Cessation of cannabis use: A retrospective cohort study

Ann-Kathrin Seidel[a,*], Anya Pedersen[b], Reiner Hanewinkel[a], Matthis Morgenstern[a]

[a] *Institute for Therapy and Health Research, Harmsstr. 2, D-24114 Kiel, Germany*
[b] *Clinical Psychology and Psychotherapy, Department of Psychology, University of Kiel, Germany*

ABSTRACT

Given recent findings of a worldwide increase in cannabis use, a better understanding of the factors associated with cannabis use is needed. Most previous studies have focused on factors that predict the initiation of cannabis use, but less is known about factors associated with cessation. The present study is a retrospective cohort study of 6467 current or former cannabis users aged 15 to 46 years (mean age 22.5, SD = 4.8). Data were collected via an online survey advertised in social media. All analyzed participants had used cannabis for at least three years. Approximately 16.3% (n = 1055) of the sample population had not used cannabis in the previous 12 months and were classified as quitters; all others (83.7%, n = 5412) reported at least monthly use. Cessation was predicted by older current age, being female, nonmigrant status, less sensation seeking, using psychological treatment, more peer cannabis use during youth and more negative first experience with cannabis. An additional predictor was a nonincrease in the frequency of cannabis use in the first three years of use, indicating that trajectories of cannabis use are set early on and might be used to identify risk groups for early preventive measures.

1. Introduction

Cannabis was the most commonly used drug, in addition to alcohol and nicotine, in 2016, with approximately 192 million cannabis users worldwide (United Nations Office on Drugs and Crime, 2018). In recent years, changes in cannabis legalization policies have reduced risk perceptions in the population regarding cannabis' harmfulness (Mechcatie, 2018; Wen et al., 2019). In Germany, cannabis use has also increased during recent decades. Approximately 42.5% of Germans aged 18–25 years reported experiences using cannabis, and there was an increase from 15% to 27% in 12-month prevalence of cannabis use from 2008 to 2018, particularly in young men (Orth & Merkel, 2019).

For some, cannabis use is harmless, and there is evidence that experimentation with cannabis use in adolescence may not necessarily determine cognitive or mental health problems (Scott et al., 2018; Silins et al., 2017). However, frequent cannabis use is associated with adverse outcomes. Meta-analyses of longitudinal studies have shown that the use of cannabis is associated with psychiatric symptoms such as anxiety and depression (Kedzior & Laeber, 2014; Lev-Ran et al., 2013). Furthermore, a meta-analysis of 83 studies on the age of first psychosis in patients with psychotic disorders found that the mean age at onset of psychosis was 2.7 years younger for cannabis users compared to nonusers (Large et al., 2011). Cannabis use has also been linked to substance use disorders (Guttmannova et al., 2017), academic failure

(Arria et al., 2015; Fergusson et al., 2015), and involvement in delinquency (Tucker et al., 2006).

There are a number of known predictors for initiating cannabis use, including being male, previous substance use, family history of substance use disorder (Blanco et al., 2018), parental cannabis use disorder (Hill et al., 2018), sensation seeking (Crawford et al., 2003), peer use (Schmits et al., 2015) and antisocial behavior (Coffey et al., 2000). Factors that predict cannabis initiation are generally not predictors of quantity or the course of cannabis use, e.g., who decreases or increases cannabis use or who quits using it (Washburn & Capaldi, 2014). However, less is known about these factors and the few studies that exist suggest that whether consumers increase or decrease their cannabis use depends mainly on parental monitoring and drug availability (Gillespie et al., 2012). Furthermore, cessation seems to be associated with being female, of older age, married, and employed and having no prior substance use but not, for example, with age of onset (Aitken et al., 2000). A study with a representative German population sample indicated that over a period of 42 months, half of all cannabis users stopped their use spontaneously in their twenties, while others reported occasional or more frequent use of cannabis (von Sydow et al., 2001). In another German study, evidence showed that cannabis use was fairly stable over time, with repeated users (five times or more) being almost three times more likely to report repeated use in a 10-year follow up assessment (Perkonigg et al., 2008). One study from the US

analyzed trajectories of cannabis use over a period of approximately 29 years and found that quitters started as early as frequent users, but a gradual decline in frequency was already visible between late adolescence (Mean age = 16) and early adulthood (Mean age = 22), with cessation at mean age 32 (Brook et al., 2016).

