



HAL
open science

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

Maria Melchior, Camille Bolze, Eric Fombonne, Pamela J. Surkan, Laura Pryor, Marie Jauffret-Roustide

► To cite this version:

Maria Melchior, Camille Bolze, Eric Fombonne, Pamela J. Surkan, Laura Pryor, et al.. Early cannabis initiation and educational attainment: is the association causal? Data from the French TEMPO study. *International Journal of Epidemiology*, 2017, 10.1093/ije/dyx065 . hal-01527313

HAL Id: hal-01527313

<https://hal.sorbonne-universite.fr/hal-01527313v1>

Submitted on 24 May 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Early cannabis and educational attainment.

Early cannabis initiation and educational attainment: is the association causal?

Data from the French TEMPO study

M Melchior¹, C Bolze¹, E Fombonne², PJ Surkan³, L Pryor¹, M Jauffret-Roustide⁴

¹ Sorbonne Universités, UPMC Univ Paris 06, INSERM, Institut Pierre Louis d'Epidémiologie et de Santé Publique (IPLESP UMRS 1136), F75012, Paris, France

² Department of Psychiatry, Oregon Health & Science University, Portland, OR, USA

³ Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD USA

⁴ Cermes 3 (Inserm U988, CNRS UMR 8211, EHESS, Paris Descartes University, F75006, Paris, France

Running head: Early cannabis and educational attainment.

Word count:

Main text: 2814

Abstract: 247

Tables: 3

Figures: 1 (Supplementary)

References:

Keywords: cannabis; education; longitudinal cohort; adolescent;

The authors declare no competing interests.

Early cannabis and educational attainment.

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.

Early cannabis and educational attainment.

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.

Early cannabis and educational attainment.

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

Early cannabis and educational attainment.

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).

Early cannabis and educational attainment.

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].

Early cannabis and educational attainment.

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

Early cannabis and educational attainment.

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

Early cannabis and educational attainment.

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-

Early cannabis and educational attainment.

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

Early cannabis and educational attainment.

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

Early cannabis and educational attainment.

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

Early cannabis and educational attainment.

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

Early cannabis and educational attainment.

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.

Early cannabis and educational attainment.

Acknowledgements: We thank TEMPO and GAZEL study participants who provided data for this project. Dominique Costagliola and Murielle Mary-Krause of INSERM Pierre Louis Institute of Epidemiology and Public Health provided much appreciated help in terms of statistical analyses and bibliography searches.

This work was supported by the the French National Research Agency (ANR); French Institute for Public Health Research-IReSP (TGIR Cohortes); the French Inter-departmental Mission for the Fight against Drugs and Drug Addiction (MILDeCA); the French Institute of Cancer (INCa); and the Pfizer Foundation.

Early cannabis and educational attainment.

References

1. EMCDDA. The state of the drugs problem in Europe. 2012.
[<http://www.emcdda.europa.eu/publications/annual-report/2012>]
2. Windle M, Wiesner M. Trajectories of marijuana use from adolescence to young adulthood: predictors and outcomes. *Develop Psychopathol.* 2004;16:1007-27.
3. Patton GC, Coffey C, Lynskey MT, et al. Trajectories of adolescent alcohol and cannabis use into young adulthood. *Addiction.* 2007;102:607-15.
4. Degenhardt L, Coffey C, Romaniuk H, et al. The persistence of the association between adolescent cannabis use and common mental disorders into young adulthood. *Addiction.* 2013;108:124-33.
5. van Ours JC, Williams J. Why parents worry: initiation into cannabis use by youth and their educational attainment. *J Health Econ.* 2009;28:132-42.
6. Lynskey MT, Coffey C, Degenhardt L, Carlin JB, Patton G. A longitudinal study of the effects of adolescent cannabis use on high school completion. *Addiction.* 2003;98:685-92.
7. Degenhardt L, Coffey C, Carlin JB, Swift W, Moore E, Patton GC. Outcomes of occasional cannabis use in adolescence: 10-year follow-up study in Victoria, Australia. *Br J Psychiatry.* 2010;196:290-5.
8. Baggio S, Iglesias K, Deline S, et al. Not in Education, Employment, or Training status among young Swiss men. Longitudinal associations with mental health and substance use. *J Adolesc Health.* 2015;56:238-43.
9. Stiby AI, Hickman M, Munafo MR, Heron J, Yip VL, Macleod J. Adolescent cannabis and tobacco use and educational outcomes at age 16: birth cohort study. *Addiction.* 2015;110:658-68.

