contexts of cannabis use (roommate, partner, family, stranger) and show their relationship to cannabis use motive groups.

However, some authors define "cannabis use contexts" more abstractly between use motives and use settings. The Social Context of Cannabis Use Scale (SCCUS; Beck et al., 2009) distinguishes the use contexts: social facilitation, emotional pain, sex seeking, peer acceptance. The Inventory of Marijuana Situations (IMS; Blevins et al., 2014) possible use contexts are: negative affective use (related to coping motive), social use (related to social, enjoyment), positive affective use. In this dissertation, "use settings strictly" refers to concrete location, not to the functional/motivational context.

1.2.7. Use trajectories: initiation and cessation

For simplicity, most literature focuses on cross-sectional prevalence. However, interventions in practice always act on a given a status quo and therefore target change outcomes such as initiation, cessation or reduction. Thus, cross-sectional analysis may not provide the relevant information for interventions.

College years are the time where adolescents turn into young adults and progressively escape their parents' control. The literature on cannabis use initiation focuses on adoles-

cents (Suerken et al., 2016), but “some youths increase their substance use during adolescence, whereas escalation does not occur for others until the college years” (Tucker et al., 2005).

For high school students/adolescents, a meta-study of literature until 2002 (Guxens, Nebot, Ariza, et al., 2007) has established following factors for cannabis use initiation: male (positively associated, +), age (-), tobacco, alcohol and other drug use (+), and peer cannabis use (+). These factors have largely been confirmed in more recent research (Guxens, Nebot, & Ariza, 2007; Pérez et al., 2010; Poikolainen et al., 2001; Schmits et al., 2015). More recently, the literature has added new factors, such as positive use expectancies (Montes et al., 2019; Schmits et al., 2015), social anxiety (Schmits et al., 2015) and early age at first sexual intercourse (Poikolainen et al., 2001).

Comparing the factors of cannabis initiation during freshman year (Hispanic ethnicity; living on campus; alcohol, tobacco and other drug use; sensation seeking) with factors for pre-college initiation (male; white; spending money >1000USD; low religiosity; alcohol, tobacco and other drug use; sensation seeking), Suerken et al. (2014) find considerable differences. On the opposite, Pinchevsky et al. (2012) find that initiation during college-years is associated with the standard factors identified in the literature on adolescents.

Few authors analyze the factors associated with cannabis use cessation. A notable exception is the study by Payne et al. (2018), showing that young adults who quit cannabis use were older, more often female, white, less tobacco users, and lower-intensity alcohol users than those who maintained cannabis use.

Sociology research has argued that some users may want to cut down instead of quitting and disavowing cannabis use, because cannabis-related lifestyle may become part of the user’s identity (Dahl, 2015).

1.3. Research questions

The main objective of this dissertation was to give an updated overview of the epidemiology of cannabis use of Berlin college students.

In this synopsis (“Manteltext”), I give an overview of the data and a detailed literature review. I describe the difference between the first and second survey wave (S1 and S2) and examine the self-selection into the panel data set. I also provide additional detail on the procedure of merging the two survey waves.

In P1, we described the cannabis use motives of Berlin college students. In particular, we studied how these use motives related to frequent cannabis use and to CUD in a cross-sectional design.

In P2, we investigated longitudinally what factors predicted initiation/cessation of cannabis use over two years of college-time. Studying the differences between college students who changed and those who maintained their cannabis use is essential for designing policy and interventions.

2. Methods

2.1. Sample and procedure

The survey was sent to most students of public higher education in Berlin (17 institutions) via the official university mailing lists in November 2016 (survey 1, S1) and May 2018 (survey 2, S2). Participation was incentivized with the chance to win €100 (prize given once) or Amazon vouchers worth €20 (prize given five times), in order to increase the response rate.

The total number of subjects who received the invitation e-mail was not known. The size of the target population is equal to the number of students registered in Berlin, i.e. N_{S1}=119,652 in autumn 2016 (50.3% female) and N_{S2}=122,911 in summer 2018 (50.4% female; Statistisches Bundesamt, 2022).

Data was collected via self-administered online surveys, the complete questionnaire can be found in the Appendix (reproduced from Viohl et al., 2019). Participants entered their data via a web-interface, managed with the open source platform 'SoSci Survey' (program-version 2.6.00-i, Munich, Germany). The Ethics Committee of the Charité University Berlin (application number: EA1/258/16) and commissioner of data privacy approved the study.

2.2. Data variables

2.2.1. Outcomes

The main outcome of interest for the research included in this dissertation was the cannabis use intensity. We constructed this variable from two items: the cannabis use prevalence ("Have you ever consumed one of the following substances? Cannabis" – never, once, within the last 12 months, within the last month) and the cannabis use frequency ("How often do you consume the following substances? Cannabis" – never, less than once a month, monthly, 2-4 times a months, 2-3 times a week, more than 3 times a week). Use intensity is defined for 9 levels, similarly to Simons et al. (1998): "8 (> 3/week), 7 (2-3/week), 6 (2-4/month), 5 (monthly), 4 (less than monthly, but within past month), 3 (less than monthly, but within last 12 months), 2 (less than monthly, but not in past 12 months), 1 (never, but has tried), 0 (never tried)" (Naegele et al., 2022).

P1 worked with the four-item “Cutting down, Annoyance by criticism, Guilty feeling, and Eye-opener“ Adapted to Include Drugs (CAGE-AID) screening test (Brown & Rounds, 1995). The binary indicator variable was positive if the respondent gave two or more “yes” answers (Naegele et al., 2022).

P2 defined both static (i.e. cross-sectional) and dynamic outcomes. The cross-sectional outcomes were regular use in S1 and regular use in S2. For those not using cannabis in S1, we defined initiation as any use in the last 12 months (use intensity>2). For those using cannabis regularly, we defined reduction as having a lower use intensity in S2 than in S1 and we defined cessation as not having used cannabis within past 12 months (use intensity≤2; Naegele et al., 2023).

2.2.2. Socio-demographic variables

Respondents were asked about their gender (female, male, other), their birth year, and nationality. We asked about their level of religiosity (5-point Likert-scale) and past psychiatric diagnosis (binary, then free input of diagnosis).

We assessed their economic status by asking about income, public financial aid (after German Federal Law on Training and Education Promotion, or short “BAföG”; this public aid is attributed based on parents’ income and served as a proxy for socio-economic status) and living situation (with parents, in own apartment, in shared living-accommodation, in dormitory, other). We also asked how they financed their studies (with the support of their family, working, scholarship, BAföG, savings, other) and whether they had any debt currently (binary, then amount).

Their study situation was assessed by asking for the number of years at university (“Hochschulsemester”), their level of education (“Fachsemester”), and their academic performance (“rate your academic performance”: better-worse compared to fellow students; average mark last semester; average mark overall; development over past year).

We assessed relationship status (single, married, divorced, monogamous relationship, open relationship, other) and sexual orientation (heterosexual, homosexual, bisexual, other). In order to assess sexual risk taking, we asked about unprotected intercourse (number of partners within past 6 months), and defined risky behavior as “unprotected intercourse with more than one regular partner” (Naegele et al., 2023).

2.2.3. Psychometric variables

The questionnaire measured two established personality traits. Impulsivity is “characterized by rapid, unplanned actions regardless of possible negative consequences” (Meule et al., 2011). We use the BIS-15 questionnaire from Meule et al. (2011) to measure impulsivity along the Barratt Impulsiveness Scale (BIS).

Internal/external locus of control (LOC) refers to the individual’s “generalized expectancy” that “reward follows from […] his own behavior or attributes versus the degree to which he feels the reward is controlled by forces outside of him-self and may occur independently of his own actions” (Rotter, 1966). We use the 10-item questionnaire of the German Socio-Economic Panel (Richter et al., 2017) to measure LOC.

P1 uses a 20-item questionnaire on cannabis use motives adapted from Boys et al. (2001); please refer to P1 for more details. P2 uses a novel questionnaire on use settings; please refer to P2 for more details.

2.3. Statistical methods

2.3.1. General

The complex processes determining long-run cannabis use are multifactorial, and therefore the research in this dissertation focused on multivariate methods, showing the relative importance of different covariates. However, given the observational nature of this research without any intervention, causality remained difficult to attribute even with the most careful statistical methodologies.

All data manipulation and analysis were performed in Stata 15. The level for statistical significance was set to 5%. Whenever multiple tests were performed, Bonferroni corrections were used for statistical significance displayed. All the data analysis in the synopsis and the publications was performed by the author.

2.3.2. Data set merge

Given the sensitive nature of substance use data, we wanted to ensure respondents trusted the anonymity of the data. Therefore, no personally identifiable information such as, for example, name or birth date/place had been recorded. Nevertheless, we wanted

to have the possibility to merge answers from both survey waves. We thus opted for subject-generated identification codes (SGICs, similar to Yurek et al., 2008) based on the following items (reproduced from the questionnaire as included in Viohl et al., 2019):

- *"Personal ID number*
    - *Please state the first letter of your mother's first name.*
    - *Please state the first letter of your own first name*
    - *Please state your month of birth by using two digits: (e.g. 09 for September)*
- *Please specify your gender.*
- *Please enter your year of birth."*

The quality of SGICs depends on stability, i.e. answers should not vary over time within a subject, and variability, i.e. answers should be diverse enough to avoid duplicates ("look-alikes"): SGICs should be probabilistically unique identifiers.

The matching algorithm, developed by the author, followed several steps. In each step, we dropped first the duplicates in S1 and duplicates in S2, and then retained subject with an exact match between S1 and S2. Each following step was applied to the remaining unmatched subjects only.

1. Match on full code (5 elements);
2. Match on full code plus university;
3. Match on full code plus subject studied;
4. Match on reduced code without gender (4 elements), for those who indicated "non-binary" or "other" in one of the surveys;
5. Match on reduced code without birth year (4 elements), for those with birth year missing in one of the surveys;
6. Match on full code again.

2.3.3. Overview statistics of the synopsis

We used filter criteria to drop respondents who did not take the time to read the questions (and presumably participated only for the lottery). The filter algorithm sequentially discarded: first, those subjects with than 20% missing answers; then, those who did not reach the last page of the survey; then, those with more than 100 malus points for very fast completion of the questionnaire (defined by SoSci); then, those with a relative speed index (Leiner, 2019) above 2; finally, those who completed the questionnaire in less than

five minutes. Other members of the working group developed the filter algorithm and the same filter algorithm was used throughout this dissertation.

For this synopsis, I established more complete descriptive statistics than those shown in the publications. In particular, I compared: S1 to S2 (cross-sectional evolution between 2016 and 2018); S1 panel to S1 drop-out (self-selection through follow-up); S1 panel to S2 panel (evolution of covariates within subject). To examine the statistical significance, the appropriate tests are used: for continuous variables, Student's *t*-test (unpaired for cross-sectional or paired for panel); for ordinal variables, Mann-Whitney *U*-test; and for categorical variables, Pearson's χ^2-test.

2.3.4. Statistical methods in P1

In Naegele et al. (2022), we performed a factor analysis in order to map 20 motive-related questions into five underlying factors. We then used multivariate linear and logistic regressions in order to show the relationship between motives, socio-demographic covariates and the three outcomes of interest: use intensity, frequent use (binary, defined as more than once per week) and potential CUD (binary, defined as positive CAGE-AID). Please refer to the publication for detailed methodology.

2.3.5. Statistical methods in P2

In Naegele et al. (2023), we used multivariate logistic regressions showing the relationship between outcomes and three groups of covariates (demographic, psychological, behavioral). In particular, we compared the results of static/cross-sectional outcomes (regular use in S1 or S2) with the results on dynamic/longitudinal outcomes (initiation, reduction, cessation). Please refer to the publication for detailed methodology.

3. Results

3.1. Participant characteristics and merge

In S1, 12,914 students answered the survey (response rate approx. 11%) of which 9,400 (73%) met the filter criteria, as shown in Figure 2. In S2, 7,023 students answered (response rate approx. 6%), of which 4,942 (70%) met the filter criteria.

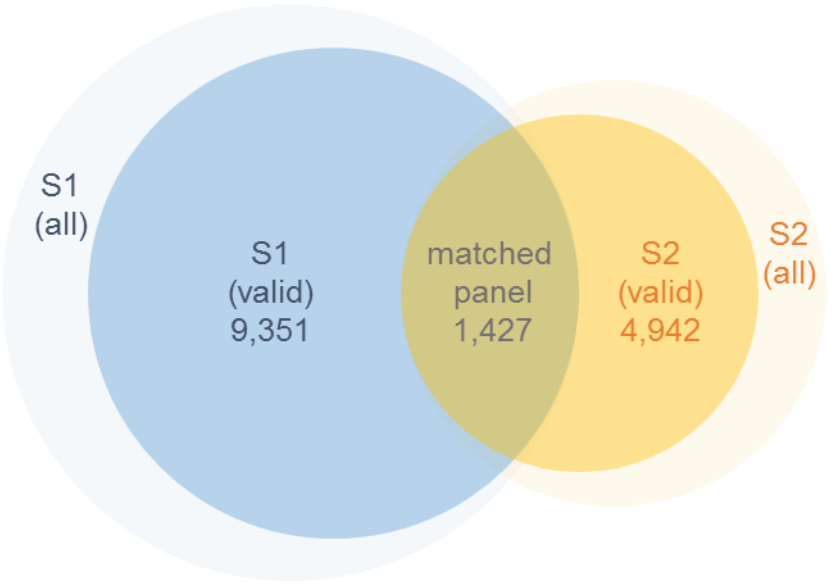

Figure 2. Number of observations in survey 1 (S1) and 2 (S2)

Note: areas proportional to group sizes; valid responses correspond to filter criteria regarding missing and response time as outlined in Section 2.3.1 (own representation: Helene Naegele)

The SGIC quality may be assessed by the number of missing values and the number of duplicates within the same survey wave (Table 1). In S2, the survey blocked progression if fields were not filled in, hence the almost zero missing rate. Overall, 1,427 subjects responded to both surveys (Figure 2).

Table 1. Merge quality overview statistics (number of subjects and percentage shares)

	S1	S2
Any elements missing (among full valid sample)	1,960/9,351 (21%)	87/4,942 (2%)
Duplicates full code (among non-missing)	744/7,391 (10%)	612/4,855 (13%)
Gender “non-binary” or “other”	62/9,351 (0.7%)	28/4,942 (0.6%)
Matched successfully	1,427/9,350 (15%)	1,427/4,942 (29%)

Table 2. Descriptive overview statistics (both surveys)

	S1 (all valid) (1)	S2 (all valid) (2)	(3)	S1 (panel) (4)	(5)	S2 (panel) (6)	(7)
N	9,351	4,942		1,427		1,427	
Age (years)	24.4	24.8	***	23.4	***	25.4	***
Use intensity (0-8) in S1	2.3	2.4		2.6	***	2.6	
30 day prevalence (30Dp)	23.9%	26.0%		29.5%	***	29.6%	
12 month prevalence (12Mp)	41.5%	42.8%		49.2%	***	47.0%	
Lifetime prevalence	67.1%	70.6%		71.1%	*	74.0%	
Alcohol use (0-8)	5.5	5.4		5.6		5.5	
CAGE pos. (any drug)	34.4%	36.2%	**	38.6%	*	39.9%	
Perceived harm (-2: helps; 2: harms)	0.37	0.43	***	0.30		0.38	
Intention to reduce (0/1)	19.6%	23.0%	**	21.5%		23.3%	
Wish for counseling (0/1)	3.7%	3.9%		4.9%		4.5%	
Religious (1-5)	1.9	1.8	***	1.8		1.8	*
Monthly income (€)	€ 833	€ 941	***	€ 817		€ 950	***
Indebted (0/1)	20.0%	19.7%		18.7%		23.3%	**
College years	3.1	3.5	***	2.9		4.0	***
Public financial aid (0/1)	22.2%	18.1%	***	21.4%		19.1%	
Grades overall (1-6)	2.1	2.3	***	2.1		2.3	
Grades last semester (1-6)	2.0	2.2	***	2.0		2.2	
LOC (1=external to 7=internal)	3.2	3.2		3.2		3.3	
Impulsivity (BIS, 16=low to 54=high)	31.4	31.3		31.2		31.2	
Stable relationship (0/1)	57.1%	55.0%		55.4%		56.4%	
Psych. diagnosis (0/1)	14.6%	15.6%		17.5%	+	18.6%	
Tobacco smoker (0/1)	40.6%	41.6%		39.7%		40.8%	
Living w/ peers (0/1)	37.1%	37.7%		40.8%		41.4%	
Number of sexual partners	8.6	9.9	***	877.9%		10.5	
Sexual risk-taking (0/1)	15.1%	22.1%	***	13.9%		20.3%	***
Sexual preferences					***		
- heterosexual	87.2%	85.4%		83.4%		85.4%	
- homosexual	4.6%	5.0%		5.9%		5.0%	
- bisexual/other	8.1%	9.6%		10.7%		9.6%	
Gender							
- man	48.7%	45.6%		48.1%		45.6%	
- woman	50.7%	53.8%		51.3%		53.8%	
- other	0.58%	0.57%		0.63%		0.57%	

Notes: Between-group comparisons (S1 vs. S2 in col. 3, S1 panel vs S1 drop-out in col. 5, panel S1 vs. panel S2 in col. 7) using independent sample t-tests for age, income, college time, LOC, impulsivity; Mann-Whitney U test for use intensity, religiosity, alcohol use, perceived harm; and chi-square test for all other variables; stars denote significance: + p-value<0.1, * p-value<0.05, ** p-value<0.01, *** p-value <0.001, after Bonferroni correction for 69 simultaneous tests. Non-users may have tried cannabis in the past and therefore have a use intensity of 1. LOC: locus of control, BIS: Barratt Impulsivity Scale, public financial aid: BAföG student loan/grant attributed depending on parents' income. Column 1 is similar to Naegele et al. (2022) Table 1; column 4 is similar to Naegele et al. (2023) Table 1.