Methodologically, cessation of cannabis use is difficult to investigate, and long observational study periods and elaborate designs are required. Cessation studies therefore usually examine small sample sizes and specific groups, such as students or patients. Predictors of cessation are rarely able to trace natural processes, and for ethical reasons, it is not possible to study intervention vs. control groups. A previous longitudinal studies by Pollard et al. (2014), used data from 358 regular cannabis users aged 12–19 years at baseline to examine factors associated with an increase or decrease in cannabis use and with cessation across 6 years. The study of von Sydow et al. (2001) examined patterns of cannabis use across 4 years in a representative sample of 2446 adolescents and young adults, but 70% were nonusers at baseline. A total of 102 participants in the study did not want to answer questions about illicit drug use and were excluded. Due to the illegality, it is difficult to find participants who will report their cannabis use. Perkonigg et al. (2008) examined a community sample of 3021 participants with a follow-up period of 10 years and approximately one-third were lifetime cannabis users. To our knowledge, Brook et al. (2016) conducted the most comprehensive study on different trajectories of the course of cannabis use. Their study examined a small US sample ($n = 548$) in New York counties but collected data in eight waves, with participants first studied at mean age 14 and last studied at mean age 43. Most of the participants reported lifetime cannabis use, and only 34.5% were classified as nonusers or experimenters. The authors themselves limited the generalizability because of the small sample size and recommended a reduction in the measurement intervals. Because of these limitations based on a bias due to illegality, small sample sizes and large intervals in the previous studies, we used a retrospective cohort design that enabled us to capture a large period of usage history for every year of usage and to survey a large number of cannabis users, who could answer questions anonymously.

Knowledge of the predictors associated with cessation of cannabis use is of preventive importance from two perspectives. On the one hand, conditions can be identified that may help users to quit. On the other hand, individuals can be identified at an early stage who, due to a risk profile, have an increased probability of becoming frequent users. Based on previous findings of initiation and the mentioned cessation studies, membership in the cessation group may be associated with intrapersonal, socioenvironmental, and substance-specific variables.

2. Methods

2.1. Data source

We conducted a retrospective cohort study in March and April 2018. For recruitment, an anonymous German-language online questionnaire was advertised on social media (Facebook). Filtering procedures determined the individual length of the questionnaire. The aims of the study were explained on the study website, where participants gave their consent via a click on a button 'Yes, I want to participate now'. Cookies and IP address blocking were used to discourage multiple participation. Respondents could win a voucher with a value of € 50 after completing the questionnaire. The target group of the Facebook advertisement was defined as people living in Germany aged between 18 and 35. Ethical approval was granted by the ethics committee of the German Psychological Society (Deutsche Gesellschaft für Psychologie,
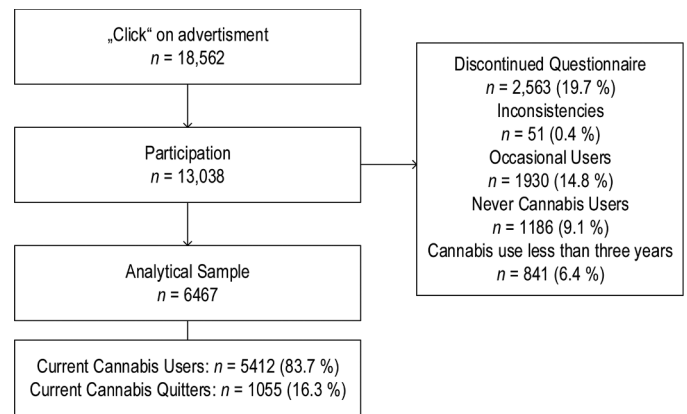

Fig. 1. Flowchart for participants selected in the analytical sample.

DGPs). Additionally, the study was registered in the German Clinical Trials Register (DRKS00014307).

2.2. Sample

A total of 13,038 respondents answered the online questionnaire. They were classified as current users (at least monthly cannabis use in the last 12 months) or current quitters (no cannabis use in the last 12 months). Participants who had never used cannabis ($n = 1186$) or current occasional users (cannabis use in the previous 12 months but 'less than once a month', $n = 1930$) and those who had been using cannabis for less than three years ($n = 841$) were excluded from the analysis (see Fig. 1). Due to the programming of mandatory questions, there were no incomplete data except for respondents who discontinued the questionnaire or for individual technical errors that disabled consistent completion. Thus, discontinued and inconsistent questionnaires were excluded. The final sample was $n = 6467$ participants with histories of 3 or more years of cannabis use from first initiation.

2.3. Measures

All measured variables are also shown in Appendix Table A.1.

2.3.1. Intrapersonal variables

Standard demographic characteristics, such as current age and gender, were measured by single items. Cultural influences were measured with the question of whether mother or father was born in Germany (No = migration background). To assess education status, participants were asked about their highest educational degree ('no qualification', low/middle/high secondary education: 'Hauptschule'/ 'Realschule'/'Abitur', 'apprenticeship', 'university degree'). Variables that are known to predict substance use, such as sensation seeking and ADHD, were also included. Sensation seeking was measured by using the 2-item version of the Sensation Seeking Scale – Form V (SSS-V; $\alpha = 0.85$; Stephenson et al. (2003)). ADHD diagnosis at least once in the lifetime was measured by a single self-reported item, 'Have you ever been diagnosed with ADHD?' ('yes', 'no'), and psychological treatment by 'Have you ever been in psychotherapeutic/psychiatric treatment?' ('yes', 'no').