Early cannabis and educational attainment.

10. Hayatbakhsh MR, Najman JM, Jamrozik K, Mamun AA, Alati R. Do parents' marital circumstances predict young adults' DSM-IV cannabis use disorders? A prospective study. *Addiction*. 2006;101:1778-86.
11. Legleye S, Beck F, Khlat M, Peretti-Watel P, Chau N. The influence of socioeconomic status on cannabis use among French adolescents. *J Adolesc Health*. 2012;50:395-402.
12. Kaynak O, Meyers K, Caldeira KM, Vincent KB, Winters KC, Arria AM. Relationships among parental monitoring and sensation seeking on the development of substance use disorder among college students. *Addict Behav*. 2013;38:1457-63.
13. Galéra C, Pingault JB, Fombonne E, et al. Attention problems in childhood and adult substance use. *J Pediatrics*. 2013;163:1677-83.
14. Pope HG, Jr., Gruber AJ, Hudson JI, Cohane G, Huestis MA, Yurgelun-Todd D. Early-onset cannabis use and cognitive deficits: what is the nature of the association? *Drug Alcohol Depend*. 2003;69:303-10.
15. Legleye S, Piontek D, Pampel F, Goffette C, Khlat M, Kraus L. Is there a cannabis epidemic model? Evidence from France, Germany and USA. *Int J Drug Policy*. 2014;25:1103-12.
16. EMCDDA. Prevalence of daily cannabis use in the European Union and Norway. 2012. [http://www.emcdda.europa.eu/system/files/publications/753/emcdda-daily-cannabis-use-2012_400271.pdf]
17. Spilka S, Ehlinger V, Le Nézet O, Pacoricona D, Ngantcha M, Godeau E. [Alcohol, tobacco and cannabis use in 2014, during "junior high school years"]. *Tendances*, 2015. [<http://www.ofdt.fr/publications/collections/periodiques/lettre-tendances/alcool-tabac-et-cannabis-en-2014-durant-les-annees-college-tendances-106-decembre-2015/>]

Early cannabis and educational attainment.

18. Spilka S, Le Nézet O, Beck F. [2014 estimations of psuchoactive drug use at age 17 years].

2015. [<http://www.ofdt.fr/publications/collections/notes/estimations-2014-des-consommations-de-produits-psychoactifs-17-ans/>]

19. Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivar Behav Res.* 2011;46:399-424.

20. Hernan M, Robbins J. IP weighting and marginal structural models. *Causal Inference.* 2013. p.11-21.

[http://www.hsph.harvard.edu/miguel-hernan/files/2013/10/hernanrobins_v2.15.02.pdf]

21. Redonnet B, Chollet A, Bowes L, Melchior M. Tobacco, alcohol and drug-use among young adults in France: the socioeconomic context. *Drug Alcohol Depend.* 2012;121:231-9.

22. Goldberg M, Leclerc A, Bonenfant S, et al. Cohort profile: the GAZEL Cohort Study. *Int J Epidemiol.* 2007;36:32-9.

23. Alonso J, Angermeyer MC, Bernert S, et al. Sampling and methods of the European Study of the Epidemiology of Mental Disorders (ESEMED) project. *Acta Psychiatr Scand Suppl.* 2004(420):8-20.

