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Early cannabis initiation and educational attainment: is the association causal?
Data from the French TEMPO study

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Key messages:

- Early cannabis initiation predicts low educational attainment, even when accounting for individual and familial vulnerability factors.
- Girls appear more vulnerable to the negative effects of early cannabis use than boys.
- Preventing adolescent cannabis use is of great public health importance, especially in a context where many countries are modifying cannabis legislation.

Abstract

Background: Adolescent cannabis use has been reported to predict later educational attainment, however results of past studies may be confounded by inappropriate control for factors that make some youths more likely to use cannabis precociously than others. We aimed to test the possibility of a causal relationship between early cannabis initiation and later academic achievement.

Methods: Analyses are based on data collected among TEMPO cohort study participants (France, 2009, n=1,103, 22-35 years). Participants were previously assessed in childhood (1991) and adolescence (1999); additionally their parents take part in a longitudinal epidemiological cohort study (GAZEL). Early cannabis initiation was defined as use at age 16 or earlier. Educational attainment was defined as the completion of a high school degree ('Baccalauréat'). Early (≤ 16 years) and late (> 16 years) cannabis use initiators were compared to non-users using logistic regression models controlled for Inverse Probability Weights (IPWs) of exposure calculated based on participants' sociodemographic, juvenile, and parental characteristics.

Results: In age and sex-adjusted analyses, early cannabis initiators were more likely than non-users to have low educational attainment (OR: 1.77, 95% CI 1.22-2.55). In IPWs-controlled analyses, this association somewhat decreased (OR: 1.64, 95% CI 1.13-2.40). Late cannabis initiators did not have lower educational attainment than non-users. Early cannabis use and educational attainment appeared more strongly associated in young women than in young men.

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Conclusions: Early cannabis can cause low educational attainment. Youths who initiate cannabis use early require attention from addiction and education specialists to reduce their odds of poor long-term outcomes.

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In Europe, adolescent cannabis use is widespread. Lifetime use is reported by 40% of youths younger than 24 years in several countries (United Kingdom, Denmark, France) and 12-14% report recent use (United Kingdom, France, Spain) [1]. Like most other forms of substance use (with the exception of tobacco), cannabis use tends to decline when youths transition to adult social roles (labour market entry, stable romantic life, parenthood) [2, 3].

However, adolescent cannabis use – particularly if it starts early, is regular or problematic – can predict later addiction risk [4], as well as poor social outcomes such as low educational attainment, unemployment and lack of stable romantic relationships [5-9]. Yet because adolescent cannabis abuse is predicted by characteristics which can independently influence long-term academic and social outcomes (ex. growing up in a disrupted family [10], low socioeconomic background [11], a temperamental predisposition for high sensation-seeking [12], disruptive behaviors [13] or low executive function [14]), there is a possibility that the relationship between adolescent cannabis use and later life outcomes is due to common causes.

In France, youths' cannabis use levels are highest in Europe and comparable to those observed in the United States [15, 16]. In 2014, 24% of French 15 year-olds had experimented cannabis and 12% had smoked at least once in the preceding month [17]. Among 17 year-olds, corresponding figures are 48% and 26% [18]. Because of its broad diffusion, in France cannabis use may be less influenced by youths' preexisting characteristics than in places where it is rare. Thus, France is an interesting setting to examine the possibility that early cannabis use causes later academic failure (school being compulsory up to age 16).

In the present study, we aimed to test the causal association between adolescent cannabis use and educational attainment. In order to do so, we use data from a longitudinal

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cohort study of youths (TEMPO) to examine the relationship between early cannabis use and educational attainment using the inverse probability weights (IPWs) method – a statistical technique which mimics random allocation of exposure [19, 20]. IPWs were calculated based on twenty selection and confounding factors that could affect the relationship between cannabis use and educational attainment, including participants' juvenile pre-exposure characteristics (such as psychological difficulties, life events, school difficulties) and parental context (such as parental socioeconomic position, marital status and substance use).

Methods

Data come from the TEMPO study, set up in 2009 among young adults ages 22-35 years [21]. All participants previously participated in a study on child and adolescent mental health and substance use in 1991 and 1999. The initial cohort (4-16 years in 1991, n=2,582) was selected among offspring of GAZEL cohort study participants [22] with the aim of being representative of children in France in terms of family composition and socioeconomic characteristics. In 2009, all youths who had participated in the 1991 study and were still alive (n=2,498; 16 had died since 1991, 4 were too ill to respond) were contacted and asked to complete the TEMPO study questionnaire. 1,103 agreed, yielding a response rate of 44.5%, comparable to other mental health surveys [23]. Factors associated with non-response were male sex, having divorced parents, low socioeconomic status family background, parental tobacco use and alcohol abstinence. Unemployment rate, as well as tobacco, alcohol and cannabis use levels in the TEMPO study are comparable to the general population of France [24, 25]. The TEMPO study received approval of the French national committee for data protection (CNIL: Commission Nationale Informatique et Liberté).