2.3.2. Social-environmental variables

Characteristics of the social environment were measured by 'Was cannabis regularly used in your family?' ('yes', 'no', 'I don't know') and

cannabis use of the peer group by 'During your school years, how many of your friends used cannabis?' ('none', 'few of them', 'most of them', 'all'). Parental influence was surveyed by parental style (scale from 1 = 'very strict parenting and no tolerance' to 10 = 'allowed to do anything and totally free'). Additional information about the family home was obtained with five items: the socioeconomic status of the childhood home, mental health of father and mother, substance use disorders in the family and stability of the childhood home (see Appendix Table for item wording and scales). The five items were combined to create the parental home risk index (PHRI, Cronbach's α = 0.73).

2.3.3. Substance-specific variables

Whether participants were current quitters or current cannabis users was assessed by two consecutive questions: 'Have you ever used cannabis (hashish/marijuana) in your life?' and 'Have you used cannabis (hashish/marijuana) in the last 12 months?' (No = current quitter). Cannabis frequency of the 12-month users was assessed by 'How often do you currently use cannabis?' ('less than once a month' = no current users; 'at least once a month, but not every week', 'at least once a week, but not every day' or 'every day' = current users). Prior substance use was operationalized by asking about the first age of e-product and other illicit drug use. To determine information about specific cannabis usage, participants were asked about their age of first cannabis use (age of onset) and the positivity of the first cannabis use (first usage experience). The trajectory of frequency of cannabis use was assessed by a 5-point scale for each year of usage from age of onset to current age (0 = 'never', 4 = 'very often'). Participants selected one value for each year of cannabis use. Legal proceedings involving cannabis were measured by a single-item question, 'Has any cannabis-related legal proceeding ever been initiated against you?' and age of the first legal proceeding.

2.4. Statistical analysis

All statistical analyses were conducted with Stata version 15 (StataCorp. 2017). Prior substance use was defined as the difference

between first age of using cannabis and first age of using other substances: prior e-product use and prior illicit substance use (0 = no "substance" initiation prior the initiation of cannabis, 1 = initial use of "substance" prior to the initiation of cannabis). Cannabis use frequency within the first three years was calculated by subtracting the frequency in the third year from the first two years (range from −4 to +4). We dichotomized cannabis use in the family (1 = 'yes', 0 = 'no', 'I don't know') and cannabis use of the peer group during adolescence (1 = 'all', 'most of them', 0 = 'none', 'few of them'). In the case of an unknown father or mother, random values (values between 1 and 10) were calculated and randomly imputed. To analyze whether there was a preliminary legal procedure during the first three years of cannabis use, a difference was calculated. The age of the first legal proceeding was subtracted from the age of the first cannabis use; the variable was dichotomized (1 = at least one legal proceeding within the first three years, 0 = no legal proceeding within the first three years). Chi-squared tests and t-tests were used to compare differences between males and females, regressions were used to estimate differences between ages in categories and were Bonferroni adjusted due to pairwise comparisons. Multiple logistic regression analysis was used to identify variables that were associated with the cessation of cannabis use. This analysis included all intrapersonal variables (age, gender, migration, educational status, sensation seeking, ADHD, psychological treatment), social-environmental variables (parental style, PHRI, parental cannabis use, peer cannabis use), and substance-specific variables (prior e-product use, prior illicit substance use, age of onset, first usage experience, cannabis use in the first 3 years, cannabis-related legal proceedings during the first three years of cannabis use) as predictors. Because participants were nested within federal states, a random intercept was added to the regression model to allow the state intercept to vary. All tests were two-sided and based on α = 0.05. Two sensitivity analyses were conducted to investigate the impact of the imputation (father/mother unknown) and to compare the results of the regression analysis if daily users were used as reference category.

Table 1
Sample characteristics stratified by age and gender.