24. Beck F, Guilbert P, Gautier A. [Health Barometer], 2005. Saint-Denis: Inpes; 2006.

25. Insee. [Educational attainment according to sex and age]. 2014. [http://www.insee.fr/fr/themes/tableau.asp?reg_id=0&ref_id=NATCCF07235]

26. Johnson LD, O'Malley P, Bachman J. National survey results on drug use from the Monitoring the Future Study, 1975-1994. Rockville, MD: National Institute on Drug Abuse, 1995.

27. Bowes L, Chollet A, Fombonne E, Galéra C, Melchior M. Lifecourse socioeconomic position and tobacco and cannabis use among young adults. *Europ J Public Health.* 2013;23:322-7.

Early cannabis and educational attainment.

28. Hayatbakhsh R, Williams G, Bor W, Najman JM. Early childhood predictors of age of initiation to use of cannabis: a birth prospective study. *Drug Alcohol Rev.* 2013;32:232-40.

29. Silins E, Fergusson DM, Patton GC, et al. Adolescent substance use and educational attainment: An integrative data analysis comparing cannabis and alcohol from three Australasian cohorts. *Drug Alcohol Depend.* 2015;156:90-6.

30. Dalous J-P, Dauphin L, Jeljoul M, et al. [School attainment and social origins since the 1980s : progress and limits. 2014. [http://www.insee.fr/fr/ffc/docs_ffc/HISTO14_e_D4_scola.pdf]

31. Rammstedt B, John OP. Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *J Res Personality* 2007;41:203-12.

32. Melchior M, Touchette E, Prokofyeva E, et al. Negative events in childhood predict trajectories of internalizing symptoms up to young adulthood: an 18-year longitudinal study. *PLoS One.* 2014;9:e114526.

33. Surkan PJ, Miller R, Melchior M. Parental relationship satisfaction in French young adults associated with alcohol abuse and dependence. *Addict Behav.* 2012;37:313-7.

34. Achenbach TM. *Achenbach System of Empirically-Based Assessment* 2007.

35. Melchior M, Chastang J-F, Walburg V, Galéra C, Fombonne E. Family income and youths' symptoms of depression and anxiety: a longitudinal study of the GAZEL Youth cohort. *Depress Anxiety.* 2010;27:1095-103.

36. Maxwell ME. *Family Interview for Genetic Studies (FIGS): A Manual for FIGS* Bethesda, Maryland: Clinical Neurogenetics Branch, Intramural Research Program, National Institute of Mental Health, ; 1992.

37. Melchior M, Chastang J-F, MacKinnon D, Galéra C, Fombonne E. The intergenerational transmission of tobacco smoking: the role of parents' longitudinal smoking trajectory. *Drug Alcohol Depend.* 2010;107:257-60.

Early cannabis and educational attainment.

39. Hernán M, Robins J. IP weighting and marginal structural models In: Causal Inference. Chapman & Hall/CRC, forthcoming, Boca Raton, pp 11-22

39. Horwood LJ, Fergusson DM, Hayatbakhsh MR, Najman JM, Coffey C, Patton GC, et al. Cannabis use and educational achievement: findings from three Australasian cohort studies. *Drug Alcohol Depend.* 2010;110:247-53.

40. Mayet A, Esvan M, Marimoutou C, et al. The accuracy of self-reported data concerning recent cannabis use in the French armed forces. *Europ J Public Health.* 2013;23:328-32.

41. Luster T, McAdoo H. Family and child influences on educational attainment: A secondary analysis of the high/scope Perry Preschool data. *Develop Psychol.* 1996;32:26-39.

42. Hooper SR, Woolley D, De Bellis MD. Intellectual, neurocognitive, and academic achievement in abstinent adolescents with cannabis use disorder. *Psychopharmacol.* 2014;231:1467-77.

43. Camargo-Figuera FA, Barros AJ, Santos IS, Matijasevich A, Barros FC. Early life determinants of low IQ at age 6 in children from the 2004 Pelotas Birth Cohort: a predictive approach. *BMC Pediatr.* 2014;14:308.