Table 2 shows the descriptive overview statistics over the two waves and the relevant subsamples for the longitudinal study.

Columns 1, 2 and 3 compare the two study waves as cross-sections. We see that subjects in the second wave were significantly older (0.4 years), less religious, wealthier, longer at college, less likely to receive BAföG, less performing in terms of grades, more sexually active and risk-taking. Overall, cannabis use intensity remained stable across the years, but in S2 more respondents scored positive in the CAGE-AID, more were interested in reducing cannabis use, and the perceived harm of cannabis use decreased.

Comparing respondents of S1 who followed-up in S2 with those who dropped out (Table 2, column 4 and 5), we see that the follow-up sample was younger (1 year), had a higher cannabis use intensity (along all measures: 9-point use intensity, 30Dp, 12Mp, lifetime prevalence), was more often CAGE-AID positive and more often homosexual and bisexual.

Columns 6 and 7 show the evolution of variables over time among the longitudinal panel of students who answered both surveys. In S2, respondents were older (2 years, i.e. the time between both surveys), had been two more years at college, were less religious, had both higher income and more debt. Their rate of sexual risk taking had increased from 14% to 20%.

3.2. Main results P1

Describing the overall prevalence of cannabis use among Berlin college students, we saw that the 30Dp was 24%, 12Mp 42% and lifetime prevalence 71% (see P1 and Table 2 column 1 of this synopsis).

The exploratory factor analysis resulted in a five-factor model. Respondents backed the following motives in decreasing order: enjoyment (mean=2.5 on a scale from 1 to 5), coping (2.4), social (1.4), intensity (1.4) and performance (1.2), see Table 3 in Naegele et al. (2022). Among frequent cannabis users, the coping motive scale scored 2.6 on average.

Higher use intensity correlated with higher rate of CUD (Figure 1 of P1). In multivariate binary logistic regressions, the significant correlates of frequent use were social (+), coping (+), intensity (-) and performance (-) motives, age (-), male or other gender (+), bisexuality (+), religiosity (-) and BIS (+). The correlates of CUD were coping motives (+), male

gender (+), psychiatric diagnosis (+), LOC (-) and BIS (+). Please refer to Table 5 of P1 for more detail.

3.3. Main results P2

We analyzed initiation of cannabis use among the sub-sample of 555 respondents who did not use cannabis in S1. Two years later, about 23% of them had initiated cannabis use (Figure 1 of P2). In a multivariate binary logistic regression (Table 2 of P2), respondents who initiated were significantly younger and more impulsive than those who remained non-users. They also used tobacco and alcohol more frequently.

We analyzed reduction and cessation (quitting) among another sub-sample of 302 students who used cannabis regularly (at least monthly) in S1. Among this sub-sample, 21% increased their cannabis use, 33% remained at equal intensity, 35% reduced somewhat and 11% quit entirely (Figure 1 of P2). In multivariate binary logistic regressions (Table 2 of the publication), reduction correlated significantly with male gender (-), age (-) and LOC (+). Cessation correlated significantly with male gender (-) and tobacco use (-). Perceived harm increased the likelihood to quit, but not to reduce. Intention to reduce and wish for substance counselling had no significant impact on reduction or cessation.

The remaining sample of 344 respondents used cannabis occasionally. Among this sub-sample, 17% quit cannabis use in S2 and 15% escalated their use to become regular users.

The sample size on use contexts/locations was small, but suggested that using cannabis at home was negatively related to decreasing/quitting use, while cannabis use at parties and for study were positively associated with decreasing/quitting.

4. Discussion

4.1 Short summary of results

The working group collected data on the substance use of Berlin college students. Although the response rate was low, the overall sample size remained large with cross-sections of over 9,000 (S1) and almost 5,000 (S2) respondents, and a panel overlap of about 1,500 students.

Berlin college students not only had a high prevalence and frequency of cannabis use, but also a higher level of coping motives, known to correlate with problematic cannabis use and use-related problems. Similar to other studies, we saw that coping motives distinguished frequent cannabis users with and without signs of CUD (Naegele et al., 2022).

Investigating the evolution of cannabis use, we saw that cannabis use intensity remained stable for the majority (53%) of the sample (Naegele et al., 2023). The dynamics of cannabis use change depended on a number of factors in a non-trivial way: some factors correlated with initiation (e.g. impulsivity), others correlated with reduction/cessation (e.g. LOC), while finally some related to both (younger participants were more likely to change behavior in both directions). Showing the differences between cross-sectional and longitudinal perspectives, this publication reminded researchers of the non-trivial dynamics behind cross-sectional results.

4.2 Interpretation of results

4.2.1 Sample

With an overall response rate of about 10% of Berlin college students, our sample was still large, but potentially subject to sample selection issues. S1 had a larger response rate than S2. In S1, the share of female respondents (50.7%) was virtually identical to the share of female students in Berlin overall (50.3%); in S2, the share of female (53.8%) was slightly higher. There was a considerable number of statistically significant differences in the descriptive statistics of both survey waves (Table 2, column 1-3). Overall, the sample selection remained difficult to assess.

The use prevalences in our sample are of similar order of magnitude, but higher than those found in a recent study on students of the Free University of Berlin: lifetime prevalence of 68% (resp. 60% in Gusy et al., 2022), 12Mp of 42% (resp. 30%), 30Dp of 25% (resp. 13%). The proportion of students using cannabis in our data is similar to other studies (e.g. Phillips et al., 2017) on college students elsewhere. Thus, it is unclear whether this difference is due to sample selection in our sample, or to the Free University being not representative of Berlin college students overall. The share of CUD is higher in Berlin than elsewhere (Seitz et al., 2020), which was confirmed in our data with over a third of respondents scoring positive on the CAGE-AID screening test.

The matching suffered from the high number of missing values in S1 (over 20% of respondents) and from the high rate of duplicate codes. The missing value problem had largely been solved in S2, by making response mandatory for page validation. The high number of duplicates in our code stemmed from the low variability in gender (only 3 possible values) and birth year (80% of respondents were born between 1988 and 1997). In future surveys, we would advise researchers to use more elements than this study or elements with higher variability, in order to increase code variability and make uniqueness of the identifiers more likely.

As shown in Table 2 (column 4 and 5), respondents with follow-up differed from drop-outs regarding age. This appears as a natural phenomenon: older students are more likely not to be in college two years after S1, and hence were not reached by our second invitation. However, we also see that respondents with follow-up had higher cannabis use intensity and were more likely to have a positive CAGE-AID. We may presume that students who consume substances had higher interest in a drug-consumption related survey and thus self-selected into the panel sub-sample.

Within the longitudinal sample, respondents were asked the same questions twice with on average 16 months between both waves. The older age and longer college-time in S2 (Table 2, column 6 and 7) reflected this time schedule. Higher income and more debt may be qualified as correlates of this growing up process and emancipation from parental households. It remains unclear, whether the higher rate of sexual risk-taking was also related to the process of growing up (within-individual evolution) or rather related to aggregate shifting of social norms (as this difference also appeared in the cross-sectional comparison of column 3).

4.2.2 Highlights of P1

The five factors resulting from our exploratory factor analysis matched the factors of the MMM, except the MMM conformity motive, which was replaced by performance in our questionnaire.

Coping motives have been the focus of the cannabis use motive literature, because they are associated with negative outcomes. Our data showed that coping motives were more frequent in Berlin sample (second most popular motive, while other studies typically place social and expansion motives above coping) and, consistently, the average level was high (mean=2.4 on a scale from 1 to 5, compared to an average of 1.9 in Bujarski et al., 2012; Johnson et al., 2010; J. Simons et al., 1998; van der Pol et al., 2013). Cannabis-users in our sample had thus a particularly problematic use motive constellation.

Similar to van der Pol et al. (2013), we studied what distinguished frequent users with and without signs of CUD. We found that “the motives predicting frequent use (sociability) were different from motives predicting CUD (coping), even when controlling for a wide array of covariates” (Naegele et al., 2022).

The results of P1 are discussed more in detail in the publication itself.

4.2.3 Highlights of P2

In this publication, we reproduced findings from the cross-sectional literature and compared them with the cannabis use change dynamics during college-time. Some findings of the literature, such as the impact of male gender on likelihood of regular use (e.g. Gusy et al., 2022; Hayatbakhsh et al., 2009), could be explained by dynamic change in our data (more initiation, less cessation). Other findings of the literature, such as the impact of religiosity (e.g. Mader et al., 2019; McCabe et al., 2021; White et al., 2006) and socio-economic status (e.g. Vijapur et al., 2021) could be confirmed in the cross-sectional data, but our results revealed that they were the result of pre-college behaviors which were carried over into college-time. Finally, some cross-sectional results such, as the impact of age, were shown to be the net effect of conflicting dynamics: younger respondents both initiated and quit cannabis use more often. We concluded that more research on the use change dynamics during college-time was needed, as some factors of adolescent cannabis initiation (religiosity, socio-economic status) did not seem to apply to college students.

Our results suggested that an analysis of use settings beyond the crude distinction solitary/social would be useful for predicting cannabis use change, although we could not confirm these results in a multivariate regression due to small sample size.

The results of P2 are discussed more in detail in the publication itself.

4.3 Embedding the results into the current state of research

Much of the research on substance use concentrates on the United States, and the literature on German or Berlin college students remains scarce. The research presented in this dissertation gave an updated epidemiology of cannabis use and its correlates among Berlin college students.

Our results replicated some findings previously discussed in the literature. In particular, the association between coping motives and problematic substance use had been firmly established (Blevins et al., 2016; Brodbeck et al., 2007; Buckner et al., 2014; Fox et al., 2011; Mader et al., 2019; Schultz et al., 2019; J. S. Simons et al., 2005; Van Der Pol et al., 2013) and could be confirmed in our sample.

However, our results also showed that our sample may be seen as a special case. The problematic coping motives were much more likely here than elsewhere (Bujarski et al., 2012; Johnson et al., 2010; J. Simons et al., 1998). Consistently, more than one-third of the sample scored positive on the CUD screening test, which was higher than for most samples in the literature. The average cannabis use rate in Berlin is higher than the German average and higher than in other cities (Rauschert et al., 2023; Schäffler et al., 2015). We thus put out the hypothesis that these phenomena are linked more to the local culture of substance use than to factors specific to college student life.

Finally, some aspects studied in this dissertation had not been established in the literature before, and it remains unclear to what extent the findings apply to other populations. Among these findings, the factors for initiation/cessation during college-time partly overlapped (e.g. impulsivity and LOC), but partly differed (religiosity, age) with the factors for initiation/cessation in adolescence, which have been studied more extensively in the literature.

4.4 Limitations

The publications P1 and P2 outlined the limitations of this dissertation, so they are only briefly mentioned here again.

First and foremost, causal inference remains limited in observational data such as used in this dissertation. However, experimental interventions on substance use are difficult, thus we believe strongly in the usefulness of observational research on this important topic.

The data was collected via self-report in online surveys, which may be subject to desirability bias and memory faults. In particular, questions about illegal behavior may harvest distorted answers (Suerken et al., 2014).

The self-selection (and conversely, representativeness) of the overall sample remains difficult to assess. Indicatively, the gender distribution in the sample was similar to the complete population, but the cannabis use prevalence were higher than what had previously been found at the Free University of Berlin (a sub-population of our target population). This synopsis showed the self-selection of subjects into the panel data set: we see that subjects with higher substance use were over-represented in the longitudinal sample compared to S1.

This research aimed at describing the epidemiology of cannabis use among Berlin college students. The introduction and discussion showed how Berlin college students were a particular population, therefore external validity to the general population or college students elsewhere was limited by construction.

4.5 Implications for practice and/or future research

P1 showed the importance of distinction between frequent use and potential CUD. Arguably, the latter should be the focus of prevention and intervention policies. Interventions aiming at building alternative coping skills similar to alcohol relapse prevention (Larimer et al., 1999) should be studied.

P2 examines the dynamics of cannabis use change, but so far there is little research on the dynamics of how and why frequent use evolves into problematic use (Beck et al., 2009). P2 has shown that the dynamic results on young adults during college-time may relate in non-trivial ways to the dynamic results on adolescents and the cross-sectional

results on college students. As a consequence, the research presented in this dissertation calls for caution when interpreting cross-sectional findings on cannabis use.

Finally, amidst a worldwide climate in favor of cannabis legalization, researchers need to monitor how evolving harm perceptions and availability change the mechanics of cannabis use initiation/cessation and the risks of developing CUD and other cannabis use-related problems.

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6. Appendix: Questionnaire

Reproduced from Viohl et al. (2019).

Student Drugsurvey I Online-Questionnaire

Dear students,

thank you for your participation.

Your answers matter to us and are very important, even if you do not use drugs at all.

To fill out the questionnaire will take you no longer than 5-10 minutes.

Within all participants we will give away 1 x 100€ cash and 5 x 20€ Amazon vouchers.

The anonymity of your answers will always be assured.

By clicking 'Next' you confirm and agree to the further processing and evaluation of your anonymously collected data.

1. Please enter your year of birth.

2. Please specify your sex.

○ Female
○ Male
○ Other:

3. Please state your citizenship.

4. What is your field of study?

5. How many semesters have you been studying?

In your field of study

At all

6. How would you rate your academic performance compared to your fellow students?

○ Much better
○ Better
○ Equal
○ Poorer
○ Much poorer

7. If possible, please state your average mark in your recent field of study (grading system: 1.0 – 5.0)

In the last semester

Overall

8. How did your academic performance develop in the last year?

○ Improved
○ Equal
○ Worsened

9. Please state, how much you agree with the following statements.

I see myself as someone who…	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
does a thorough job.	○	○	○	○	○	○	○
is talkative.	○	○	○	○	○	○	○
is sometimes rude to others	○	○	○	○	○	○	○
is original, comes up with new ideas.	○	○	○	○	○	○	○
worries a lot.	○	○	○	○	○	○	○
has a forgiving nature.	○	○	○	○	○	○	○
tends to be lazy.	○	○	○	○	○	○	○
is outgoing, sociable.	○	○	○	○	○	○	○
values artistic, aesthetic experience.	○	○	○	○	○	○	○
gets nervous easily.	○	○	○	○	○	○	○
does things efficiently.	○	○	○	○	○	○	○
who is reserved.	○	○	○	○	○	○	○
Is considerate and kind to almost everyone	○	○	○	○	○	○	○
has a strong imagination.	○	○	○	○	○	○	○
who is relaxed, handles stress well.	○	○	○	○	○	○	○

10. The statements below describe attitudes towards life and the future. Please state, how much you agree with the following statements:

	Not at all						Absolutely
How my life goes depends on me.	○	○	○	○	○	○	○
Compared to other people, I have not achieved what I deserve.	○	○	○	○	○	○	○
What a person achieves in life is above all a question of fate or luck.	○	○	○	○	○	○	○
If a person is politically active, she/he can have an effort on social conditions.	○	○	○	○	○	○	○
I frequently have the experience that other people have a controlling influence over my life.	○	○	○	○	○	○	○
One has to work hard to succeed.	○	○	○	○	○	○	○
If I run up against difficulties in life, I often doubt my own abilities.	○	○	○	○	○	○	○
The opportunities I have in my life are determined by the social conditions.	○	○	○	○	○	○	○
Innnate abilities are more important than any efforts one can make.	○	○	○	○	○	○	○
I have little control over the things that happen in my life.	○	○	○	○	○	○	○

11. Have you ever been given a psychiatric diagnose (includes addictions)?

○ Yes

○ No

If yes, which?