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Measures

Data for this analysis primarily come from the 2009 TEMPO study questionnaire. Participants' juvenile characteristics were reported by their parents in 1991 and by themselves and their parents in 1999. Parental characteristics were collected directly from parents through yearly GAZEL study mailed questionnaires (1989-2009).

Adolescent cannabis use

In 2009, TEMPO study participants were asked about lifetime cannabis use and, among users, age at first use [26]. In accordance with international recommendations, we considered 16 years or younger as indicative of early initiation [27, 28]. 16 years is not only the average age of cannabis initiation in many countries, but also the age at which most youths enter high school and in France the age up to which schooling is mandatory.

In supplementary analyses, we studied regular cannabis use (≥ 10 times in the preceding 12 months) reported in 1999 by participants aged 18 years or less ($n=229$). We were also able to verify that the measure of early cannabis initiation obtained in 2009 was valid as compared with reports obtained in 1999 ($\rho=0.63$). In case of discordance, in 67% of cases the later assessment yielded an older age of cannabis initiation.

Educational attainment

Following prior research in this area [29], educational attainment was dichotomized based on whether or not participants had obtained a high school degree ('Baccalauréat'). This cutoff was used to match the increasing level of education in France: in 2009, nearly 80% of youths growing up in France had graduated high school [30].

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Covariates

Factors potentially associated with youths' cannabis use and later educational attainment that were used to calculate Inverse Probability Weights of early cannabis initiation were:

- Socio-demographics and personality: *sex* (male vs. female), *age* (< vs. ≥ 30 years in 2009), *personality* (openness, conscientiousness, extraversion, agreeableness, neuroticism ascertained using the OCEAN questionnaire [31]);
- Juvenile characteristics: *academic difficulties* (assessed by: a) youths' poor academic performance in 1991; b) learning difficulties in 1991 and c) grade retention by 1999) [27], *negative life events* (e.g. losing someone close, parental conflicts; 0 vs. ≥ 1) [32], *social isolation* reported by parents in 1991 and parents and youths in 1999, the *quality of family relations* ascertained by parents and youths in 1999 (poor vs. satisfactory) [33], *childhood internalizing or externalizing problems* as well as *thought disorders* in 1991 (measured using the Child Behavioral Checklist (CBCL) with an 85th percentile cut-off to define clinically significant difficulties [34]), *early tobacco initiation* (<age 13 vs. ≥ 13 years or never)[27];
- Parental characteristics: *low income* (\leq vs. > 2408 euros/month)[35], *occupational grade* (low, intermediate or high), *divorce* (yes vs. no), *alcohol abuse* (parent-reported in the yearly GAZEL study questionnaire and youths-ascertained using the Family Interview for Genetic Studies (FIGS) questionnaire [36]), *tobacco use* (parent-reported in the yearly GAZEL study questionnaire)[37] and *depression* (ascertained by ≥ 3 parental reports of treated depression in the yearly GAZEL study questionnaire and by youths using the FIGS questionnaire [36]).

Statistical analyses

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The association between early cannabis initiation and educational attainment was examined as follows. First, to take into account loss to follow-up between 1991 and 2009, we calculated the probability of responding based on participants' baseline characteristics such as sociodemographic factors as well as parental and youth mental health problems. All variables associated with follow-up participation ($p < 0.05$) were included. Based on this model, we calculated Inverse Probability Weights (IPWs) of participation.

Second, we calculated propensity scores and Inverse Probability Weights (IPWs) of early cannabis initiation [20] based on all potentially relevant covariates [19]. This method balances the characteristics of study groups being compared, by creating a "pseudo-population" where the independent variable and covariates are not correlated, which approximate random exposure allocation to the independent variable (here early cannabis initiation). To calculate inverse probability weights (IPWs), we used the equation $IPW = 1/PS_1$ for those who were not cannabis users, $IPW = 1/PS_2$ for those who started cannabis after age 16 and $IPW = 1/PS_3$ for those who used cannabis before age 16 [38]. These were normalized and the maximum IPW was set at the value of the 99th percentile IPW (5.39) to avoid including excessively high weights in subsequent analyses. The final model was weighted on the product of participation weights and Inverse probability weights of cannabis use. We verified that the distribution of each risk factor among early cannabis-initiators and cannabis non-initiators were made comparable after applying the IPWs. Additionally, based on the hypothesis that the consequences of cannabis use may vary in men and women [39], we conducted sex-stratified analyses.