44. Ibanez G, Bernard JY, Rondet C, Peyre H, Forhan A, Kaminski M, et al. Effects of antenatal maternal depression and anxiety on children's early cognitive development: a prospective cohort study. *PLoS One.* 2015;10:e0135849.

45. Flouri E, Mavroveli SF-T, Nikos, Tzavidis N. Cognitive ability, neighborhood deprivation, and young children's emotional and behavioral problems. *Soc Psychiatry Psychiatr Epidemiol.* 2012;47:985-92.

46. Fergusson DM, Boden JM. Cannabis use and later life outcomes. *Addiction.* 2008;103:969-76.

Early cannabis and educational attainment.

47. Silins E, Horwood LJ, Patton GC, et al. Young adult sequelae of adolescent cannabis use: an integrative analysis. *Lancet Psychiatry*. 2014;1:286-93.

48. Mokrysz C, Landy R, Gage SH, Munafo MR, Roiser JP, Curran HV. Are IQ and educational outcomes in teenagers related to their cannabis use? A prospective cohort study. *J Psychopharmacol*. 2016;30:159-68.

49. Scholes-Balog KE, Hemphill SA, Evans-Whipp TJ, Toumbourou JW, Patton GC. Developmental trajectories of adolescent cannabis use and their relationship to young adult social and behavioural adjustment: A longitudinal study of Australian youth. *Addict Behav*. 2016;53:11-8.

50. Becker MP, Collins PF, Luciana M. Neurocognition in college-aged daily marijuana users. *J Clin Exp Neuropsychol*. 2014;36:379-98.

51. Chabrol H, Rodgers R, Sobolewski G, van Leeuwen N. Cannabis use and delinquent behaviors in a non-clinical sample of adolescents. *Addict Behav*. 2010;39:1766-8.

52. Meier MH, Hill ML, Small PJ, Luthar SS. Associations of adolescent cannabis use with academic performance and mental health: A longitudinal study of upper middle class youth. *Drug Alcohol Depend*. 2015;156:207-12.

53. Meier MH, Caspi A, Ambler A, et al. Persistent cannabis users show neuropsychological decline from childhood to midlife. *Proc Natl Acad Sci*. 2012;109:E2657-564.

54. Degenhardt L, Chiu WT, Sampson N, et al. Toward a global view of alcohol, tobacco, cannabis, and cocaine use: findings from the WHO World Mental Health Surveys. *PLoS Med*. 2008;5:e141.

55. Green KM, Zebrak KA, Robertson JA, Fothergill KE, Ensminger ME. Interrelationship of substance use and psychological distress over the life course among a cohort of urban African Americans. *Drug Alcohol Depend*. 2012;123:239-48.

Early cannabis and educational attainment.

56. Medina KL, McQueeney T, Nagel BJ, Hanson KL, Yang TT, Tapert SF. Prefrontal cortex morphometry in abstinent adolescent marijuana users: subtle gender effects. *Addiction Biol.* 2009;14:457-68.

57. Lev-Ran S, Imtiaz S, Taylor BJ, Shield KD, Rehm J, Le FB. Gender differences in health-related quality of life among cannabis users: results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Drug Alcohol Depend.* 2012;123:190-200.

58. Khan SS, Secades-Villa R, Okuda M, et al. Gender differences in cannabis use disorders: results from the National Epidemiologic Survey of Alcohol and Related Conditions. *Drug Alcohol Depend.* 2013;130:101-8.

59. Patton GC, Coffey C, Carlin JB, Degenhardt L, Lynskey M, Hall W. Cannabis use and mental health in young people: cohort study. *Br Med J.* 2002;325(7374):1195-8.

60. Juon HS, Fothergill KE, Green KM, Doherty EE, Ensminger ME. Antecedents and consequences of marijuana use trajectories over the life course in an African American population. *Drug Alcohol Depend.* 2011;118:216-23.