| Characteristics | Total | Gender | | Age (*Mean* = 22.5, *SD* = 4.8) | | |
| | | Male | Female | < 21 | 21–25 | > 25 |
	n = 6467	*n* = 4000	*n* = 2467	*n* = 2871	*n* = 2274	*n* = 1322
Current quitters	16.3%	13.0%	21.8%	11.3%	16.4%	27.2%
Years of cannabis use (*Mean, SD*)	7.2 (4.2)	7.4 (4.2)	6.8 (4.1)	4.8 (1.5)	7.0 (2.3)	12.7 (5.4)
Intrapersonal variables						
Migration	27.9%	27.7%[a]	28.3%[a]	28.8%[a]	29.2%[a]	23.7%
Sensation seeking (*Mean, SD*, Range: 1–5)	2.2 (1.0)	2.3 (0.9)	2.0 (0.9)	2.3 (0.9)	2.1 (0.9)	1.9 (0.9)
ADHD	13.1%	16.2%	8.1%	12.0%[a]	14.8%[b]	12.6%[a,b]
Psychological treatment	34.4%	25.4%	49.0%	33.0%[a]	32.8%[a]	39.9%
Social-environmental variables						
Parental style (*Mean, SD*, Range: 1–10)	5.8 (2.1)	5.8 (2.0)	5.7 (2.3)	5.9 (2.0)[a]	5.8 (2.2)[a,b]	5.6 (2.2)[b]
Parental home risk index (*Mean, SD*, Range: 6.5–50)	24.1 (6.8)	23.5 (6.6)	25.0 (7.0)	23.9 (6.7)[a,b]	24.2 (6.8)[a,c]	24.4 (7.0)[b,c]
Parental cannabis use	6.6%	5.8%	7.9%	7.4%[a,b]	6.2%[a,c]	5.8%[b,c]
Peer use of cannabis	45.1%	46.2%	43.3%	51.8%	40.6%[a]	38.2%[a]
Substance-specific variables						
Prior e-product use	16.8%	16.4%[a]	17.4%[a]	26.3%	12.3%	3.8%
Prior illicit substance use	9.0%	6.8%	12.7%	8.6%[a,b]	8.9%[a,c]	10.2%[b,c]
Age of onset (*Mean, SD*)	15.1 (2.0)	15.2 (2.0)[a]	15.1 (2.1)[a]	14.6 (1.5)	15.5 (1.9)[a]	15.6 (2.8)[a]
First usage experience (*Mean, SD*, Range: 1–10)	7.6 (2.4)	7.7 (2.3)	7.4 (2.5)	7.8 (2.3)	7.5 (2.4)[a]	7.4 (2.5)[a]
Increasing cannabis use first 3 years (*Mean, SD, Range: -4-4*)	0.8 (1.4)	0.9 (1.3)	0.7 (1.4)	1.1 (1.4)	0.8 (1.3)	0.4 (1.2)
Cannabis-related legal proceedings	9.4%	12.6%	4.1%	11.0%[a]	9.2%[a]	6.0%

Figures sharing superscript letters within rows are not significantly different from each other; pairwise comparisons are Bonferroni adjusted.

3. Results

3.1. Sample characteristics

A descriptive overview of the sample characteristics stratified by current age and gender can be found in Table 1. The survey was completed by participants aged 15 to 46 years (M = 22.5 years; 61.9% male) with at least three years of cannabis use. The majority (83.7%) of the sample reported current (monthly) cannabis use, and 16.3% were classified as quitters (no use during the last 12 months). There was evidence for significant gender differences for almost all study variables except migration background, prior e-cigarette use and age of onset (see Table 1). Male respondents were less often quitters, had a longer history of cannabis use, reported more sensation seeking, more often had an ADHD diagnosis, had a more free parental style, reported more peer use of cannabis, had a more positive first use experience, had a higher slope in frequency of consumption in the first 3 years of use, and more frequently had undergone cannabis-related legal proceedings. Psychological treatment, prior illicit substance use, and parental home risk factors were more often reported by females. Several significant differences were also found to be dependent on the age of the participant (<21, 21–25, >25). The number of quitters and the total years of cannabis use increased with age. An opposite trend could be shown for sensation seeking; older participants reported less sensation seeking than younger participants. E-product use was reported seven times more often by younger than by older participants. The younger age groups also reported a more rapid increase in consumption and more frequent cannabis-related legal proceedings in the first three years than the older age group.

3.2. Prediction of cessation

After simultaneously adjusting for intrapersonal, socio-environmental and substance-specific variables (incl. education), several predictors remained significant (Table 2). Cessation of cannabis use was predicted by older current age, being female, nonmigrant status, less sensation seeking, reported psychological treatment, more peer use during youth, and more negative subjective first experience with cannabis. An additional predictor was the frequency of cannabis use in the first three years of use, with a higher rate of increase being associated with not cessation. No significant associations were found for ADHD, parental style, family environment, parental cannabis use, prior substance use, age of onset, and cannabis-related legal proceedings.

3.3. Results of the sensitivity analyses

An analysis with complete cases only (missing values in case of unknown father/mother) revealed similar results as the imputed data. The only difference between the two models was that "migration" was only marginally significant in the complete case model. Eliminating nondaily users (n = 2728) from the analysis changed coefficients in the following way: The AOR for sensation seeking changed from 0.90 to 0.92 (p = .063), for ADHD from 0.82 to 0.76 (p = .024), for parental cannabis use from 0.75 to 0.63 (p = .004), for age of onset from 1.02 to 1.17 (p < .001) and prior illicit substance use from 0.86 to 0.78 (p = .062).

Table 2
Association between study variables and cessation of cannabis use (reference: currently monthly use). n = 6467.