In secondary analyses we tested the longitudinal association between early cannabis initiation ascertained in 1999 and educational attainment in the subsample of participants with both data points. Additionally, a) we tested a younger age of cannabis initiation (14 years), and

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defined low educational attainment as b) failure to complete high school (< high school degree, n=79), c) failure to complete higher education (<postsecondary degree, n=421). Missing data were imputed using the multiple imputation method. All analyses were conducted using SAS 9.4 (Carey, NC).

Results

Table 1 shows characteristics of TEMPO study participants by early cannabis initiation status (39.0% of never users, 39.0% of late initiators, 22.0% of early initiators). Early cannabis initiation was associated with male sex ($p<0.001$), younger age ($p<0.001$), high extraversion ($p=0.002$), high openness ($p=0.04$), low conscientiousness ($p=0.008$), preexisting academic difficulties ($p<0.001$), poor quality of family relations ($p<0.001$), externalizing symptoms ($p<0.001$), early tobacco initiation ($p<0.001$), high family income ($p<0.001$), parental depression ($p=0.007$), and parental divorce ($p=0.03$).

Table 2 shows the association between early cannabis initiation and low educational attainment ($p<0.001$).

As shown in **Supplementary Figure 1**, before comparing groups of cannabis use with regard to educational attainment in regression analyses, we verified that the distribution of propensity scores predicting the group that participants belonged to were comparable.

As shown in **Table 3**, controlling for age and sex, early cannabis initiators were 1.77 times more likely to have low educational attainment than never-users of cannabis (OR: 1.77, 95% CI 1.22-2.55). In IPWs-controlled analyses, this association somewhat decreased (OR: 1.50, 95% CI 1.06-2.10).

Table 4 shows the results of analyses stratified on participants' sex. Early cannabis use initiation was more strongly associated with low educational attainment in women (IPW-

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controlled OR: 2.42, 95% CI 1.44-4.08) than in men (IPW-controlled OR: 0.98, 95% CI 0.62-1.55) (interaction between cannabis initiation ≤ 16 and sex: $p=0.01$).

In secondary analyses, participants who in 1999 reported using cannabis regularly had a two-fold probability of low educational attainment in 2009 (age and sex-adjusted OR=2.28, 95% CI 0.39-13.22). Cannabis initiation prior to age 14 years predicted low educational attainment (age and sex-adjusted OR=2.16, 95% CI 1.18-3.97) but the association decreased after controlling for all covariates (IPW-adjusted OR=1.42, 95% CI 0.68-2.95).

Additionally, early cannabis initiators appeared to have an increased probability of not completing high school (IPW-adjusted OR=1.39, 95% CI 0.80-2.42) and not obtaining a higher education degree (IPW-adjusted OR=1.32, 95% CI 0.94-1.86).

Discussion

Main findings

Our study, conducted among a longitudinal sample of community youths, shows that early cannabis initiation predicts educational attainment even after rendering users and non-users comparable on individual and family selection factors. There is indication that this may be especially the case among young female users, who are less numerous than their male counterparts. Youths who engage in early cannabis use require particular attention from professionals in the fields of addiction and education.

Strengths and limitations

Our study's main strengths are 1) a community based sample of youths recruited independently of their patterns of substance use; 2) an 18-year prospective follow-up making it possible to account for juvenile characteristics; 3) a familial design with parallel data

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collection on parents and participating youths; 4) the use of the Inverse Probability Weights statistical method to balance characteristics of exposed and unexposed youths, mimicking random assignment of exposure.

Nevertheless, we also acknowledge limitations. First, as many cohort studies, ours was characterized by selective attrition and our final sample over-represents individuals with high socioeconomic status. As a result, proportions of early cannabis initiators and youths who drop out of school are probably lower than in the general population. This implies that, although the association between early cannabis association and educational attainment we report is consistent with prior research conducted in Australasia [29, 39], it may be stronger in the population at large. Second, adolescent cannabis use was self-reported and may suffer from error. There is no reason why individuals would report a younger age of cannabis initiation than true, but they may report a somewhat older age because of recall difficulties or desirability bias. Data in our study were collected via confidential questionnaires, which are less biased than in-person interviews [40]. Moreover, in a subsample with longitudinal follow-up, we verified that measures obtained in 2009 were closely related to prior reports. Therefore measurement error among participants who reported early cannabis initiation appears limited. Third, our results may be influenced by residual confounding. In particular, we were not able to control for cognitive ability, which is a strong predictor of educational attainment [41] and heavy cannabis use [42]. Our analyses did control for factors which may capture part of the variation in educational attainment related to youths' cognitive ability, including family socioeconomic background, parental mental health and early life psychological difficulties [43-45].