12. How often do the following statements describe you?

	Never	Sometimes	Often	(Almost) Always
I plan tasks carefully.	○	○	○	○
I do things without thinking.	○	○	○	○
I don’t pay attention.	○	○	○	○
I concentrate easily.	○	○	○	○
I save regularly.	○	○	○	○
I squirm on my chair at talks or lectures.	○	○	○	○
I (over-) think careluffly.	○	○	○	○
I plan for my career.	○	○	○	○
I say things before thinking about them.	○	○	○	○
I act impulsively.	○	○	○	○
I am easily bored when solving thought problems.	○	○	○	○
I act on the sur of the moment.	○	○	○	○
I buy things on impulse.	○	○	○	○
I am restless at lectures or talks.	○	○	○	○
I plan for the future.	○	○	○	○

Overall, I am satisfied with my life.

Strongly disagree									Totally agree
○	○	○	○	○	○	○	○	○	○

So far, I have gotten all the important things I want in life.

Strongly disagree									Totally agree
○	○	○	○	○	○	○	○	○	○

13. How often did you feel … in the last four weeks?

	Very rare	Rare	Sometimes	Often	Very often
Angry	○	○	○	○	○
Scared	○	○	○	○	○
Sad	○	○	○	○	○
Happy	○	○	○	○	○

14. How do you live?

○ With your parents
○ In an own apartement.
○ In a shared linving-accomodation.
○ In a dormitory.
○ Other: _____

15. How do you finance your studies?

○ With the support of your family?
○ Working
○ Scholarship
○ BAföG (German Federal Law on Training and Education Promotion)
○ Savings
○ Other: _____

16. In total, how much money do you have at your disposal for one month? (This includes rent, budgetary costs and free-time activities.)

_____

17. Do you have liabilities right now?

○ No.

○ Yes, approximately: _____ Euro

In the following, we will ask you some questions regarding your substance consumption behaviour.

18. How often did you smoke tobacco in the last 3 months?

- ○ Never smoked at all
- ○ Never
- ○ Sometimes
- ○ Daily

19. How often did it occur, that under the effects of alcoholic beverages you were so drunk, that you couldn't walk straight anymore, had to throw up or could not remember what happened?

Never	Less than once a month	Monthly	2-4 timas a month	2-3 times a week	More than 3 times a week
○	○	○	○	○	○

20. Have you ever consumed one of the following substances?

Please mark where applicable. Multiple answers are possible.
Please do NOT state medication prescribed by a physician.
.

	Never	Once already	Within the last 12 months	Within the last month
Alcohol	○	○	○	○
Cannabis (Marihuana)	○	○	○	○
Amphetamine (Speed, Pep)	○	○	○	○
Methamphetamine (Chrystal Meth)	○	○	○	○
MDMA (Ecstasy, Molly)	○	○	○	○
LSD (Acid)	○	○	○	○
Heroin (Smack)	○	○	○	○
Opiate based painkillers (e.g. Oxycodone, Hydromorphone)	○	○	○	○
Cocaine	○	○	○	○
Neuro-Enhancer (e.g. Methylphenidate)	○	○	○	○

Psilocybin (Magic Mushrooms)	○	○	○	○
Synthetic cannabinoids ("Spice")	○	○	○	○
Synthetic cathinones ("Bath Salt“)	○	○	○	○
2-CB	○	○	○	○
Modafinil (e.g. Provigil®)	○	○	○	○
Benzodiazepines (e.g. Valium®, Tavor®)	○	○	○	○
Amylic Nitrites (Poppers)	○	○	○	○
Crack	○	○	○	○
DMT (Ayahuasca)	○	○	○	○
GBH/ GBL (“G“, Liquid Ecstasy)	○	○	○	○
Ketamine (Keta, "K")	○	○	○	○
Other:	○	○	○	○

21. How often do you consume the following substances?

	Never	Less than once a month	Monthly	2-4 times a months	2-3 times a week	More than 3 times a week
Alcohol	○	○	○	○	○	○
Cannabis (Marihuana)	○	○	○	○	○	○
Amphetamine (Speed, Pep)	○	○	○	○	○	○
Methamphetamine (Chrystal Meth)	○	○	○	○	○	○
MDMA (Ecstasy, Molly)	○	○	○	○	○	○
LSD (Acid)	○	○	○	○	○	○
Heroin (Smack)	○	○	○	○	○	○
Opiate based painkillers (e.g. Oxycodone, Hydromorphone)	○	○	○	○	○	○

Cocaine	○	○	○	○	○	○
Neuro-Enhancer (e.g. Methylphenidate)	○	○	○	○	○	○
Psilocybin (Magic Mushrooms)	○	○	○	○	○	○
Synthetic cannabinoids ("Spice")	○	○	○	○	○	○
Synthetic cathinones ("Bath Salt“)	○	○	○	○	○	○
2-CB	○	○	○	○	○	○
Modafinil (e.g. Provigil®)	○	○	○	○	○	○
Benzodiazepines (e.g. Valium®, Tavor®)	○	○	○	○	○	○
Amylic Nitrites (Poppers)	○	○	○	○	○	○
Crack	○	○	○	○	○	○
DMT (Ayahuasca)	○	○	○	○	○	○
GBH/ GBL (“G“, Liquid Ecstasy)	○	○	○	○	○	○
Ketamine (Keta, "K")	○	○	○	○	○	○
Other:	○	○	○	○	○	○

22. Overall, the consumption of ...

	Harms me.				Helps me.
Alcohol	○	○	○	○	○
Cannabis (Marihuana)	○	○	○	○	○
Amphetamine (Speed, Pep)	○	○	○	○	○
Methamphetamine (Chrystal Meth)	○	○	○	○	○
MDMA (Ecstasy, Molly)	○	○	○	○	○

LSD (Acid)	○	○	○	○	○
Heroin (Smack)	○	○	○	○	○
Opiate based painkillers (e.g. Oxycodone, Hydromorphone)	○	○	○	○	○
Cocaine	○	○	○	○	○
Neuro-Enhancer (e.g. Methylphenidate)	○	○	○	○	○
Psilocybin (Magic Mushrooms)	○	○	○	○	○
Synthetic cannabinoids ("Spice")	○	○	○	○	○
Synthetic cathinones ("Bath Salt“)	○	○	○	○	○
2-CB	○	○	○	○	○
Modafinil (e.g. Provigil®)	○	○	○	○	○
Benzodiazepines (e.g. Valium®, Tavor®)	○	○	○	○	○
Amylic Nitrites (Poppers)	○	○	○	○	○
Crack	○	○	○	○	○
DMT (Ayahuasca)	○	○	○	○	○
GBH/ GBL (“G“, Liquid Ecstasy)	○	○	○	○	○
Ketamine (Keta, "K")	○	○	○	○	○
Other:	○	○	○	○	○

23. Do you want to reduce your consumption of the following substances within the next 12 months?

	Yes	No
Alcohol	○	○
Cannabis (Marihuana)	○	○
Amphetamine (Speed, Pep)	○	○
Methamphetamine (Chrystal Meth)	○	○
MDMA (Ecstasy, Molly)	○	○
LSD (Acid)	○	○

Heroin (Smack)	○	○
Opiate based painkillers (e.g. Oxycodone, Hydromorphone)	○	○
Cocaine	○	○
Neuro-Enhancer (e.g. Methylphenidate)	○	○
Psilocybin (Magic Mushrooms)	○	○
Synthetic cannabinoids ("Spice")	○	○
Synthetic cathinones ("Bath Salt“)	○	○
2-CB	○	○
Modafinil (e.g. Provigil®)	○	○
Benzodiazepines (e.g. Valium®, Tavor®)	○	○
Amylic Nitrites (Poppers)	○	○
Crack	○	○
DMT (Ayahuasca)	○	○
GBH/ GBL (“G“, Liquid Ecstasy)	○	○
Ketamine (Keta, "K")	○	○
Other:	○	○

24. Have you ever felt that you ought to cut down on your drinking or drug use?

○ Yes.

○ No.

25. Have people annoyed you by criticizing your drinking or drug use?

○ Yes.

○ No.

26. Have you ever felt bad or guilty about your drinking or drug use?

○ Yes.

○ No.

27. Have you ever had a drink or used drugs first thing in the morning to steady your nerves or to get rid of a hangover?

- ○ Yes.
- ○ No.

Finally, here are some questions about your relationship status, your mindset towards religion and your sexuality.

28. How important is religion to you?

Not important at all				Very important
○	○	○	○	○

29. What is your current relationship status?

- ○ Single
- ○ Married
- ○ Divorced
- ○ Firm and permanent relationship
- ○ Open relationship
- ○ Other:

30. What sexuality do you identify with?

- ○ Heterosexual
- ○ Homosexual
- ○ Bisexual
- ○ Other:

31. How many sexual partners (including oral interaction) did you have...

… in the last 6 months? Partners

… in your life (until now)? Partners

32. Approximately, with how many different sexual partners did you have ... in the last 6 months?

… unprotected intercourse Partners

… unprotected intercourse under the influence of alcohol _____ Partners

… unprotected intercourse under the influence of illicit substances _____ Partners

33. Personal ID-Number

To examine changes in consumption behaviour, it is important for us to link your current answers to those from future studies. Please support us by filling in the information below. We will thus create an individual code that enables the assignment.

Your data remains **anonymous** despite the assignment of the questionnaires!

Please state the first letter of your mother's first name: _____

Please state the letter of your own first name: _____

Please state your month of birth by using two digits:
(e.g. 09 for September) _____

34. Do you feel the need for or have interest in an individual counselling for substance use?

○ Yes.

○ No.

35. If interested, please state your email address or write to: drugsurvey@charite.de.

YOUR E-MAIL ADDRESS AND THE ANSWERS OF THE QUESTIONNAIRE WILL BE TRANSFERRED SEPARATELY FROM EACH OTHER. THERE WILL BE NO POSSIBLE LINK TO YOUR PERSON, EMAIL OR IDENTITY!

○ I want to participate in the raffle. I agree to my email address being temporarily stored. My given details in this survey remain anonymous, my email address will not be handed out to others.

○ I am interested in the results of this survey and would like to receive a summary via email.

○ I am interested in informations about participating in payed medical studies.

E-Mail: _____

36. Möchten Sie uns noch etwas mitteilen?

Thank you very much for your participation!

Your answers have been saved.

Statutory Declaration

“I, Helene Blanche Naegele, by personally signing this document in lieu of an oath, hereby affirm that I prepared the submitted dissertation on the topic “Higher education – Epidemiology of cannabis use among Berlin college students / Higher education – Epidemiologie des Cannabiskonsums Berliner Studierender”, independently and without the support of third parties, and that I used no other sources and aids than those stated.

All parts based on the publications or presentations of other authors, either in letter or in spirit, are specified as such in accordance with the citing guidelines. The sections on methodology (in particular regarding practical work, laboratory regulations, statistical processing) and results (in particular regarding figures, charts and tables) are exclusively my responsibility.

Furthermore, I declare that I have correctly marked all of the data, the analyses, and the conclusions generated from data obtained in collaboration with other persons, and that I have correctly marked my own contribution and the contributions of other persons (cf. declaration of contribution). I have correctly marked all texts or parts of texts that were generated in collaboration with other persons.

My contributions to any publications to this dissertation correspond to those stated in the below joint declaration made together with the supervisor. All publications created within the scope of the dissertation comply with the guidelines of the ICMJE (International Committee of Medical Journal Editors; http://www.icmje.org) on authorship. In addition, I declare that I shall comply with the regulations of Charité – Universitätsmedizin Berlin on ensuring good scientific practice.

I declare that I have not yet submitted this dissertation in identical or similar form to another Faculty.

The significance of this statutory declaration and the consequences of a false statutory declaration under criminal law (Sections 156, 161 of the German Criminal Code) are known to me.”

15.09.2023 _____

Date

_____

Signature

Declaration of your own contribution to the publications

Helene Naegele contributed the following to the below listed publications:

Publication 1 (P1): Naegele, H., Betzler, F., Viohl, L., Koslowski, M., Ernst, F., & Petzold, M. B. (2022). Cannabis Use, Use Motives and Cannabis Use Disorder Among Berlin College Students. *Journal of Drug Issues*, 52(4), 568–584. https://doi.org/10.1177/00220426221086877.

Contribution:

I contributed the literature review, definition of the research question, data cleaning, statistical methodology, data analysis, and writing of the drafts. I created all Tables and Figures from the data. My supervisors and the research group regularly provided precious feedback on the research question, methodology and writing, which I integrated into the final publication. Other members of the research group conceived the questionnaire and collected the data.

Publication 2 (P2): Naegele, H., Petzold, M. B., Viohl, L., Bendau, A., Helmer-Ohlmeier, S., & Betzler, F. (2023). Determinants of Cannabis Initiation and Cessation among Berlin College Students – A Longitudinal Study. Substance Use & Misuse, 58(10), 1262-1272. https://doi.org/10.1080/10826084.2023.2215320.

Contribution:

I contributed the literature review, definition of the research question, data cleaning, statistical methodology, data analysis, and writing of the drafts. I created all Tables and Figures from the data. My supervisors and the research group regularly provided precious feedback on the research question, methodology and writing, which I integrated into the final publication. Other members of the research group conceived the questionnaire and collected the data. I developed the methodology for merging these two anonymous data sets.

_____

Signature, date and stamp of first supervising university professor

_____

Signature of doctoral candidate

Printing copies of the publications

P1: Cannabis Use, Use Motives and Cannabis Use Disorder

Naegele, H., Betzler, F., Viohl, L., Koslowski, M., Ernst, F., & Petzold, M. B. (2022). Cannabis Use, Use Motives and Cannabis Use Disorder Among Berlin College Students. Journal of Drug Issues, Sage, 52(4), 568–584. https://doi.org/10.1177/00220426221086877.

Article

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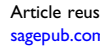

Cannabis Use, Use Motives and Cannabis Use Disorder Among Berlin College Students

Helene Naegele[1], Felix Betzler[1], Leonard Viohl[1], Michael Koslowski[1], Felicitas Ernst[1], and Moritz Bruno Petzold[1]

Abstract

This study described cannabis use behavior among college students in Berlin, in particular, differences in use motives between subjects with frequent use and those with signs of cannabis use disorder (CUD). Cross-sectional data were collected via an online survey among Berlin college students (*N*=9350; 50.7% women; Mage=24.4). Motivation scales were computed based on an exploratory factor analysis. Effects of these motive scales were compared using multivariate regression models, where the dependent variable was use intensity (ordinal), frequent use (twice or more per week, binary) or a positive substance use disorder screening test (binary). Cannabis use is known to be particularly prevalent among Berlin college students, which was confirmed by our data. The most frequent use motive was enhancement, which, however, was not associated with frequent use or CUD. The motives predicting frequent use (sociability) are different from motives predicting CUD (coping), even when controlling for a wide array of covariates.

Keywords

cannabis use severity, cannabis use disorder, young adults, motives, coping motives

Introduction

Cannabis is the most commonly used illicit substance worldwide (European Monitoring Centre for Drugs and Drug Addiction (EMCDDA), 2020). Lifetime prevalence of cannabis consumption in the general population is estimated at 27.2% in the European Union (EU), while past-year prevalence is 15.0% for young adults (15–24 years; EMCDDA, 2020). Young adults are more likely to consume cannabis heavily and experience adverse effects of cannabis use (Hall & Degenhardt, 2009; Johnston et al., 2019), in particular, in Berlin (Jochmann et al., 2019). The reputation of Berlin as the capital of European nightlife and techno scene particularly attracts students interested in a lifestyle

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that is often related to drug use and substance use disorders (Ding, He, Shoptaw, Gao, & Detels, 2014; Kelly, Parsons, & Wells, 2006; Palamar, Griffin-Tomas, & Ompad, 2015). As a consequence, Berlin college students are particularly likely to use cannabis (Viohl et al., 2019) and might therefore be at high risk for CUD and use-related problems (Helmer et al., 2021).