Characteristics	AOR[a]	95% CI[b]	p-value[c]
Intrapersonal variables			
Age (M = 0, SD = 1)	1.37	1.28–1.46	<0.001
Gender (1 = Male)	.63	.54–0.73	<0.001
Migration (1 = yes)	.82	.70–0.96	.015
Sensation seeking (M = 0, SD = 1)	.90	.84–0.97	.007
ADHD (1 = yes)	.82	.66–1.03	.084
Psychological treatment (1 = yes)	1.45	1.24–1.68	<0.001
Social-environment variables			
Parental style (M = 0, SD = 1)	1.04	.97–1.12	.268
Parental home risk index (M = 0, SD = 1)	.98	.91–1.05	.604
Parental cannabis use (1 = yes)	.75	.56–1.01	.059
Peer use of cannabis (1 = All/Most of them)	1.47	1.28–1.70	<0.001
Substances-specific variables			
Prior e-product use (1 = yes)	.89	.72–1.10	.291
Prior illicit substance use (1 = yes)	.86	.67–1.09	.205
Age of onset (M = 0, SD = 1)	1.02	.95–1.09	.613
First usage experience (M = 0, SD = 1)	.79	.74–0.85	<0.001
Increasing cannabis use first 3 years (M = 0, SD = 1)	.73	.68–0.79	<0.001
Cannabis-related legal proceedings (1 = yes)	1.01	.78–1.31	.944

Pseudo R^2 = 0,078.
[a] AOR = Adjusted odds ratio; adjusted for all variables in the table, including educational level; random intercept for "federal state".
[b] CI = Confidence Interval.
[c] p-value = Observed significance level.

4. Discussion

Data from more than 6000 current and former cannabis users have been used to study factors associated with the cessation of cannabis use. Previous research found that approximately 18% of adolescents stopped using cannabis after six years (Pollard et al., 2014). This is in line with the cessation rate of 16.3% in the present sample. Several factors that are known to be associated with the initiation of cannabis use also negatively predict cessation, e.g., gender (Blanco et al., 2018) and sensation seeking (Crawford et al., 2003). Additionally, as expected, current age was associated with cessation; participants 20-years-old or younger reported a cessation rate of 11.3% compared to a cessation rate of 27.2% in those over 25 years old.

As described above, peer use was associated with the initiation of cannabis use in previous research (Schmits et al., 2015). However, in the present study, we found evidence that a large number of cannabis users reported no or only a few friends using cannabis during their school years (48.2% to 61.8% depending on age). Furthermore, in the final prediction model, cannabis users with more cannabis using peers were more likely to stop using it. This result might reflect that cannabis use for social reasons is associated with higher peer use, which in turn has been shown to accelerate cessation compared to cannabis use due to mood regulation (Chen & Kandel, 1998). Cannabis use for emotional reasons may occur more often alone, and this is associated with the development of cannabis use disorder (Creswell et al., 2015). However, "no peer use during school years" is not the same as solitary use; hence, this explanation needs to be approached with caution. Further research is necessary to more deeply investigate the motivational reasons to use cannabis independently of the peer group.

Whether legal proceedings have a positive or negative influence on cannabis users has led to intense political debates, but to our knowledge, this issue has not been researched in Germany. There were no associations found between cessation of cannabis use and reported legal proceedings. On average, the first three years of use occurred between ages 15 and 18, as suggested by a mean onset age of 15.1 years. It is conceivable that the majority of young people would consider the proceedings to be irrelevant due to their nonlegal age and thus might not expect any negative consequences from the outcome. Additionally, legal proceedings were reported more frequently among the participants under 21 years old (11%) than among those over 25-years-old (6%). In contrast to our findings, Palamar et al. (2014) emphasized that legalization is associated with the initiation of cannabis use, which suggests – in contrast to lifetime cannabis users – that nonusers are affected by legal proceedings. Further studies will need to examine the influences of legal proceedings on nonusers and specific user groups.

Brook et al. (2016) reported that quitters started as early as frequent users. In line with these results, the age of onset was not a significant predictor of being a quitter. However, increasing cannabis use in the first three years of use was identified as a negative predictor of cessation of cannabis use. Previous researchers found evidence that successful cessation is associated with role conflicts in adulthood (Yamaguchi & Kandel, 1985), e.g., being married or having children (Chen & Kandel, 1998; Hammer & Vaglum, 1990). It is possible that the individuals experiment with monthly cannabis use during university or college and quit once they transition out of this phase of life. However, this early, potentially crucial interval revealed differences in the natural course between current quitters and current users before role conflicts in adulthood were evident. The expectation of having to take an adult role in the future could be one explanation. Additionally, transitions from first cannabis use to cannabis use disorder are faster than transitions for nicotine or alcohol (Behrendt et al., 2009). These results highlight the importance of early preventive measures for cannabis users, especially for those with an early increase in cannabis use.