61. Legleye S, Beck F, Peretti-Watel P, Chau N, Firdion JM. Suicidal ideation among young French adults: association with occupation, family, sexual activity, personal background and drug use. *J Affect Disord.* 2010;123:108-15.

62. Melchior M. Commentary on Kosty et al. (2015): Cannabis abuse from one generation to the next-a heightened vulnerability in women? *Addiction.* 2015;110:1118-9. .

63. van Ours JC, Williams J. Cannabis prices and dynamics of cannabis use. *J Health Econ.* 2007;26:578-96.

64. Legleye S, Janssen E, Beck F, Chau N, Khlaf M. Social gradient in initiation and transition to daily use of tobacco and cannabis during adolescence: a retrospective cohort study. *Addiction.* 2011;106:1520-31.

Early cannabis and educational attainment.

65. Sutherland A. Is parental socio-economic status related to the initiation of substance abuse by young people in an English city? An event history analysis. *Soc Sci Med*. 2012;74:1053-61.

66. Galea S, Nandi A, Vlahov D. The social epidemiology of substance use. *Epidemol Rev*. 2004;26:36-52.

67. OECD. Population with tertiary education. 2015. [<https://data.oecd.org/eduatt/population-with-tertiary-education.htm#indicator-chart2015>]

68. OECD. How does educational attainment affect participation in the labour market? 2009. [<http://dx.doi.org/10.1787/888933115711>]

69. Melchior M, Chollet A, Elidemir G, Galéra C, Younès N. Unemployment and substance use in young adults: does educational attainment modify the association? *Europ Addiction Res*. 2014;21:115-23.

70. Fontes MA, Bolla K, Cunha P, et al. Cannabis use before age 15 and subsequent executive functioning. *Br J Psychiatry*. 2011;198:442-7.

71. Mahu IT, Doucet C, O'Leary-Barrett M, Conrod PJ. Can cannabis use be prevented by targeting personality risk in schools? Twenty-four-month outcome of the adventure trial on cannabis use: a cluster-randomized controlled trial. *Addiction*. 2015;110:1625-33.

72. Newton N, Teesson M, Vogl L, Andrews G. Internet-based prevention for alcohol and cannabis use: final results of the Climate Schools course. *Addiction*. 2010;105:749-59.

73. Walton MA, Resko S, Barry K, et al. A randomized controlled trial testing the efficacy of a brief cannabis universal prevention program among adolescents in primary care. *Addiction*. 2014;109:786-97.

74. Ariza C, Perez A, Sanchez-Martinez F, Dieguez M, Espelt A, Espelt A, et al. Evaluation of the effectiveness of a school-based cannabis prevention program. *Addiction*. 2013;132:257-64. .

Early cannabis and educational attainment.

75. Kumpfer KL, Alvarado R. Family-strengthening approaches for the prevention of youth problem behaviors. *Am Psychol.* 2002;58:457-65.

76. Rose G. Sick individuals and sick populations. *Int J Epidemiol.* 1985;30:809-17.

77. Delva J, Lee W, Sanchez N, et al. Ecological factors and adolescent marijuana use: results of a prospective study in Santiago, Chile. *Int J Env Res Public Health.* 2014;11:3443-52.

78. Ghosh TS, Van Dyke M, Maffey A, Whitley E, Erpelding D, Wolk L. Medical marijuana's public health lessons--implications for retail marijuana in Colorado. *New Engl J Med.* 2015;372:991-3.

79. Harper S, Strumpf E, Kaufman JS. Do medical marijuana laws increase marijuana use? Replication study and extension. *Annals Epidemiol.* 2012;22:207-12.

80. Wall MM, Mauro C, Hasin DS, et al. Prevalence of marijuana use does not differentially increase among youth after states pass medical marijuana laws: Commentary on and reanalysis of US National Survey on Drug Use in Households data 2002-2011. *Int J Drug Policy.* 2016;29:9-13.

81. Williams J, Bretteville-Jensen AL. Does liberalizing cannabis laws increase cannabis use? *J Health Econ.* 2014;36:20-32.