While cannabis use prevalence has remained stable over the past decade, the demand for treatment for cannabis-related problems has increased by 76% between 2006 and 2017 in the EU (EMCDDA, 2019; Manthey, 2019). A likely explanation is the increase in cannabis use disorder (CUD) prevalence (Manthey, 2019). In Germany, cannabis use prevalence has increased seemingly without such an accompanying increase in cannabis-related disorders (Seitz et al., 2019). Frequent cannabis use increases the risk of dependence, nevertheless most subjects using cannabis frequently are not dependent (Foster, Arterberry, Iacono, McGue, & Hicks, 2018; Van Der Pol et al., 2013). Foster et al. (2018) show that subjects using cannabis frequently (weekly and more) reported more substance use problems and externalizing behavior than subjects not using cannabis; at the same time, subjects using cannabis frequently *without* signs of CUD have significantly less psychiatric comorbidity and psychosocial impairment than subjects *with* CUD. These findings highlight the importance of differentiating between cannabis use, frequent use, and CUD, where arguably the latter deserves the main weight in counseling and prevention targeting. As only a fraction of subjects with CUD seek treatment (Specht, Dauber, Künzel, & Schwarzkopf, 2020), the prevalence of CUD among Berlin college students was unknown prior to this study, even though this population with high prevalence of cannabis consumption may be at high risk of CUD.

Substance use motives may be seen as the final pathway through which more distal factors, both external (availability, use context) and internal (traits, affect, expectancies), influence use behavior (Buckner, Zvolensky, Farris, & Hogan., 2014; J. S. Simons, Gaher, Correia, Hansen, & Christopher, 2005; Vangsness, Bry, & LaBouvie, 2005). Recent literature gives an increasing importance to cannabis use motives, measured typically with one of several different motive questionnaires. Drawing on interviews with "young poly-substance users," Boys, Marsden, and Strang. (2001) identify a series of use motives, giving rise to an 18-item questionnaire. The Marijuana Motives Measure (MMM) has been derived from models of alcohol motives and is characterized in five scales: enhancement, coping, social, expansion, and conformity (Simons, Correia, Carey, & Borsari, 1998). The Comprehensive Marijuana Motives Questionnaire (CMMQ, Lee, Neighbors, Hendershot, & Grossbard, 2009) identifies as many as 12 motive scales for use, including boredom, social anxiety, and sleep.

Subjects using cannabis frequent generally score higher on all motives (Beck et al., 2009; Bonar et al., 2017; Pearson, Bravo, Conner, & Parnes, 2019). The literature finds that coping motives are associated with more frequent cannabis use (Bonar et al., 2017; Mader, Smith, Afzal, Szeto, & Winters, 2019) and correlate with mental health problems and CUD (Beck et al., 2009; Phillips, Lalonde, Phillips, & Schneider, 2017). Subjects using cannabis stating social and conformity motives generally experience less psychopathologies (Bonar et al., 2017; Schultz, Bassett, Messina, & Correia, 2019). While we know that Berlin college students have a high prevalence of cannabis consumption, we know little about the use motives in this high-risk population.

Aside socio-demographic characteristics and use motives, certain personality characteristics are associated with more frequent cannabis use. Individuals with external locus of control (LOC)—defined as believing in a weak effect of their behavior on their future life events—are more likely to use cannabis (Heckman, Stixrud, & Urzua, 2006; Mendolia & Walker, 2014). Likewise, high impulsivity—defined as a tendency to show "rapid, unplanned actions regardless of possible negative consequences" (Meule, Vögele, & Kübler, 2011)—has been shown to predict substance use and use disorder (Acton, 2003). Hecimovic, Barrett, Darredeau and Stewart. (2014) that the literature has largely failed to provide a consistent pattern of personality traits among subjects using

cannabis within the classical five factor model. They attribute this failure to the heterogeneity of cannabis use contexts and motives: Cannabis seems to differ from other substances, in the sense that it fulfills a wider array of different functions in subjects' lives than other substances (O'Hara, Armeli, & Tennen, 2016), for example, ecstasy or cocaine.

The purpose of this study was twofold. First, this study aims at quantifying cannabis use and CUD among college students in Berlin. Further, the study examines the correlation between use motives and cannabis use and CUD in this population, controlling for personality traits and other factors in a multivariate analysis. Based on the literature, we hypothesize that (a) Berlin students have a higher use intensity and a high rate of CUD compared to similar age groups in other cities and compared to other population groups in Berlin, (b) the main use motive scales include enhancement, sociability and coping, (c) motive scales have significant impact on use intensity and CUD even when controlling for other covariates, (d) coping motives are positively associated with CUD, and (e) high BIS and external LOC are associated with CUD.

Materials and Methods

Sample and procedure

The cross-sectional data were gathered as part of the Student Drug Survey among students of 17 institutions of higher education in Berlin, conducted online between 11/2016 and 09/2017. Invitation was sent by the university via email to all students in public colleges in Berlin. Participation was incentivized with a lottery to win 100 Euro once or five Amazon vouchers worth 20 Euros each. Please refer to Viohl et al. (2019) for more details and the original version of the survey, as well as the full questionnaire. The study was approved by the Ethics Committee (application number: EA1/258/16) and commissioner of data privacy of the Charité University Medicine Berlin.

Questionnaire

Primary outcomes: Cannabis use and CUD. Cannabis use prevalence, excluding prescribed medical use, was assessed by self-report over the past month, past year, and lifetime. Respondents who indicated any use were further asked to report frequency (never, < monthly, monthly, 2–4/month, 2–3/week, >3/week). Interacting prevalence and frequency answers, a 9-level measure of use intensity was constructed similarly to Simons et al. (1998): 8 (>3/week), 7 (2–3/week), 6 (2–4/month), 5 (monthly), 4 (less than monthly, but within past month), 3 (less than monthly, but within last 12 months), 2 (less than monthly, but not in past 12 months), 1 (never, but has tried), 0 (never tried). Moreover, the four-item "Cutting down, Annoyance by criticism, Guilty feeling, and Eye-opener" Adapted to Include Drugs (CAGE-AID) screening test (Brown & Rounds, 1995) was used to screen for alcohol and substance use disorder (positive if two or more "yes" answers).

Primary predictor of interest: Cannabis use motives. Use motives were assessed using an adapted version of the questionnaire by Boys et al. (2001). Boys' questionnaire assesses use motives for several substances, this study concentrates on cannabis. Therefore, we dismissed the item "keep going" which applied mostly to amphetamines and ecstasy. Inspired by the literature (Lee et al., 2009; J. Simons et al., 1998), we added three items ("to be creative", "to reduce my fears" and "to understand others' points of view"). This resulted in a use motive questionnaire with 20 items (5-point Likert scale).

Covariates: Socio-demographics and psychosocial factors. Information was collected about socio-demographic information, such as gender (woman, man, or free text input), age, and sexual orientation (heterosexual, homosexual, bisexual, or free text input). The level of religiosity was assessed (5-point Likert scale). Participants further indicated any diagnosis of psychiatric disorder. Academic outcomes were self-assessed by the participants with average grade (German grades from 1=very good to 5=fail). Personality was assessed along the dimensions of impulsivity and LOC. Impulsivity was measured using a short form of the Barratt Impulsivity Scale (BIS-15) (Meule et al., 2011), with total scores ranging from 16 (low impulsivity) to 54 (high impulsivity). LOC was measured using the questionnaire from the German socioeconomic-panel (Richter et al., 2017), with a final score ranging from 1 (external) to 7 (internal).

The raw data may be available to interested researchers on request.

Statistical methods

Data was analyzed using Stata 15. We excluded respondents who had too many missing answers (max. 20%), incomplete questionnaires, and implausibly short overall response time; for more details, please refer to Viohl et al. (2019).

We provided descriptive statistics on cannabis use prevalence, frequency and CAGE-AID screening test. A descriptive analysis showed overall means and frequencies of socio-demographic covariates. We provided a comparison (a) between the frequent use group and other subjects and (b) between CAGE-AID positive and negative groups, testing for equality using Student's t-test for ordinal/continuous variables and a chi-square test for categorical variables. Across the study, our threshold for significance lies at 5% and we applied Bonferroni corrections for multiple testing.

We performed an exploratory factor analysis using the principal factor method. The number of factors was determined using parallel analysis (Horn, 1965), as implemented in Stata (Dinno, 2009). In order to reduce the number of items needed to explain each factor, we applied a promax oblique rotation, allowing the factors to correlate; scales were constructed based on items loading >.40 and excluding cross-loading items (procedure similar to Simons et al., 1998, or Grilo et al., 2010). Factors were labeled based on face validity. We computed the correlations and internal consistency (α after Cronbach, 1951) of the resulting motive scales; we consider α above 0.75 satisfactory and above 0.65 acceptable (Cortina, 1993; Taber, 2018). Only participants who indicated having used cannabis ever were included in the factor and subsequent regression analysis (N=4102) because use motives were considered interpretable only for those who actually use cannabis.

We performed linear ordinary-least-squares regressions predicting use intensity, both using only cannabis use motives ("unconditional") and use motives combined with known cannabis use covariates from the literature ("conditional"). Graphical analysis was performed to check the distribution of the residuals for bias and heteroskedasticity. Further, we provided the results of unconditional and conditional binary logistic regressions, both on the outcome of frequent use and positive CAGE-AID, indicating potential CUD. We compared the results of unconditional and conditional regressions in order to assess whether use motives provide an explanatory advantage over more standard cannabis use covariates. The covariates included are: socio-demographic variables age, gender, and sexuality (Hemsing & Greaves, 2020; Vangsness et al., 2005); religiosity (Mader et al., 2019; Pinchevsky et al., 2012); LOC and BIS as known personality correlates of cannabis use/initiation (Acton, 2003; Helmer, Krämer, & Mikolajczyk, 2012; Mendolia & Walker, 2014; Vangsness et al., 2005); and an existing psychiatric diagnosis (Mader et al., 2019; Schlossarek, Kempkensteffen, Reimer, & Verthein, 2016). Grades were considered but not included

in the regression because the descriptive statistics indicated that they were not linked to frequent use or CUD.

Results

Sample

After contacting about 100,000 students, the initial data set included a total number of 12,914 respondents. Using the exclusion criteria (cf. Viohl et al., 2019), we reduced the sample to 9350 valid responses. The socio-demographic characteristics are listed in Table 1. The average participant was 24.4 years old, 50.7% were women, 87.2% were heterosexual, 14.7% had a psychiatric diagnosis in their life, similarly to Viohl et al. (2019) which was based on the same data set.

Table 1. Socio-demographic variables for total sample and subject with frequent use (cannabis use twice or more per week).

	Total sample (*N*=9350)	Frequent use (*N*=793)		CAGE-AID positive (*N*=2263)	
Categorical variables	*N (%)*	%	χ^2	%	χ^2
Gender			148.5 ***		193.3 ***
Woman	**4737 (50.7%)**	**30.8%**		**38.0%**	
Man	**4553 (48.7%)**	**68.0%**		**61.2%**	
Other	**54 (0.6%)**	**0.9%**		**0.7%**	
Sexual orientation			23.3 **		41.0 ***
Heterosexual	**8158 (87.2%)**	**83.7%**		**83.6%**	
Homosexual	**433 (4.6%)**	**4.4%**		**6.1%**	
Bisexual	**609 (6.5%)**	**10.2%**		**8.6%**	
Other	**119 (1.3%)**	**1.6%**		**1.7%**	
Psychiatriac diagnosis	1376 (14.7%)	16.5%	2.3	**20.7%**	80.5 ***
CAGE-AID drugs positive	**2263 (24.2%)**	**65.2%**	798.2 ***		
Ordinal/continuous variables	*M (SD)*	*M (SD)*	*Δ*	*M (SD)*	*Δ*
Use intensity (0–8)	**2.3 (2.4)**	**7.6 (0.5)**	5.8 ***	**4.0 (2.7)**	2.1 ***
Age (years)	24.4 (4.7)	24.1 (4.2)	−0.3	24.6 (4.5)	0.3
BIS (16–54)	**31.3 (6.0)**	**33.5 (5.8)**	2.4 ***	**33.3 (6.1)**	2.5 ***
LOC (1:external to 7:internal)	4.77 (0.67)	4.79 (0.66)	0.03	**4.71 (0.66)**	−0.1 ***
Religiosity (1–5)	**1.91 (1.22)**	**1.59 (0.95)**	−0.35 ***	**1.77 (1.11)**	−0.1 *
Grade average (1: V. Good to 5: Fail)	2.02 (0.62)	2.04 (0.60)	0.02	2.02 (0.62)	0.0

Notes: The last column compares the frequent use group, defined as subjects consuming cannabis twice or more per week, with the rest of the respondents; significant group differences are bold; for categorical variables, we indicate the number of positive responses (*N* and percentage), chi-square (χ^2) test for the difference between frequencies in two groups and corresponding *p*-value; for ordinal/continuous variables, we indicate the averages (M), standard deviations (SD), the difference (Δ) between groups. The category "other" summarizes all free text input alternatives. Stars denote the *p*-value of the t-test for difference of group means. We perform a Bonferroni correction (0.05/30): * *p*-value < 0.002, ** *p*-value < 0.0003, *** *p*-value < 0.00, 003.

Cannabis use prevalence and risk factors

Cannabis use prevalence over the past month was 23.9%, over the past year 41.5% and lifetime prevalence was 67.1% (as in Viohl et al., 2019). Among those indicating having used cannabis in their lifetime, the majority (70.1%) used it less than monthly, while 8.3% consumed cannabis monthly, 9.0% 2–4 times a month, 5.4% 2–3 times a week and 7.3% more than 3 time per week.

Figure 1 shows the distribution of subjects across use intensity (yellow bars). The largest group is the subjects who never used cannabis. Figure 1 also shows the share of subjects with a positive CAGE-AID test within each use intensity level (blue dots). Overall, 24.2% of the respondents had a positive CAGE-AID screening test, and Figure 1 shows that positive CAGE-AID was more frequent in respondent groups consuming more cannabis. In this study, we will focus in particular on the group of subjects with use intensity of 7 or 8, that is, subjects consuming cannabis twice or more per week. In this group with frequent use, the share of subjects with a positive CAGE-AID test is over 50%, so that we considered them a group at high risk of CUD.

Subjects with frequent cannabis use indicated more often men and "other" gender. Respondents with frequent use were also more impulsive and less religious. The distribution of sexual preferences was significantly different with less respondents identifying as heterosexual and homosexual and more as bisexual or selecting the free text input. Differences in age, LOC and psychiatric diagnosis were not statistically significant.

The CAGE-AID screening test for CUD was significantly more often positive for subjects with frequent use. Women had significantly less often a positive CAGE-AID than men and "other" gender. Respondents with positive CAGE-AID indicated less often heterosexual preferences. Moreover, subjects with a positive CAGE-AID had significantly higher BIS, more external LOC and lower religiosity. Average grades did not differ significantly between subjects with frequent use or positive CAGE-AID and other respondents.

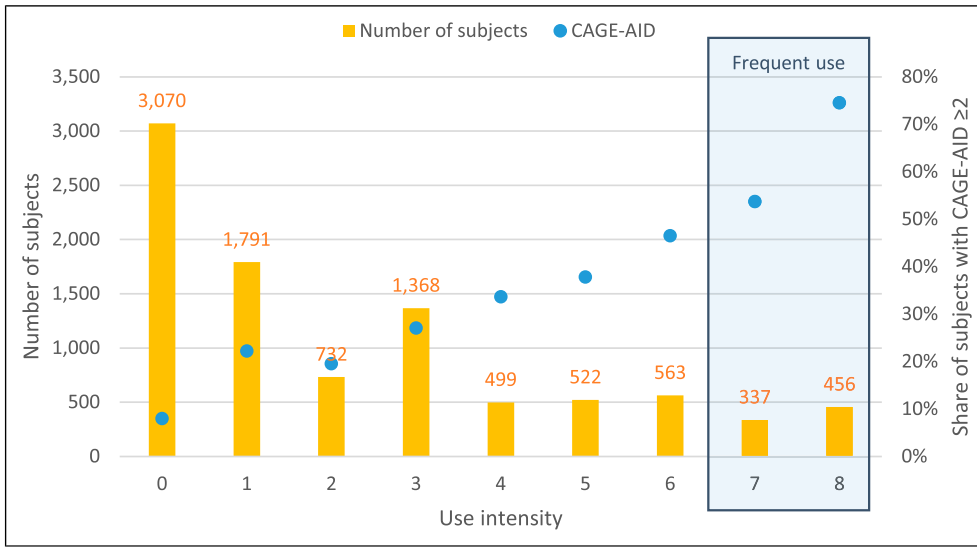

Figure 1. Histogram of use intensity (left axis) and share of respondents with a positive CAGE-AID screening test, indicating potential CUD (right axis).

Cannabis use motives

The average scores (5-point Likert scale) of the 20 motive items are shown on Figure 2 for those who consume cannabis, as use motives are not applicable to those not using cannabis. The motives yielding the highest agreement among respondents were euphoria, relaxation, and inebriety (Figure 2). However, the overall agreement was generally low with even the most popular items scoring on average around 2.5 (middle of the scale).