These findings must be considered in light of relevant limitations. One limitation of the research is the retrospective cohort design. The design does not allow for causal interpretations, and the reliance on retrospective reports about psychosocial variables should be approached with caution, especially in estimating event frequencies (Henry et al., 1994). The second limitation of the research is its focus on social media users, decreasing the generalizability of the findings. This sampling procedure leads to selective samples, and the possibility that social media users clicking on ads are systematically different from the same-aged general population cannot be ruled out. Participants recruited via social media were significantly younger than participants recruited via other traditional means (Frandsen et al., 2013). Third, some constructs (ADHD, legal proceedings) are narrowly assessed, which might be a reason for nonsignificance. Fourth, some of the significant results are associated with small AORs (e.g., migration = 0.82 and sensation seeking = 0.90) and may be due to the large sample size. Fifth, the analysis assumed that cannabis use remains constant after one transition, i.e., once users quit, they never restart. A 12-month abstinence reduces the likelihood of a restart but does not exclude it. Sixth, self-reported questionnaires can always be subject to bias. Although a number of studies have suggested that self-reports of cannabis use are valid (Johnson & Mott, 2001; Large et al., 2012; Martin et al., 1988), less is known about the reliability and validity of retrospective cannabis use measures. Finally, as in all observational studies, unmeasured confounding cannot be excluded. Possible unmeasured confounders are, for example, depressed mood, anxiety or neuroticism, as well as further social-environmental characteristics such as cannabis use of siblings.

However, this study also has strengths: Advertising campaigns via the internet are the most effective ways to collect data from cannabis users in internet-based research (Temple and Brown, 2011), especially if asking for information about illegal behavior, such as cannabis possession (Temple et al., 2011). The possibility of anonymous data collection may allow for more authentic insight into the past of current quitters and current users. Moreover, this retrospective design enabled us to examine the natural course of cannabis use over a large period of usage history and collect data for every single year of usage. The requirement for cessation (no cannabis use in the last 12 months) is not literature-based, but it seemed to be a high-level criterion. Other researchers compared the cessation of cannabis use after one year (19%) and after six years (18%), suggesting that regular cannabis users who were abstinent for one year will successfully stop using cannabis for a substantially longer period (Pollard et al., 2014).

Conclusion

Most studies have focused on the initiation of cannabis use, while factors that predict cessation are understudied. These results offer the possibility not only to identify predictors related to cessation but also to identify potential risk groups among cannabis users. There is now evidence to show that the long-term trajectories of cannabis use can be predicted – at least to some degree – after the first years of use. In addition, to further replicate these findings, future research will need to focus on respondents who never started cannabis use, users with less than 3 years of cannabis use and those who reinitiated cannabis use after abstinence. These are interesting groups that might provide useful information about risk and preventive factors, especially in comparison with long-term users and those who resumed use after cessation.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Appendix

Table A.1

Table A.1
Item wording and response format.

Intrapersonal variables	
How old are you?	age in years (drop-down list)
How is your gender?	'male, 'female'
Was your mother born in Germany?	'yes', 'no'
Was your father born in Germany?	'yes', 'no'
What is your current maximum educational achievement?	'no qualification', low/middle/high secondary education: 'Hauptschule'/ 'Realschule'/ 'Abitur', 'apprenticeship', 'university degree'
How often do you do dangerous things to have fun?	'not at all', 'occasionally', 'sometimes', 'often', 'very often'
How often do you do exciting things, even if they are dangerous?	'not at all', 'occasionally', 'sometimes', 'often', 'very often'
Have you ever been diagnosed with ADHD?	'yes', 'no'
Have you ever been in psychotherapeutic / psychiatric treatment?	'yes', 'no'
Social-environmental variables	
How were you educated?	1 = 'very strict upbringing and no tolerance' to 10 = 'allowed to do anything and totally free'
Parental home risk index (PHRI)	
On a ladder from 1 to 10: How do you rate the social status of your parents' home?	1 = 'lowest level' and 10 = 'highest level compared to others'
How do you assess the relationship with your parents?	1 = 'broken home and very hurtful' to 10 = 'supportive home and very secure'
Has anyone in your family ever been addicted to alcohol, pills, cannabis, or other illegal drugs?	'definitely no', 'probably no', 'probably yes', 'definitely yes'
How would you rate your mother's mental health?	1 = 'very mentally ill' to 10 = 'very mentally healthy' / mother unknown
How would you rate your father's mental health?	1 = 'very mentally ill' to 10 = 'very mentally healthy' / father unknown
Was cannabis regularly used in your family?	'yes', 'no', 'I don't know'
During your school years: How many of your friends used cannabis?	'none', 'few of them', 'most of them', 'all'
Substance-specific variables	
Have you ever used cannabis (hashish/marijuana) in your life?	'yes', 'no'
Have you used cannabis (hashish/marijuana) in the last 12 months?'	'yes', 'no'
How often do you currently use cannabis?	'less than once a month', 'at least once a month, but not every week', 'at least once a week, but not every day', 'every day'
How old were you when you tried other drugs or illegal drugs for the first time?	age in years (drop-down list)
At what age did you try cannabis for the first time?	age in years (drop-down list)
How did you experience your first cannabis use?	1 = 'very negative' to 10 = 'very positive'
Please try to estimate for each given age how often you have consumed cannabis during this time.	0 = 'never', 4 = 'very often'
Has any cannabis-related legal proceeding ever been initiated against you?	'yes', 'no'
How old were you at the time of your first cannabis-related legal proceeding?	age in years (drop-down list)