Early cannabis initiation and low educational attainment: potential mechanisms

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Our results, showing that early cannabis users have worse academic achievement than non-users even when they are statistically matched, are consistent with recent research [6, 7, 9, 39, 46, 47] but contrast with some other studies [48, 49]. This discrepancy in findings probably reflects methodological differences in the way common causes of early cannabis use and educational attainment are accounted for. The use of the IPW method to control for selection and confounding factors is a strength of our study design [20].

Importantly, our secondary analyses suggested that regular cannabis use in adolescence predicts academic failure to a similar degree as early initiation (albeit with lower statistical power), which is consistent with evidence showing that early users are at high risk of using regularly and developing cannabis addiction [47]. Future research should aim to distinguish whether it is the age of initiation or the pattern of use in adolescence that is most strongly associated with later life outcomes.

The mechanisms through which cannabis use may influence educational attainment include decreases in motivation, memory impairments [50], delinquent behaviors [51], and poor school performance [52]. Yet, it is also important to acknowledge that youths who regularly use cannabis have lower baseline cognitive levels than those who do not [14, 53], which may put them at risk of academic failure regardless of their use of psychoactive substances [42]. We found no evidence that later cannabis initiation predicts educational failure, indicating that early initiators are a particularly vulnerable group.

Moderation by sex and socioeconomic position

In our study, young women who used cannabis early on appeared more likely than young men to have low educational attainment. This is consistent with research showing that young women are less likely than young men to use cannabis [54], but more likely to experience

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cognitive, psychological and social impairment [55-61]. Young women may be more vulnerable to the biological and social consequences of cannabis, but it may also be that those who use cannabis are selected and have high levels of preexisting individual and familial difficulties [62]. In particular, because cannabis use is perceived as more negative in women than in men, young women who use cannabis may have lower levels of self-esteem and higher levels of psychological difficulties than young men. More research is needed to gain a better understanding of sex-specific risk factors of early cannabis use as well as long-term trajectories of use in young men and young women.

Interestingly, in our study youths from low income families were less likely than those from intermediate/high income backgrounds to initiate cannabis use early, which may be explained by higher financial means in the most advantaged group [63]. Nevertheless, youths from disadvantaged backgrounds have systematically higher levels of problematic cannabis use [21, 64, 65], highlighting the complex role of social determinants with regard to addictive behaviors [66].

Clinical and policy implications

Across industrialized countries, adolescent cannabis use is widespread [1]. In parallel, low educational attainment is frequent (in France, approximately 56% of young adults do not have tertiary education [67]) and predicts later health and labor market difficulties [68]. Our results suggest that early cannabis use can have a negative influence on educational outcomes, potentially setting the stage for a vicious lifecourse circle of low socioeconomic position and addiction [69]. Moreover, cannabis use in adolescence, during a sensitive period of brain development, is linked to long-term neurocognitive deficits [53, 70]. It is therefore crucial to prevent cannabis use in youths – especially those who experience behavioral and school

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difficulties and may be most vulnerable to the consequences of substance use [71]. Effective prevention strategies include information on possible short and long-term consequences of cannabis use, the assessment of youths' motives of use, the build-up of youths' and their parents' psychosocial skills (e.g. self-esteem, conflict resolution), as well as support of positive family dynamics [72-75].

More broadly, early cannabis initiation can be considered as the tail of the distribution of cannabis use in the population at large [17]. Therefore, preventing precocious and problematic use may entail lowering cannabis consumption across the board [76]. An important determinant of cannabis use is substance availability [77], which raises questions about possible unintended consequences of policies liberalizing cannabis use, ranging from decriminalization to legalization, which are being implemented in many settings. Evaluations of such policy changes have yielded mixed results – some studies find no effect on cannabis use in youths [78-80], while others suggest an increase in use [81]. Liberalizing policies related to cannabis use may yield other benefits (e.g. surveillance of drug quality, prevention of individual and societal legal costs, tax revenue, reduction in the experimentation of other illegal drugs because of market separation). Nonetheless, updating knowledge on long-term effects on patterns of use – especially in youths – is necessary to ascertain the public health consequences of such regulatory change.

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