The data met basic appropriateness criteria for factor analysis: Kaiser–Meyer–Olkin measure of sampling adequacy was 0.878 and the Bartlett's test (χ^2= 41,094.4, df = 190, $p < 0.001$) was significant. Using parallel analysis (Horn, 1965), we obtained a five-factor solution in our exploratory factor analysis. Table 2 shows the factor loadings for the rotated solution. There were no items failing to load sufficiently on any factor. Two items loaded>.40 on more than one factor; these cross-loading items were excluded (gray in Table 2).

Table 3 contains means, standard deviations, pairwise correlations, and Cronbach's α for the five scales. Cronbach's α ranged from .66 to .79, indicating acceptable internal consistency. The highest scoring scale was enhancement (similar to MMM). This scale was followed by coping (avoid problems, alleviate bad mood, relax) and social (empathy, self-esteem, showing emotions), again similarly to MMM. We did not include items on psychedelic effects (expansion) and conformity, however we had additional scales on improving performance (concentrate on work, lose weight, stay awake) and intensity (increased sexual pleasure, reducing boredom, modulating effect of other drugs).

Table 4 show mean scores and the shares of respondents scoring high (above 2) on each scale for three groups: all respondents using cannabis, respondents with frequent use and respondents with a positive CAGE-AID. Enhancement and coping were the two main motives for cannabis consumption with average scores of 2.52 (resp. 2.38) and a share of respondents scoring high of 56.8% (resp. 45.4%). Subjects with frequent use agreed significantly more than others to the

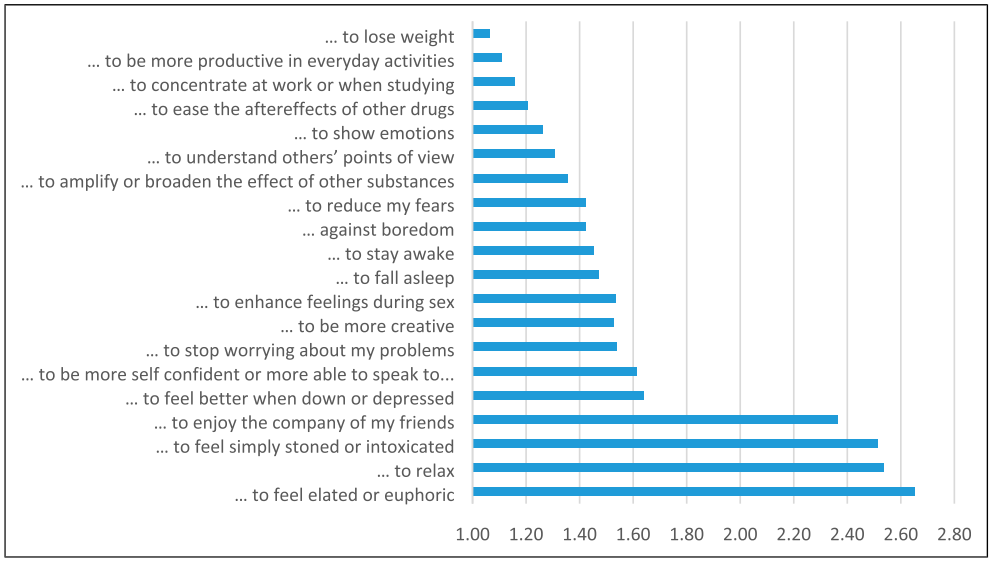

Figure 2. Motives for cannabis consumption, average of 5-point Likert scale (1= does not apply, 5= fully applies, *N* = 4102).

Table 2. Standardized factor loadings of the 20 motive items for the five factor model (N = 4102).

	Social	Coping	Enjoyment	Intensity	Performance
I use cannabis… to show emotions	0.98	−0.08	−0.17	−0.02	−0.09
… to understand others' points of view	**0.92**	−0.19	−0.20	0.19	−0.05
… to be more self-confident or more able to speak to others in social situations	**0.58**	0.15	0.29	−0.42	0.04
… *to be more creative*	***0.50***	*−0.05*	*−0.10*	***0.48***	*−0.05*
… to stop worrying about my problems	−0.06	**0.89**	0.09	−0.12	0.14
… to feel better when down or depressed	−0.13	**0.87**	0.19	−0.10	0.18
… to relax	−0.15	**0.61**	0.31	0.17	−0.20
… to reduce my fears	0.35	**0.57**	−0.15	−0.32	0.18
… *to fall asleep*	***−0.05***	***0.51***	*−0.19*	***0.43***	*0.05*
… to feel elated or euphoric	−0.12	0.15	**0.92**	−0.02	−0.14
… to feel simply stoned or intoxicated	−0.25	0.13	**0.86**	0.20	−0.17
… to enjoy the company of my friends	0.31	0.05	**0.50**	−0.06	−0.28
… to ease the aftereffects of other drugs	−0.05	−0.08	0.03	**0.76**	0.16
… to amplify or broaden the effect of other substances	0.14	−0.24	0.24	**0.61**	0.10
… against boredom	0.05	0.15	0.15	**0.44**	0.11
… to enhance feelings during sex	0.18	−0.07	0.25	**0.42**	−0.02
… to concentrate at work or when studying	−0.14	0.19	−0.17	0.14	**0.88**
… to be more productive in everyday activities	−0.01	0.12	−0.17	0.17	**0.85**
… to lose weight	0.03	0.00	−0.04	0.25	**0.58**
… to stay awake	−0.07	−0.16	0.35	−0.08	**0.52**

Notes: Factor analysis with principal component method, promax oblique rotation; items are associated to the scale on which they load with more than 0.40; the items in gray are excluded because of cross-loading on more than one scale. Kaiser–Meyer–Olkin measure of sampling adequacy = 0.878; Bartlett's test χ^2= 41,094.4, df = 190, $p < 0.001$.

Table 3. Pairwise Pearson's correlation, Cronbach's alpha (α), means (M), and standard deviations (SD) of motive scales (N = 4102).

	Social	Coping	Enjoyment	Intensity	Performance
	(3 Items)	(4 Items)	(3 Items)	(4 Items)	(4 Items)
Coping	0.47***				
Enjoyment	0.49***	0.51***			
Intensity	0.43***	0.51***	0.49***		
Performance	0.36***	0.21***	0.19***	0.30***	
Cronbach's α	0.786	0.660	0.707	0.732	0.703
M (SD)	1.40 (0.70)	2.38 (1.21)	2.52 (1.24)	1.38 (0.64)	1.20 (0.49)

Notes: We performed a Bonferroni correction (0.05/10): * p-value <0.005, ** <0.001, ***<0.0001.

social, coping and enhancement scales, while the only significant difference between CAGE-AID positive and negative respondents was found for coping.

Cannabis use motive scales were significant predictors for use intensity in our sample (column (1) and (2) of Table 5). An unconditional (using only motive scales) linear regression showed that social and coping motives were associated with higher use intensity, while intensity and

Table 4. Motive scales for all respondents, and for subjects with heavy use and CAGE-AID.

	All respondents				Frequent use			CAGE-AID positive		
	N	M	SD	%	N	%	*p*-value (H_0: freq. = other)	N	%	*p*-value (H_0: pos = neg)
Social	4209	1.40	0.70	13.4	692	**17.2**	<0.01	1378	13.9	0.504
Coping	4211	2.38	1.21	46.4	690	**51.3**	<0.01	1377	**50.1**	<0.001
Enhancement	4213	2.52	1.24	56.8	688	**62.2**	<0.01	1377	58.4	0.128
Intensity	4212	1.38	0.64	11.8	691	**9.3**	0.022	1377	10.7	0.158
Performance	4214	1.20	0.49	4.6	693	3.5	0.131	1381	4.3	0.729

Notes: The table shows the number of observations (*N*), the mean (M), the standard deviation (SD) and the percentage of respondents scoring 2 or higher on a given scale (%).The *p*-value corresponds to a Student t-test for equality of means between the frequent use, resp. CAGE-AID positive, group and the remaining sample; significant differences (*p*-value <0.05) are in bold.

performance motives were associated with lower use intensity. The enhancement motive had no significant impact, although this scale scored the highest general agreement (Table 4). These effects persisted in a multivariate linear regression including other covariates, which had been discussed in the literature.

A binary logistic regression predicting the probability of frequent use showed a similar pattern (column (3) and (4) of Table 5): social and coping had odds ratios above one, signifying a higher probability of frequent use, while intensity and performance had odds ratios below one, meaning that subjects scoring high on these scales have a lower probability of frequent use. Endorsing social motives more by one standard deviation increased the likelihood of frequent use by 30%, all else equal. These effects remained statistically significant after controlling for covariates.

A binary logistic regression predicting the probability to score positive in the CAGE-AID screening test for substance use disorder showed that coping significantly increased the risk to have a positive CAGE-AID and intensity significantly decreased the risk (column (5) and (6) of Table 5). The effect of coping motives remained after controlling for covariates, whereas the effect of intensity was not significant anymore. One standard deviation higher endorsement of coping motives increased the likelihood of a positive CAGE-AID by 12%.

Age decreased the likelihood of frequent cannabis use (column (2) and (4) of Table 5). Controlling for other factors, men were more than twice as likely as women to show frequent use (column (4)) and a positive CAGE-AID (column (6)); other gender (49 respondents) were significantly more likely to show frequent use. All else equal, bisexual preferences increased the probability to show frequent cannabis use, while CAGE-AID was not significantly related to sexual preferences. Religiosity was negatively correlated to use intensity, but not likelihood of potential CUD. Impulsivity was positively correlated to use intensity and a positive CAGE-AID. An internal LOC had no impact on use intensity, but decreased the likelihood of a positive CAGE-AID. An existing psychiatric diagnosis increased use intensity and the likelihood to have a positive CAGE-AID.

Discussion

The cannabis use prevalence found in our sample is consistent with the literature on Berlin college students, albeit moderately higher than the prevalence found in a similar sample by Jochmann et al. (2019): we found a 30 day prevalence (30Dp) of 24% versus 17% in their sample, a past year prevalence (12Mp) of 41%, and lifetime prevalence (Lp) of 68% versus 63%. As hypothesized,

Table 5. Linear regression model predicting use intensity, and logistic regression predicting frequent use and positive CAGE-AID; each with and without covariates.

	Use intensity (linear)		Frequent use (logistic)		CAGE-AID pos. (logistic)	
	Unconditional B (1)	Conditional B (2)	Uncond OR [CI] (3)	Cond OR [CI] (4)	Uncond OR [CI] (5)	Cond OR [CI] (6)
Motive scales (standardized)						
social	0.22***	0.19***	1.32*** [1.20, 1.45]	1.30*** [1.17, 1.44]	1.07	1.04
coping	0.14***	0.13**	1.15** [1.04, 1.27]	1.15* [1.03, 1.29]	1.11** [1.02, 1.20]	1.12* [1.02, 1.22]
enhancement	0.00	0.02	1.00	1.00	1.02	1.03
intensity	−0.19***	−0.20***	0.79*** [0.70, 0.88]	0.76*** [0.68, 0.86]	0.91** [0.84, 0.99]	0.89
performance	−0.09**	−0.10*	0.88* [0.80, 0.98]	0.88* [0.79, 0.98]	0.95	0.93
Age (years)		−0.07***		0.98* [0.96, 1.00]		1.00
Gender (base category: Woman)						
man		0.25		2.26*** [1.86, 2.75]		2.20*** [1.90, 2.55]
other		−0.84***		2.74* [1.05, 7.19]		1.75
homosexual		0.13		1.09		1.40
bisexual		0.82***		1.69** [1.23, 2.31]		1.26
other		0.52		1.00		1.26
Religiosity (standardized)		−0.18***		0.84*** [0.76, 0.92]		1.02
Psychiatric diagnosis (binary)		0.21*		1.27		1.54*** [1.27, 1.87]
LOC (standardized)		0.02		1.06		0.91** [0.84, 0.97]
BIS (Standardized)		0.39***		1.30*** [1.19, 1.42]		1.30*** [1.20, 1.39]
Constant	3.65***	5.60***	0.19*** [0.17, 0.21]	0.18*** [0.11, 0.31]	0.49*** [0.46, 0.52]	0.25*** [0.17, 0.37]
(Pseudo-)R^2	0.13	0.11	0.03	0.06	0.02	0.05
N	4102	3757	4093	3763	4109	3750

Notes: Stars denote *p*-values: * <0.05, ** <0.01, ***<0.001; use intensity is an ordered 9-step scale (linear regression), frequent use and CAGE-AID positive are binary outcomes (logistic regression); B are unstandardized linear regression coefficients; OR are odds ratio; 95% confidence intervals (CI) are given in brackets when statistically significant at the 5% level; the category "other" summarizes all free text input alternatives; continuous variables are standardized: cannabis use motive scales, locus of control (LOC) with low=external LOC and high=internal, Barratt Impulsiveness Scale (BIS-15) with low= low impulsivity, and religiosity; N is smaller for conditional regressions because some variables are missing.

these prevalences were higher than in similar age groups in Germany (Orth & Merkel, 2018: 30Dp=10%, 12Mp=23%, Lp=423%; Seitz, Böttcher, Atzendorf, Rauschert, & Kraus, 2021: 30Dp=9%, 12Mp=30%, Lp=43%) or the US (SAMHSA, 2020: 12Mp=35%). The prevalences of this study were about twice as high as the general population in Berlin (Kraus, Seitz, & Rauschert, 2020: 30Dp=8%, 12Mp=17%, Lp=48%), and much higher than Germany (Seitz et al., 2021: 30Dp=3%, 12Mp=7%, Lp=28%) or the US (SAMHSA, 2020: 12Mp=18%). The hypothesis that Berlin as the "party capital of Europe" shows higher prevalences of substance use seemed thus supported by our data set.

With 24.2% of respondents scoring positive on the CAGE-AID, lifetime incidence of CUD appeared higher in our sample than 9.4% found in an American sample of first-year college students by Caldeira, Arria, O'Grady, Vincent, & Wish (2008). Compared to yearly diagnosed CUD incidences in Berlin in general (Kraus et al., 2020: 1.8%) or the European Union (EMCDDA, 2020: 1%) or the US (SAMHSA, 2020: 5.1%), our findings are high, but one may expect most CUD to be never clinically diagnosed (Caldeira et al., 2008).

The 20-item questionnaire on cannabis use motives gave rise to five motive scales, which were similar to other scales used within the literature (Lee et al., 2009; Schnell, Gliese, Schröter, Kasten, & Gouzoulis-Mayfrank, 2017; J. Simons et al., 1998): coping, social, enhancement, intensity, and performance. Our empirically determined structure of the scales showed only moderate overlap with the scales postulated ex ante by Boys et al. (2001), except for our coping scale which represents their "changing mood" scale; we believe this difference stemmed from different methodologies applied.

In our data, the highest scoring scale was enhancement of positive affect, similar to MMM (J. Simons et al., 1998). However, previous literature found that social reasons were the second most common motive (Glodosky & Cuttler, 2020; Norberg, Olivier, Schmidt, & Zvolensky, 2014; J. Simons et al., 1998), while in our data coping (endorsed by 46.4%) was much more common than social (endorsed by 13.4% of all respondents, 17.2% of subjects using cannabis frequently). Social motives were associated with less intense and less problematic cannabis use in the literature (Glodosky & Cuttler, 2020). This work at hand was the first study on cannabis use motives focusing on students in Berlin. The unusually high share of respondents indicating coping motives could explain the high levels of frequent use and CUD in this population, as coping is known to be associated with frequent use and CUD (Lee et al., 2009; Phillips et al., 2017; Schultz et al., 2019). At this stage, it remained unclear whether this was a selection effect stemming from the attractiveness of Berlin's nightlife for students interested in a substance-affine lifestyle or whether the living conditions in Berlin induced these coping motives.

We found that high scores on the coping (forgetting problems, avoiding sadness) and social (showing emotions, increasing empathy) motive scales significantly predicted higher use intensity (similar to Bonar et al., 2017; Norberg et al., 2014), while intensity and performance were associated with lower use intensity. Despite being the most common cannabis use motive, enhancement had no significant impact on use intensity in a regression including all five motive scales: this motive seemed to be shared equally among respondents with frequent and not so frequent cannabis use. Across the three outcomes of this study, we saw that motive scales had a significant impact even when controlling for other covariates.