References

Aitken, S.S., DeSantisa, J., Harfordb, T.C., Fe Cacesc, M., 2000. Marijuana use among adults a longitudinal study of current and former users. J. Subst. Abuse 12, 213–226.

Arria, A.M., Caldeira, K.M., Bugbee, B.A., Vincent, K.B., O'Grady, K.E., 2015. The academic consequences of marijuana use during college. Psychol. Addict. Behav. 29 (3), 564–575.

Behrendt, S., Wittchen, H.U., Höfler, M., Lieb, R., Beesdo, K., 2009. Transitions from first substance use to substance use disorders in adolescence: is early onset associated with a rapid escalation? Drug Alcohol Depend. 99 (1–3), 68–78.

Blanco, C., Flórez-Salamanca, L., Secades-Villa, R., Wang, S., Hasin, D.S., 2018. Predictors of initiation of nicotine, alcohol, cannabis, and cocaine use: results of the national epidemiologic survey on alcohol and related conditions (NESARC). Am. J. Addict. 27 (6), 477–484.

Brook, J.S., Zhang, C., Leukefeld, C.G., Brook, D.W., 2016. Marijuana use from adolescence to adulthood: developmental trajectories and their outcomes. Soc. Psychiatry Psychiatr. Epidemiol. 51 (10), 1405–1415.

Chen, K., Kandel, D.B., 1998. Predictors of cessation of marijuana use: an event history analysis. Drug Alcohol Depend. 50 (2), 109–121.

Coffey, C., Lynskey, M., Wolfe, R., Patton, G.C., 2000. Initiation and progression of cannabis use in a population-based Australian adolescent longitudinal study. Addiction 95 (11), 1679–1690.

Crawford, A.M., Pentz, M.A., Chou, C.-P., Li, C., Dwyer, J.H., 2003. Parallel developmental trajectories of sensation seeking and regular substance use in adolescents. Psychol. Addict. Behav. 17 (3), 179.

Creswell, K.G., Chung, T., Clark, D.B., Martin, C.S., 2015. Solitary cannabis use in adolescence as a correlate and predictor of cannabis problems. Drug Alcohol Depend. 156, 120–125.

Fergusson, D.M., Boden, J.M., Horwood, L.J., 2015. Psychosocial sequelae of cannabis use and implications for policy: findings from the Christchurch health and development study. Soc. Psychiatry Psychiatr. Epidemiol. 50 (9), 1317–1326.

Frandsen, M., Walters, J., Ferguson, S.G., 2013. Exploring the viability of using online social media advertising as a recruitment method for smoking cessation clinical trials. Nicotine Tob. Res. 16 (2), 247–251.

Gillespie, N.A., Lubke, G.H., Gardner, C.O., Neale, M.C., Kendler, K.S., 2012. Two-part random effects growth modeling to identify risks associated with alcohol and cannabis initiation, initial average use and changes in drug consumption in a sample of adult, male twins. Drug Alcohol Depend. 123 (1–3), 220–228.

Guttmannova, K., Kosterman, R., White, H.R., Bailey, J.A., Lee, J.O., Epstein, M., Jones, T.M., Hawkins, J.D., 2017. The association between regular marijuana use and adult mental health outcomes. Drug Alcohol Depend. 179, 109–116.

Hammer, T., Vaglum, P., 1990. Initiation, continuation or discontinuation of cannabis use in the general population. Br. J. Addict. 85 (7), 899–909.

Henry, B., Moffitt, T.E., Caspi, A., Langley, J., Silva, P.A., 1994. On the" remembrance of things past": a longitudinal evaluation of the retrospective method. Psychol. Assess. 6 (2), 92.

Hill, M., Sternberg, A., Suk, H.W., Meier, M.H., Chassin, L., 2018. The intergenerational transmission of cannabis use: associations between parental history of cannabis use and cannabis use disorder, low positive parenting, and offspring cannabis use. Psychol. Addict. Behav. 32 (1), 93.

Johnson, T.P., Mott, J.A., 2001. The reliability of self-reported age of onset of tobacco, alcohol and illicit drug use. Addiction 96 (8), 1187–1198.