Coping motives were the only significant motives scale for predicting a positive CAGE-AID and thus a potential CUD, after controlling for a list of potential confounding factors. This strengthened the finding from previous literature that coping was associated with more cannabis use, dependence and other negative outcomes (Lee et al., 2009; Phillips et al., 2017; Schultz et al., 2019). However, previous literature had found differences between subjects using cannabis with and without signs of CUD in other motive scales, like

enhancement, social and expansion (Bonn-Miller & Zvolensky, 2009; Patterson, Vu, Haardörfer, Windle, & Berg, 2020; Pearson et al., 2019), which could not be confirmed in our data.

The literature has hypothesized that coping motives mediate the relationship between previous vulnerability and CUD: subjects suffering from psychiatric symptoms could develop coping motives, and these coping motives could increase the likelihood of developing a CUD (Bujarski, Norberg, & Copeland, 2012; Fox, Towe, Stephens, Walker, & Roffman, 2011; Johnson, Mullin, Marshall, Bonn-Miller, & Zvolensky, 2010; Vangsness et al., 2005). Indeed, a psychiatric diagnosis had no direct significant impact on the probability of frequent use, but showed a significant association with potential CUD. There remained a significant impact of coping motives on the probability of CUD in our data, even when controlling for psychiatric diagnosis.

The impact of socio-demographic characteristics in our sample was similar to other studies. As in many studies, men had higher levels of use intensity and CUD than women: Hemsing & Greaves (2020) provide an interesting discussion on how this finding may be explained by "'male-typical or masculine' identity." Similar to Mader et al. (2019), religiosity decreased the risk of frequent use in our sample, but not CUD: another instance where a nuanced inspection of use frequency and CUD appeared adequate. Age had a small impact on use frequency and no impact on CUD; this would be consistent with the pattern documented by Caldeira, O'Grady, Vincent and Arria (2012) that cannabis use by university students is "typically heaviest in the first year of study and tends to reduce over the course of academic studies." Strong associations had been found previously between frequency of cannabis use and psychiatric disorders (Caldeira et al., 2008). In our data, frequent use was not significantly correlated to psychiatric diagnosis, while potential CUD was correlated with a psychiatric diagnosis as in previous studies (Chabrol, Ducongé, Casas, Roura, & Carey, 2005; Schlossarek et al., 2016).

LOC did not impact cannabis use frequency in our sample, which is consistent with Mendolia & Walker (2014). Although internal LOC is known to impact a variety of health behaviors, the impact on substance use seems minor (Helmer et al., 2012). However, respondents with more internal LOC showed significantly less CUD in our sample. This is consistent with the idea, that internal LOC is a protective factor on many life outcomes (Heckman et al., 2006). Similar to the literature, impulsivity, as measured by BIS in our sample, increased both use intensity and CUD rates. Vangsness et al. (2005) shows that impulsivity both directly impacts the frequency of cannabis use and indirectly via less negative cannabis use expectancies. Hecimovic et al. (2014) explain that "impulsive individuals are marked by their inability to weigh immediate reward against long term consequences […] and might use cannabis […] as a short term solution to problems," which might induce subsequent CUD.

Limitations. There are limitations in this research that demand caution when interpreting the results.

Sample selection among the overall college student population of Berlin (N= 111,007, estimated response rate=11.6%) was difficult to assess, although the sample gender distribution matched roughly the overall gender distribution of the population (Viohl et al., 2019). Subjects using alcohol and other substances have generally higher response rate and the monetary incentive may cause a further bias toward higher substance use (Betzler, Viohl, & Romanczuk-Seiferth, 2017).

Usual limitations for self-report based data apply: socio-demographic data could not be verified, information may have been subject to desirability bias and memory faults (Parra, O'Neill, & Sher, 2003; Williams & Nowatzki, 2005). Nevertheless, self-report is a well-validated (Harrison & Hughes, 1997) and widely used substance use measurement technique. Cross-sectional studies cannot provide causal analysis and the timing of events remains unclear; longitudinal studies, prospective and interventional, would be needed for more clarity on the mechanisms. This study

presented the results of exploratory analysis on use motives, and the replicability of exploratory analysis needs to be confirmed in further research.

A core hypothesis of this study was that a positive CAGE-AID captures potential CUD. Although no simple screening tool could replace the diagnosis of CUD by a clinician, this measure has performed reasonably well in other studies (Brown, Leonard, Saunders, & Papasouliotis, 1998; Couwenbergh, Van Der Gaag, Koeter, De Ruiter, & Van den Brink, 2009). In Germany, collecting data on race and ethnicity is highly problematic (Balestra & Fleischer, 2018), so that we could not control for these factors despite their known impact on cannabis use patterns (e.g. Pacek, Mauro, & Martins, 2015).

Conclusion

This study has shown that Berlin college students use cannabis frequently and are at high risk for CUD. In our sample, we confirm the known link between coping motives and CUD and show that coping motives are highly prevalent in this sample. Further research is needed to understand why Berlin college students endorse coping use motives more than other samples in the literature.

We believe that coping motives could be useful for identifying subjects with problematic use (Fox et al., 2011), as they may be potentially less subject to social desirability than CAGE-AID items in non-anonymous surveys. Moreover, knowing about the high rates of coping motives may be useful to primary and secondary prevention campaigns in Berlin. Following the classification of Foxcroft (2014), such campaigns may cover informational functions aiming at showing that cannabis use is a maladaptive coping mechanism (Glodosky & Cuttler, 2020) and developmental functions aiming at teaching vulnerable subject groups other coping strategies. Clinically, further research should elaborate more in detail what problems college students are trying to cope with by using cannabis and what would be more helpful alternative coping strategies.

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P2: Determinants of Cannabis Initiation and Cessation

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Determinants of cannabis initiation and cessation among Berlin college students – a longitudinal study

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Keywords

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Abstract

Objective: As a big European city famous for its party scene, Berlin attracts college students that are a high-risk population for cannabis use and use disorder. College years are often associated with new behavior patterns, but the factors leading to cannabis initiation are rarely studied past adolescence. This study describes the longitudinal evolution of college students' cannabis use over two years and its correlates.

Method: Data was collected among all students of Berlin's public colleges via two online surveys (N=1,201, mean interval=16 months). Multivariable binary logistic regressions were performed on four outcomes: regular use, use initiation, use reduction and use cessation. Several dimensions of covariates were used: socio-demographic factors, psychological (locus of control, impulsivity, psychiatric diagnosis), behavioral (other substance use), perceived harm, declared intention to reduce and setting of cannabis use.

Results: Overall, the majority of respondents did not change their cannabis use. The factors for use initiation (impulsivity, tobacco and alcohol use) were not fully symmetric to the factors leading to cutting down/quitting (locus of control, perceived harm, tobacco use). Perceived harm had an impact on quitting, but not on reducing use. The intention to reduce did not significantly predict subsequent use behavior. Most regular users use cannabis at home, which was associated with a low probability to reduce.

Conclusions: No simple symmetry exists between correlates of initiation and cessation: tobacco co-use is important for both, while impulsivity and alcohol use lead to initiation and internal locus of control facilitates cessation.

1. Introduction

With a 12-month-prevalence of 41.5% (Viohl et al., 2019), college students in Berlin are more likely to use cannabis than young adults in other German regions (Rauschert et al., 2023; Schäffler et al., 2015) and in other European countries (average for 15-34 years is 12%, highest national rates in Czechia with 23% and France with 22%; EMCDDA, 2022). The high prevalence among college students in Berlin may be related to three main aspects: first, the age group: young adults are the main user group of cannabis (Seitz et al., 2019; SAMHSA, 2020). Second, college life: it is unclear whether college students use cannabis more than same-age subjects not enrolled in college (Pauly & Klein, 2012; Schäffler et al., 2015) or not (McCabe et al., 2021). Third, the local culture: big cities are known to have higher substance use rates than rural areas (Coughlin et al., 2019; Strizek et al., 2021). Berlin is known for its nightlife and attracts people from all over the world interested in the techno scene (Betzler et al., 2019). This “club culture” is related to a high risk of substance use (Ding et al., 2014; Kelly et al., 2006; Palamar et al., 2015).

As a consequence, Berlin college students are at high risk for frequent cannabis use, cannabis use disorder (CUD) and use-related problems (Viohl et al., 2019). Cannabis use during college years has been shown to correlate with negative outcomes later in life (Arria et al., 2015; Degenhardt et al., 2010), although causality can often not be established clearly (Lorenzetti et al., 2020; Pearson, 2019). Knowing the factors associated with initiation, as well as cessation, of cannabis use is crucial for the development of effective intervention programs. We thus review the literature on the potential factors of cannabis initiation by college students and those of cessation.

College students are in a transition phase of “emerging adulthood” that has been identified as a second “period of vulnerability” for substance use, as many adolescents move out of their parental homes (Tucker et al., 2005). In an Australian prospective study, more participants initiated regular use after high school (young-adult onset) than in adolescence (Chan et al., 2021). Nevertheless, the factors leading to initiation are rarely studied past adolescence (Beck et al., 2009; Pinchevsky et al., 2012). According to a systematic review by Guxens et al. (2007), common factors associated with adolescent cannabis initiation include: male sex (mostly positively associated with cannabis initiation), availability of drugs (positive), peer influence (positive), tobacco consumption (positive), alcohol consumption (mostly positive), low socio-economic status (mostly positive), age (negative), academic performance (sometimes negative), religiosity and church activity (negative; Thomas et al., 2021; Wallace et al., 2007), substance use expectancies (positive; Montes et al., 2019). Longitudinal studies are the appropriate design to identify predictive factors of cannabis initiation (Guxens et al., 2007).

Studies have shown that there are connections between cannabis use and other risky activities. In particular, tobacco and alcohol consumption are related to cannabis use (Lemyre et al., 2019; Masters et al., 2018; Vijapur et al., 2021). Aside the gateway hypothesis ("legal drugs are necessary intermediates between nonuse and marihuana"; Kandel, 1975), “reverse gateway theory, route of administration theory, and common liability theory” have been discussed in the literature (Lemyre et al., 2019). Common etiology

can derive from latent factors, as risky behavior correlates with impulsivity: more impulsive subjects are known to be more prone to cigarette, alcohol and cannabis use (Acton, 2003; Vangsness et al., 2005). Cannabis users also tend to use condoms less often than non-users, thereby increasing the risk of sexually transmitted infections and unplanned pregnancies (Buckner et al., 2018; Bustamante et al., 2022; Palamar et al., 2018; Ross et al., 2019).

Factors of cessation of cannabis use are less studied than factors for its onset. While some theories would presume that there may be a symmetry between initiation and cessation (e.g. Acton, 2003), the empirical literature (Hammer & Vaglum, 1990) has found that some factors explain initiation, while others account for cessation. Zuckermann et al. (2019) show that adolescents are less likely to quit cannabis use if they binge drink, use tobacco, and do less sports. Several studies have shown that tobacco use decreases the chances of a successful attempt to quit cannabis (Masters et al., 2018; Peters et al., 2012).

Consistent with the Health Belief Model (Maiman & Becker, 1974), perceived harm has been found to predict individuals' cannabis and other substance use (Arria et al., 2008; Piontek et al., 2013; Swaim, 2003). Beyond individual effects, differences in perceived harm have been used to explain historical (Bachman et al., 1988) and geographical (Piontek et al., 2013; Wadsworth & Hammond, 2019) differences in cannabis use.

Schwarzer (2008) hypothesizes in the Health Action Process Approach (HAPA) that the adoption of health behaviors, such as reducing/quitting cannabis use, consists of a motivation and a volition phase. In the motivational phase, outcome expectancies (e.g. risk perception) and self-efficacy lead to an intention to change; in the volition phase, these intentions have to be translated into change of behavior and its maintenance. Schwarzer underlines the importance of self-efficacy for the second phase, but also situational barriers and opportunities should be taken into account. In a more general framework, within the Theory of Planned Behavior (Ajzen, 2002) one may say that the Health Belief Model stresses the behavioral beliefs (consequences of the behavior) and HAPA underlines the importance of control beliefs. Self-efficacy and beliefs about controllability (LOC) are conceptually distinct (Ajzen, 2002), but empirically highly correlated aspects of control beliefs (Judge & Bono, 2001; Stewart & De George-Walker, 2014).

Context of cannabis use vary widely, but the analysis of cannabis use settings (locations) has so far been limited to the distinction solitary vs. social use. The literature has found solitary use to be positively associated with cannabis-related problems (Buckner et al., 2016; Guo et al., 2021; Noack et al., 2011; Tucker et al., 2006). Alcohol drinking contexts have been studied as a choice combining aspects of use motives, peer influences (especially via drinking rituals, such as buying rounds), use patterns (intensity vs. frequency) and, potentially, risk of problematic use (e.g. Nyaronga et al., 2009). Looby et al. (2021) is the only article examining use locations ("at their home, at a friend's home, at a stranger's home, outside, in a car, at a party, other") and their link to simultaneous cannabis use. Drawing parallels from alcohol use, one may hypothesize that the setting of bars, clubs and parties may be associated with occasional but heavy use, while home,

study and work settings may be associated with less heavy but more regular use (Linden-Carmichael & Lau-Barraco, 2017).

In this study, we investigated the associations of socio-demographic, psychological and behavioral factors with the changes in cannabis use over two years in a sample of Berlin college students. This study thereby contributed to the scarce literature on onset and discontinuation of cannabis use beyond adolescence and focused on a high-risk sample. We compared cross-sectional results with longitudinal findings on the dynamics of initiating and quitting cannabis use. We hierarchically compared the explanatory power of adding sequentially socio-demographic, psychological and behavioral factors, as well as perceived harm and use settings.

Based on the literature, we hypothesized that (a.) the covariates male gender, low socioeconomic status, low religiosity, psychiatric diagnosis, tobacco and alcohol use, and sexual risk taking predicted initiation positively and cessation negatively, (b.) internal locus of control (as a measure of subjective controllability) predicted reduction/cessation, while high impulsivity predicted initiation, (c.) perceived harm and intention to reduce predicted reduction/cessation, (d.) among use locations (settings), club, bar and party were associated with less frequent use than study, home, and work, and (e.) the cross-sectional variable “regular use” reflected a non-trivial combination of college years initiation and cessation, and pre-college events.

2. Materials and methods

2.1. Study design

The longitudinal data were gathered with the online Student Drug Survey among students of 17 institutions of higher education in Berlin. The first survey (S1) was conducted between 11/2016 and 09/2017, the second survey (S2) between 05/2018 and 02/2019. We collected valid replies from 9,400 subjects in S1 (response rate approx. 11%), and from 7,023 subjects in S2 (response rate approx. 8%). A subset of 1,280 subjects answered both surveys (follow-up rate=14%). On average, 16 months passed between the first and second participation. Invitation was sent by the university to students via e-mail. The study was approved by the Ethics Committee (application number: EA1/258/16). This study was not pre-registered. More information and the original version of the survey of the Student Drug Survey can be found in Viohl et al. (2019).

2.2. Measures

Outcomes. Cannabis use prevalence, excluding prescribed medical use, over the past month, past year and lifetime was assessed by self-report. Respondents who indicated any use were further asked to report frequency (never, < monthly, monthly, 2-4/month, 2-3/week, >3/week). We interacted prevalence and frequency, in order to construct a 9-point measure of use intensity similarly to Simons et al. (1998): 0 (never tried), 1 (no use, but has tried), 2 (less than monthly, not in past 12 months), 3 (less than monthly, but within last 12 months), 4 (less than monthly, but within past month) , 5 (monthly), 6 (2-4/month) , 7 (2-3/week), 8 (> 3/week).

Based on the cross-sectional cannabis use intensity, we defined our three dynamic outcomes: among regular users (respondents using cannabis at least monthly, i.e. use intensity>4), we defined that a respondent had *reduced* cannabis use if the use intensity in S2 was lower than the use intensity in S1. Among the same set of regular users, we defined that a respondent had quit cannabis use if use intensity≤2; note that, by this definition, all users who quit cannabis use also reduced use. Among those who did not use cannabis in S1 (use intensity<2), we defined that a respondent had *initiated* cannabis use if use intensity>2 in S2.

Covariates. Information was collected about socio-demographic information, such as gender, age, sexual preferences. The level of religiosity was assessed with a 5-point rating. In Germany, students whose parents have an income below a certain threshold receive a financial support from the state (called "BAföG"), which we used as a proxy for low socio-economic background.

Participants were asked about past diagnosis of psychiatric disorder. Personality was assessed along the dimensions of impulsivity and LOC. Impulsivity was measured using a short form of the Barratt Impulsivity Scale (BIS-15) after Meule et al. (2011), with total scores ranging from 16 (low impulsivity) to 54 (high impulsivity). LOC was measured using the questionnaire from the German socioeconomic-panel (Richter et al., 2017), with a final score ranging from 1 (external LOC) to 7 (internal LOC).