Kedzior, K.K., Laeber, L.T., 2014. A positive association between anxiety disorders and cannabis use or cannabis use disorders in the general population-a meta-analysis of 31 studies. BMC Psychiatry 14 (1).

Large, M.M., Sharma, S., Compton, M.T., Slade, T., Nielssen, O., 2011. Cannabis use and earlier onset of psychosis: a systematic meta-analysis. Arch. Gen. Psychiatry 68 (6), 555–561.

Large, M.M., Smith, G., Sara, G., Paton, M.B., Kedzior, K.K., Nielssen, O.B., 2012. Meta-analysis of self-reported substance use compared with laboratory substance assay in general adult mental health settings. Int. J. Methods Psychiatr. Res. 21 (2), 134–148.

Lev-Ran, S., Roerecke, M., Le Foll, B., George, T.P., McKenzie, K., Rehm, J., 2013. The association between cannabis use and depression: a systematic review and meta-analysis of longitudinal studies. Psychol. Med. 44 (4), 797–810.

Martin, G.W., Wilkinson, D.A., Kapur, B.M., 1988. Validation of self-reported cannabis use by urine analysis. Addict. Behav. 13 (2), 147–150.

Mechcatie, E., 2018. The impact of legalization of medical and recreational marijuana.

Am. J. Nurs. 118 (7), 16.

Orth, B., Merkel, C., 2019. Der cannabiskonsum jugendlicher und junger erwachsener in deutschland - Ergebnisse des alkoholsurveys 2018 und trends. BZgA-Forschungsbericht. Bundeszentrale für gesundheitliche Aufklärung., Köln.

Palamar, J.J., Ompad, D.C., Petkova, E., 2014. Correlates of intentions to use cannabis among US high school seniors in the case of cannabis legalization. Int. J. Drug Policy 25 (3), 424–435.

Perkonigg, A., Goodwin, R.D., Fiedler, A., Behrendt, S., Beesdo, K., Lieb, R., Wittchen, H.U., 2008. The natural course of cannabis use, abuse and dependence during the first decades of life. Addiction 103 (3), 439–449.

Pollard, M.S., Tucker, J.S., de la Haye, K., Green, H.D., Kennedy, D.P., 2014. A prospective study of marijuana use change and cessation among adolescents. Drug Alcohol Depend. 144, 134–140.

Schmits, E., Mathys, C., Quertemont, E., 2015. A longitudinal study of cannabis use initiation among high school students: effects of social anxiety, expectancies, peers and alcohol. J. Adolesc. 41, 43–52.

Scott, J.C., Slomiak, S.T., Jones, J.D., Rosen, A.F.G., Moore, T.M., Gur, R.C., 2018. Association of cannabis with cognitive functioning in adolescents and young Adults: a systematic review and Meta-analysis. JAMA Psychiatry 75 (6), 585–595.

Silins, E., Swift, W., Slade, T., Toson, B., Rodgers, B., Hutchinson, D.M., 2017. A prospective study of the substance use and mental health outcomes of young adult former and current cannabis users. Drug Alcohol Rev. 36 (5), 618–625.

Stephenson, M.T., Hoyle, R.H., Palmgreen, P., Slater, M.D., 2003. Brief measures of sensation seeking for screening and large-scale surveys. Drug Alcohol Depend. 72 (3),

279–286.

Temple, E.C., Brown, R.F., 2011. A comparison of internet-based participant recruitment methods: engaging the hidden population of cannabis users in research. J. Res. Pract. 7 (2), 1–20.

Temple, E.C., Brown, R.F., Hine, D.W., 2011. The 'grass ceiling': limitations in the literature hinder our understanding of cannabis use and its consequences. Addiction 106 (2), 238–244.

Tucker, J.S., Ellickson, P.L., Collins, R.L., Klein, D.J., 2006. Are drug experimenters better adjusted than abstainers and users? A longitudinal study of adolescent marijuana use. J. Adolesc. Health 39 (4), 488–494.

United Nations Office on Drugs and Crime, 2018. World Drug Report 2018, United Nations Publications.

von Sydow, K., Lieb, R., Pfister, H., Höfler, M., Sonntag, H., Wittchen, H.-U., 2001. The natural course of cannabis use, abuse and dependence over four years: a longitudinal community study of adolescents and young adults. Drug Alcohol Depend. 64 (3), 347–361.

Washburn, I.J., Capaldi, D.M., 2014. Influences on Boys' marijuana use in high School: a two-part random intercept growth model. J. Res. Adolesc. 24 (1), 117–130.

Wen, H., Hockenberry, J.M., Druss, B.G., 2019. The effect of medical marijuana laws on marijuana-related attitude and perception among US adolescents and young adults. Prev. Sci. 20 (2), 215–223.

Yamaguchi, K., Kandel, D.B., 1985. On the resolution of role incompatibility: a life event history analysis of family roles and marijuana use. Am. J. Sociol. 90 (6), 1284–1325.