We computed three variables measuring behavior potentially associated with cannabis consumption: tobacco smoking (binary), alcohol use intensity (0-8, defined analogously to cannabis use intensity) and risky sexual behavior (binary), which was defined as unprotected intercourse with more than one regular partner.

Respondents who used cannabis assessed perceived harm, i.e. whether cannabis rather "helped" or "harmed them" on a 5-point rating scale-. Moreover, we asked whether they intended to reduce their consumption in the next 12 months and whether they had interest in medical counseling on substance use (both binary).

Respondents were asked to indicate use settings for cannabis among the following options: club, bar, house party, study, work, at home, and other. Among the free text input for other, "nature" appeared repeatedly and some answers were classifiable directly into one of the previous categories. The remaining "other" answers were excluded from the analysis.

Materials and analysis code for this study are available by emailing the corresponding author. The publication of the data and code on an open data server is in progress.

2.3. Statistics

All data management and analysis were executed using Stata 15.1. We computed means and proportions, and compared groups (reduce vs. same/increase; initiate vs. abstain) using independent samples *t*-test (continuous variables), Mann-Whitney *U*-test (ordinal variables) and χ^2-test (categorical variables). The threshold for statistical significance was set to 5%.

We performed multivariable binary logistic regressions, using the static outcome “regular use” (in S1 and S2) and the dynamic outcomes reduce, quit and initiate. While static outcomes (using cannabis regularly) are very common in the literature, we consider that they are always the result of dynamic (longitudinal) changes in behavior (initiation, cessation). We perform both cross-sectional and longitudinal analysis, thereby providing a detailed explanation of the more common cross-sectional results. We used three dimensions of covariates: socio-demographic covariates were gender (man, woman), age (years), religiosity (0-5), heterosexual preferences (binary), public financial support (binary); psychological factors were locus of control, impulsivity and any past psychiatric diagnosis (binary); and behavioral variables were smoking tobacco (binary), alcohol use intensity (0-8), and sexual risk taking (binary).

Finally, we used a hierarchical model comparison using likelihood ratio test (similar to Brackenbury et al., 2016), in order to assess whether the different groups of covariates added significant explanatory power to the model. The comparison comported five steps: first, only socio-demographic variables were entered, and then psychological factors, behaviors, perceived damage and use setting were added incrementally.

3. Results

3.1. Participant characteristics

The initial overlapping data set between the two waves of the survey consisted of 1,280 subjects. We excluded 16 subjects, because they had missing data in one or more of the variables used in the main regression. We further excluded 63 subjects, because they indicated implausible use patterns, such as declaring never having consumed cannabis in S2 after having declared regular use in S1. The resulting main sample contained 1,201 subjects distributed across use intensity groups as shown in Figure 1.

The first column of Table 1 shows the descriptive statistics for the whole sample. The average age of participants was 23.3 years and they had been studying for almost 3 years. 39% of participants used tobacco and 17% had a psychiatric diagnosis.

3.2. Descriptive statistics

Table 1 also shows the descriptive statistics for two sub-samples.

Among regular cannabis users in S1 (subsample A, N=302), we compared those who reduced their consumption in S2 and those who did not reduce (increase or constant). Respondents who reduced their cannabis consumption were younger (Δ=1.1 years), more religious, more often women, had a more internal LOC, and *more* often a psychiatric. Respondents who subsequently reduced cannabis use saw cannabis as helpful on average, but less so than respondents who did not reduce.

Within the non-user group in S1 (subsample B, N=555), we compared students who subsequently picked up cannabis use with those who abstained. The students initiating cannabis use were significantly younger (Δ=1.2), less religious, more impulsive, and used alcohol and tobacco more frequently.

3.3. Multivariate regressions

Table 2 shows the adjusted odds ratios from binary logistic regressions of the main outcomes: regular use, initiation of cannabis consumption, reduction, and cessation.

In the cross-section, we found that male gender, younger age, less religiosity, non-heterosexuality, low socio-economic status, stronger impulsivity, and alcohol and tobacco use significantly increased the likelihood of using cannabis regularly.

Among regular users in S1 (subsample A), reduction was related to female gender, younger age and having an internal LOC: one standard deviation more internal LOC increased the likelihood to reduce cannabis use by 36%. Smoking tobacco reduced the likelihood to quit cannabis use by 70%.

Among non-users in S1 (subsample B), initiation was related to younger age, higher impulsivity, and alcohol and tobacco use. The effect of other substance use was large: smoking tobacco multiplied the likelihood to initiate cannabis use by 2.5 and one standard deviation higher alcohol use intensity increased it by 45%.

3.4. Perceived harm and intention to reduce

Figure 2 shows that higher use intensity correlated with lower perceived harm/higher perceived help, the wish for counseling and the intention to reduce cannabis. Table 3 shows the impact of perceived harm and the wish to reduce/be counseled, controlling for the covariates of

Table 2. In the cross-sections, all three variables had a strong effect on the likelihood of regular use (contemporary in S1 and future in S2). However, none of these three variables predicted reduction, and only perceived harm predicted cessation. Overall, the strong cross-sectional correlations did not result in corresponding changes in use behavior.

3.5. Use setting

In order to characterize the nature of cannabis consumption better, one may look at the context in which users typically consume the substance. Figure 3 shows that the most popular settings for regular users were at home (81% of all regular users) and at parties (44%); virtually no respondents used cannabis for studying or working (3%).

Figure 3 shows significant differences between use change groups (descriptive statistics, not controlling for covariates). Consuming cannabis at home was negatively associated with reducing and quitting use. On the opposite, consuming cannabis in a party context was associated with a higher likelihood of reducing use. Surprisingly, those who quit cannabis were using it more for study/work.

The number of respondents in this section was small and only few regular users quit cannabis use over the course of our study. Therefore, a multivariable regression of cessation on use setting was not feasible (several settings predicted the outcome perfectly). The negative effect of using cannabis at home on the likelihood of reducing use remained statistically significant in a multivariable regression (Table 4).

3.6. Hierarchical model comparison

A hierarchical regression model (Table 5, more complete version in the Appendix) indicated that all three variable groups – demographic, psychological, and behavioral – contributed significant and unique variance to the cross-sectional prediction of belonging to the regular use group. While the psychological block added significant variance for reduction and initiation, the behavioral block only added variance for initiation and cessation, not for reduction. The perceived damage block predicted cessation but not reduction (no data for initiation). Finally, the use setting predicted the likelihood of regular use (statically), but not the likelihood of use reduction (dynamically).

4. Discussion

Epidemiology. About 25% of non-users initiated cannabis use in the average 16 months between the two surveys, similar to the results of Pérez et al. (2010) on Spanish adolescents. About one third of regular users reduced their consumption and 10% of them quit use. Overall, cannabis use was relatively stable, with 53% having the same use intensity in both surveys.

Main results. Consistent with the literature (e.g. Guxens et al., 2007), men were more likely to be regular cannabis users and had a lower probability to reduce use in our study, compared to women. Overall, in our data women initiated cannabis use almost as often as men, but were much more likely to quit, resulting in less regular use. In Spanish data (Guxens, Nebot, & Ariza, 2007), the gender difference had disappeared in recent times with changing gender norms, but in our data this gender difference persisted strongly. Heterosexual preferences negatively predicted regular use in the cross-sections, which, however, was not clearly related to use dynamics. Similar to Pinchevsky et al. (2012), we saw more limited evidence of the protective influence of religiosity on substance use than other literature (Wallace et al., 2007). Low socio-economic background has been a factor for cannabis use in past research (McGee et al., 2000; Redonnet et al., 2012). While we observed a contemporary correlation to regular use in our study, low socio-economic status did not predict future regular use, initiation or cessation. One may hypothesize that this result stems from selection, as many young adults with low socio-economic do not pursue higher education.

Similarly to Coffey & Patton (2016), we found that the influence of psychiatric co-morbidity, well documented for adolescents (Struble et al., 2019), could not be confirmed in our sample of college students. The coefficients (significant only at the 10% level) showed a complex image: dynamically, a diagnosis *increased* the likelihood of reducing/quitting use and *decreased* the likelihood of initiating (contrary to our hypothesis), while cross-sectionally, subjects with a psychiatric diagnosis were more likely use cannabis regularly. These results suggest that many subjects with a psychiatric diagnosis were already cannabis users *before S1*, such that the dynamics during college years did not explain their cross-sectional cannabis use.

Consistent with the HAPA model, internal LOC (related to self-efficacy) had a significantly positive impact on reducing cannabis use: believing to have the control over one's own

health outcomes increases motivation to engage in protective health behaviors. However, in our sample the effect was not strong enough to significantly impact the likelihood of regular use.

We found high impulsivity to be a significant predictor for use initiation. This was consistent with the idea that impulsive subjects are "marked by their inability to weigh immediate reward against long term consequence" (Hecimovic et al., 2014) and thus engage more in potentially harmful substance use.

Risky behavior, such as the use of other substances, is a known risk factor for cannabis use. Cross-sectionally, both alcohol and tobacco co-use effects could be confirmed in our data with respect to students of higher education (as in Aitken et al., 2000; Coffey & Patton, 2016; Masters et al., 2018). Dynamically, this effect results from increased initiation (and no effect on reduction), consistent with the gateway theory. While the rate of risky sexual behavior was higher among regular cannabis users, this dimension of risk-taking did not predict any of our outcomes when controlling for other covariates (similar to Smith et al., 2010).

Our results using both cross-sectional and longitudinal outcomes showed that the regular use in the second survey was the composition of dynamic processes of initiation and cessation, and of the baseline use before S1. For some covariates, a consistent pattern appeared: for example, tobacco smokers were more likely use cannabis regularly, to initiate and not to quit. For other covariates, the pattern appeared more conflicting: younger age significantly predicted both reduction and initiation, showing that younger respondents had a higher tendency to change use habits in any direction; the resulting negative effect of age on regular use in the cross-section masked this complexity. Yet for other variables, such as psychiatric diagnosis or heterosexual preferences, dynamics during college years seem inconclusive, while we saw a correlation to regular use: in these cases, the dynamics leading to the "static" result must have occurred in pre-college times (or at least earlier than S1). Overall, our results suggested that there was no simple symmetry in the sense that positive predictors of initiation would be negative predictors of cessation, and *vice versa*.

Perceived damage and intention to reduce. The descriptive statistics on perceived harm and the wish to reduce revealed an inner tension: more intensive cannabis users claimed that cannabis consumption *helped* them, while at the same time they wanted to *reduce* their consumption. This reveals a certain degree of cognitive dissonance, where the stated appraisal of the situation and the intended behavioral consequences did not match. Consistently, cross-sectional analysis showed a strong *positive* correlation between intention to reduce and actual cannabis use (contemporary and future), which may *a priori* appear as an unintuitive result. Dynamically, the declared wish to reduce did not predict reduction or cessation. Overall, intention to reduce seemed to be a characteristic of frequent cannabis users, rather than a predictor of future behavior.

Similarly, the wish for counseling did not impact reduction or cessation. Even with serious substance use disorders, college students rarely seek help (Caldeira et al., 2009), so that

we may presume that the students declaring interest in substance counseling did not actually reach out to counseling services.

Higher perceived harm correlated strongly with contemporary regular use, while the dynamic effect was much smaller (significant only for use cessation, not reduction). Having a reason to reduce is not enough, when self-efficacy is insufficient or situational barriers are large (Zhang et al., 2019): in practice, many individuals make unsuccessful attempts at quitting cannabis (e.g. 12% success rate in a sample from Chauchard et al., 2013).

Cannabis use setting. The two most frequent use settings in our sample were associated with very different types of cannabis use: those using at home had typically a higher consumption and were unlikely to reduce or quit cannabis. On the opposite, those consuming cannabis in a party context were more likely to have lower use intensity and to reduce/quit cannabis use over time. Beyond the difference between solitary and social, use setting may be differentiated along other dimensions, such as exceptional or everyday events. In our data, cannabis use at home and cannabis use for study could both be described as “solitary”, but had opposite consequences for the evolution of use.

Limitations. A limitation of this study may be unknown sample selection, similar to other opt-in web surveys where little is known about the overall population. Viohl et al. (2019) discussed the sample selection of the initial survey, showing that the gender distribution is similar in the sample and the overall population. This study added a second survey wave: with an overlap of 1,280 respondents, the follow-up rate was 14%. Comparing characteristics (in S1), respondents were more likely to follow-up if they were younger and less advanced in their studies (likely because older respondents graduated and were not in the university’s e-mail lists anymore), but also more likely to have higher cannabis/alcohol use intensity (mean use intensity 2.6 in follow-up vs. 2.2 in attrition, p-value<0.001) and not to be heterosexual (83.4% vs. 87.9%, p-value<0.001); all other covariates have similar distributions in the overall and follow-up sample. We conclude that these differences are statistically significant, but not large in magnitude. Within a similar setting, Barratt et al. (2017) conclude that “opt-in web surveys of hard-to-reach populations are an efficient way of gaining in-depth understanding of stigmatized behaviors (…), as long as they are not used to estimate drug use prevalence of the general population.” This study takes interest in the dynamic *change* of cannabis use, so that we cannot perform the analogous analysis using data from respondents who did not reply to both surveys (list-wise deletion). The cannabis use behavior in our data is very stable, such that the number of respondents changing (e.g. initiation, cessation) is small which reduces the statistical power for analyzing the factors of such use change. With a sample larger than most samples in the literature, we hope to contribute to the understanding of cannabis use change behavior, even when overall representativeness cannot be guaranteed.

Methodologically, our data relied on students' self-reports, which may be subject to some underreporting bias in particular regarding substance use (Suerken et al., 2014). Our measure of use intensity was based on frequencies only: a more nuanced analysis involving consumed quantities and related substance use disorders would be helpful. We

had no data on peer influence, exposure and race, although these factors have been discussed as influential in the literature (Pacek et al., 2015; Vijapur et al., 2021).

In Germany, collecting data on race and ethnicity is highly sensitive (Balestra & Fleischer, 2018), so that we cannot control for ethnicity although it may be an important factor (e.g. Pacek et al., 2015).

Conclusion. This study explored the factors associated with initiating, reducing and quitting cannabis use among a sample of Berlin college students. This study filled a gap in the literature, as initiation is mostly studied in adolescents, while college students are still at a high risk for initiation – in particular in a nightlife-oriented setting such as Berlin's universities. Moreover, we also look at factors of quitting cannabis use.

Our results showed the importance of longitudinal studies, as the cross-sectional results do not fully match the results from longitudinal change in cannabis use behavior. The factors for initiation (impulsivity, alcohol use) were different from the factors leading to cutting down/quitting (LOC, perceived harm), except for tobacco which is related to both initiation and cessation. We believe that use setting should be studied beyond the distinction solitary/social. Interestingly, the stated intention to reduce had no significant correlation to actual reduction: on the contrary, regular users were more likely to declare an intention to reduce and to still be a regular user two years later. The cross-sectional effect of perceived harm on regular is much larger than the longitudinal effect on the likelihood to reduce/quit cannabis use, dampening somewhat the expectations regarding the effectiveness of interventions on harm perceptions. This difference between static and dynamic results should be borne in mind when interpreting cross-sectional data.

In a context of rising availability of cannabis in many countries around the world, preventing intensive use and helping cannabis users to reduce their consumption will become more important. Our research has different implications for prevention strategies (avoiding initiation) and treatment strategies (inducing reduction/quitting).

Regarding prevention strategies, cannabis use initiation seemed highly related in our data to more general life aspects, such as alcohol and tobacco use. To a certain extent, this suggests that prevention campaigns of cannabis use and other substances may be combined. Moreover, unspecific factors such as impulsivity play an important role and may be targeted by general measures such as physical activity, relaxation or mindfulness interventions aiming to reduce impulsiveness.

Regarding treatment strategies, our research shows that the intention to reduce alone had little effect, consistent with the focus of HAPA (Zhang et al., 2019). Moreover, our data suggested that perceived harm was less impactful than what (a.) is generally assumed and (b.) our cross-sectional results suggested. Nevertheless, successful reduction/quitting in our data depended both on the motivation to quit (perceived harm of cannabis use) and on control beliefs (internal LOC). While motivational interviewing (working on the motivation/intention to quit) is a well-established method for addiction therapy, our results underline the importance of working also on control beliefs, in line with HAPA model (Zhang et al., 2019).

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Tables

Table 1. Descriptive statistics

	All	Sample A: Cannabis users in S1				Sample B: Non-users in S1			
		total	reduce	same/in-crease		total	initi-ate	ab-stain	
N	1,201	302	140	162		555	125	430	
Use intensity (0-8) in S1	2.62	6.36	6.36	6.37		0.35	0.53	0.35	
Use intensity (0-8) in S2	2.70	5.41	3.73	6.86	***	1.05	3.44	0.30	***
Age (years)	23.3	22.8	22.2	23.3	**	23.6	22.6	23.8	***
Monthly income	€814	€801	€804	€799		€797	€790	€800	
Public financial aid (0/1)	22%	26%	29%	24%		22%	20%	22%	
College years	2.8	2.7	2.6	2.8		2.7	2.5	2.8	
Religious (1-5)	1.9	1.6	1.7	1.5	*	2.0	2.0	2.1	*
Sexual preferences									
- heterosexual	84%	76%	75%	78%		88%	90%	87%	
- homosexual	6%	5%	4%	6%		5%	4%	6%	
- bisexual/other	10%	62%	50%	72%		7%	6%	7%	
Gender					***				
- man	49%	62%	50%	72%		39%	40%	39%	
- woman	51%	38%	50%	28%		61%	60%	61%	
LOC (1=external to 7=internal)	3.2	3.2	3.3	3.1	*	3.2	3.2	3.2	
Impulsivity (BIS, 16=low to 54=high)	31.1	32.7	32.6	32.9		30.0	31.5	29.6	**
Psych. diagnosis (0/1)	17.0%	17.9%	22.9%	13.6%	*	16.2%	12.0%	17.4%	
Alcohol use (0-8)	5.58	6.39	6.31	6.46		4.77	5.40	4.58	***
Tobacco smoker (0/1)	39.2%	74.2%	74.3%	74.1%		16.4%	28.8%	12.8%	***
Sexual risk-taking (0/1)	13.7%	19.9%	17.9%	21.6%		10.5%	11.2%	10.2%	
Perceived harm (-2: helps; 2: harms)		-0.23	-0.14	-0.31	*				
Intention to reduce (0/1)		31.8%	33.6%	30.2%					
Wish for counseling (0/1)		12.9%	15.0%	11.1%					

Notes: Between-group comparisons (reduce vs. same/increase, initiate vs. abstain) using independent sample *t*-tests for age, income, college time, LOC, impulsivity; Mann-Whitney *U*-test for use intensity, religiosity, alcohol use, perceived harm; and χ^2-test for all other variables; stars denote significance: $^+$ p-value<0.1, * p-value<0.05, ** p-value<0.01, *** p-value <0.001. Non-users may have tried cannabis in the past and therefore have a use intensity of 1. Perceived harm, intention to reduce and wish for counseling were not asked for those not using cannabis. LOC: locus of control, BIS: Barratt Impulsivity Scale, public financial aid: BAföG student loan/grant attributed depending on parents' income. Except "use intensity in S2," all descriptive statistics shown refer to S1.

Table 2. Multivariable logistic regression (odds ratios) predicting use behavior as a function of demographic, psychological and behavioral covariates

	Static		Dynamic		
	Regular use S1 aOR (SE)	Regular use S2 aOR (SE)	Reduce (Sample A) aOR (SE)	Quit (Sample A) aOR (SE)	Initiate (Sample B) aOR (SE)
1. Demographic					
Male (female omitted)	2.22*** (0.35)	3.10*** (0.49)	0.42** (0.11)	0.48^{+} (0.19)	1.10 (0.24)
Age	0.70*** (0.06)	0.84* (0.07)	0.70* (0.11)	0.87 (0.22)	0.68** (0.08)
Religious	0.77*** (0.06)	0.79** (0.06)	1.29^{+} (0.17)	1.25 (0.22)	0.96 (0.08)
Heterosexual (0/1)	0.70^{+} (0.14)	0.65* (0.12)	1.22 (0.37)	0.78 (0.34)	1.71 (0.62)
Public financial aid (0/1)	1.55* (0.28)	1.34 (0.24)	1.22 (0.35)	0.98 (0.42)	0.95 (0.26)
2. Psychological					
LOC (high=internal)	0.96 (0.08)	0.96 (0.08)	1.36* (0.19)	0.90 (0.20)	1.14 (0.12)
Impulsivity (BIS)	1.19* (0.10)	1.18* (0.09)	0.93 (0.13)	1.41 (0.30)	1.28* (0.14)
Psych. diagnosis (0/1)	1.49^{+} (0.32)	1.46^{+} (0.31)	1.59 (0.52)	2.12^{+} (0.94)	0.78 (0.26)
3. Behavioral					
Tobacco smoker (0/1)	6.03*** (0.98)	3.93*** (0.62)	0.95 (0.27)	0.31** (0.13)	2.51*** (0.66)
Alcohol use intensity	1.86*** (0.21)	1.47*** (0.14)	1.01 (0.19)	0.75 (0.18)	1.45*** (0.16)
Sexual risk taking (0/1)	1.23 (0.26)	1.31 (0.27)	0.69 (0.22)	0.55 (0.30)	0.85 (0.30)
Constant	0.13*** (0.04)	0.14*** (0.04)	0.79 (0.37)	0.31^{+} (0.21)	0.19*** (0.08)
R^2	0.24	0.18	0.08	0.10	0.08
N	1201	1201	302	302	555

Note: The first two columns show the adjusted odds ratios (aOR) of a binary logistic regression using the static outcome regular use (vs. to being an occasional or never user) in the first or second survey. The last three columns show the results of binary logistic regressions using the dynamic outcomes decreasing (vs. same frequency or more), quitting (vs. staying a regular user), and initiating (vs. not using cannabis). Continuous variables (age, religiosity, LOC, BIS, alcohol use and income) have been standardized to mean zero and SD=1. Stars denote significance: $^{+}$ p-value<0.1, * p-value<0.05, ** p-value<0.01, *** p-value <0.001. LOC: locus of control, BIS: Barratt Impulsivity Scale.

Table 3. Multivariable logistic regression including perceived help/harm and intention to reduce

	Regular use S1	Regular use S2	Reduce	Quit
	OR (SE)	OR (SE)	OR (SE)	OR (SE)
Perceived harm (-2: helps; 2: harms)	0.31*** (0.04)	0.47*** (0.05)	1.22 (0.20)	1.68* (0.43)
Intention to reduce (0/1)	5.64*** (1.49)	2.89*** (0.66)	1.16 (0.35)	1.69 (0.77)
Wish for counseling (0/1)	8.21*** (3.73)	1.98^{+} (0.69)	1.35 (0.52)	1.41 (0.80)
Covariates from Table 2 included	Yes	Yes	Yes	Yes
R^2	0.33	0.21	0.09	0.13
N	775	775	292	292

Notes: Stars denote significance: $^{+}$ p-value<0.1, * p-value<0.05, ** p-value<0.01, *** p-value <0.001. Perceived harm was standardized to mean=0 and SD=1.

Table 4. Descriptive statistics on use setting and multivariable logistic regression of reduction as a function of use setting (regular use only)

	Share	Average use intensity	Reduce OR (SE)
Home	80.6%	6.5	0.33* (0.18)
Party	43.8%	6.0	1.42 (0.61)
Club/bar	20.0%	6.8	0.49 (0.26)
Nature	4.4%	6.1	5.45^{+} (4.80)
Study/work	2.5%	6.0	0.50 (0.66)
Covariates from Table 2 included			Yes
R^2			0.09
N		160	160

Notes: Stars denote significance: $^{+}$ p-value<0.1, * p-value<0.05, ** p-value<0.01, *** p-value <0.001. Study/work is omitted automatically, because none of the subjects indicating this setting have reduced or quit cannabis consumption.

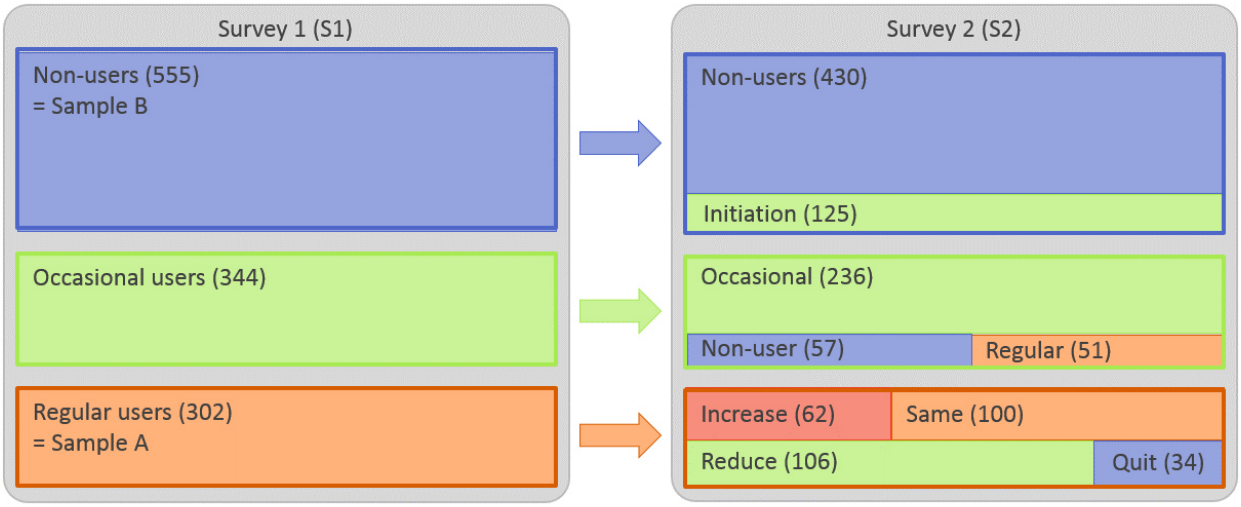
Table 5. Hierarchical regression model comparison (p-values of likelihood ratio test)

	adding psychological	adding behavioral	adding perceived damage	adding use setting
Regular use S1	p<0.001	p<0.001	p<0.001	p<0.001
Regular use S2	p<0.001	p<0.001	p<0.001	p<0.001
Reduce	p=0.05	p=0.72	p=0.27	p=0.27
Quit	p=0.31	p=0.01	p=0.01	-
Initiate	p=0.01	p<0.001	-	-

Notes: Sequential model comparison using likelihood ratio test, showing p-value of comparison χ^2. Baseline model includes only demographic variables, as listed in Table 2. Perceived damage and use setting were only asked from respondents using cannabis, therefore no results for initiation. Use settings were provided only by a subset of respondents, therefore too few observations for cessation. A more complete version of this Table can be found in the Supplemental Materials (Table S1).

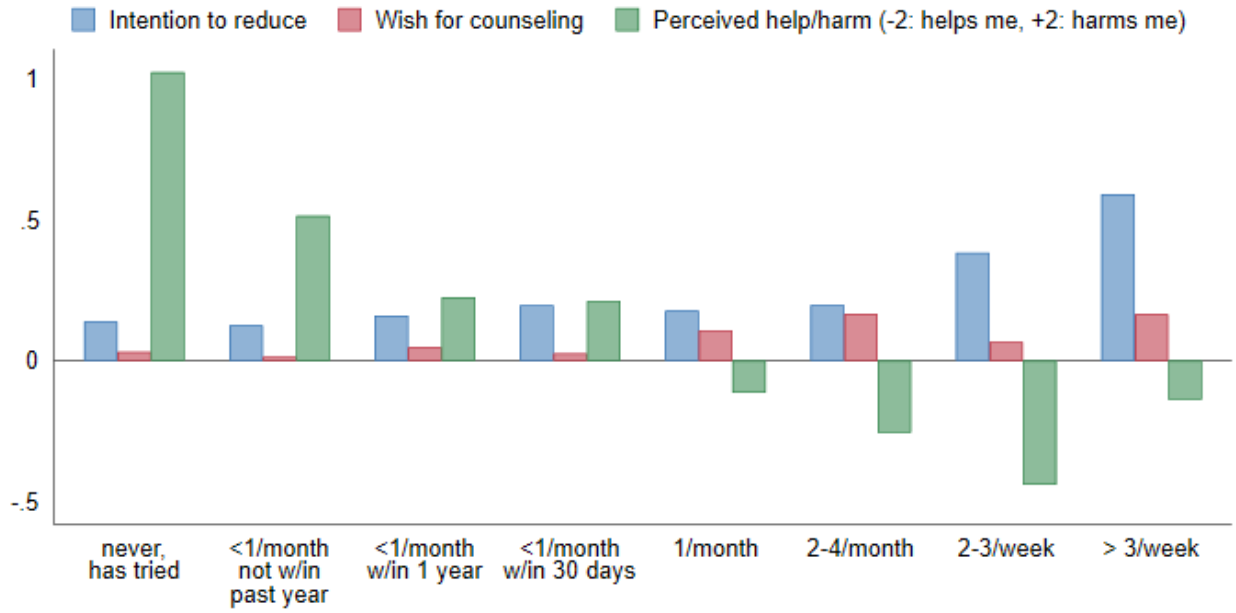
Figures

Figure 1. Use intensity in S2 as a function of use in S1 (areas proportional to group sizes)



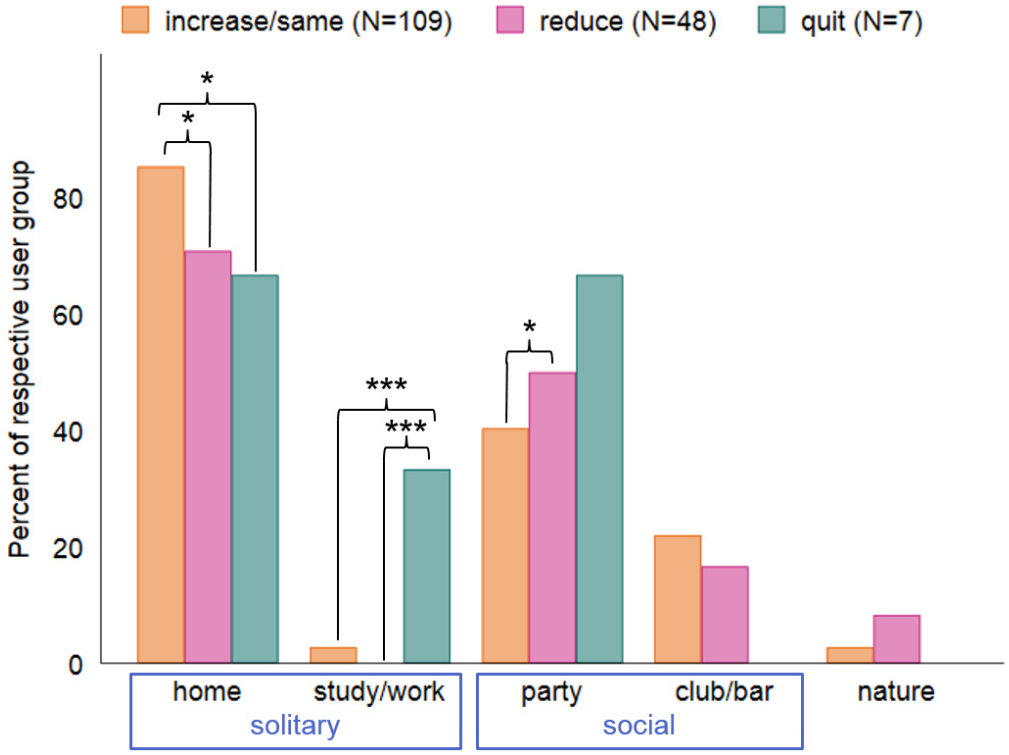
Note: Use intensity 0 or 1 were classified as non-users, use intensity 2-4 as occasional users and use intensity>4 as regular users.

Figure 2. Perceived help/harm, intention to reduce and wish for counseling by use intensity in S1



Note: Bars show average value for each use intensity group (1-8). All variables measured in survey 1 (S1); intention to reduce and wish for counseling are binary variables; perceived harm is a bi-directional 5-point rating from -2 (helps me) to 2 (harms me). Students who had never used cannabis (use intensity=0) were not asked these questions.

Figure 3. Cannabis use setting by group of cannabis use evolution (regular use in S1 only)



Note: Users could name more than one use setting. Not all users named any setting. Pairwise t-tests compared increase/same, reduce, and quit groups. Stars denote significance: $^{+}$ p-value<0.1, * p-value<0.05, ** p-value<0.01, *** p-value <0.001.

Curriculum Vitae

Mein Lebenslauf wird aus datenschutzrechtlichen Gründen in der elektronischen Version meiner Arbeit nicht veröffentlicht.

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- Naegele, H., Betzler, F., Viohl, L., Koslowski, M., Ernst, F., & Petzold, M. B. (2022). Cannabis Use, Use Motives and Cannabis Use Disorder Among Berlin College Students. *Journal of Drug Issues*, 52(4), 568–584. https://doi.org/10.1177/00220426221086877
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