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Academic, socioeconomic and interpersonal consequences of cannabis use: A narrative review

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Abstract: This article reviews the literature on the association between cannabis use (CU) and psychosocial functioning, operationalized here as academic achievement, economic prospects, social relationships and quality of life. So far, study results have been inconsistent. To clarify whether CU has an impact on psychosocial functioning, this article mainly reviewed prospective and longitudinal studies published since 2000 and examined whether studies controlled for confounding factors (e.g., socio-demographics, other substance use, psychopathology, social environment). The review suggested that when confounding variables are controlled for, the association between CU and psychosocial outcomes is generally small or non-significant. When significant associations remain, they are for chronic, dependent or early onset CU specifically, suggesting that the frequency of use and age of onset may be necessary elements to detect persistent, however small, psychosocial consequences. These results illustrate the importance of controlling for intra- and inter-individual differences to examine the link between CU and later psychosocial functioning. Results also suggest that policy and prevention efforts should consider targeting the individual and environmental factors (e.g., early academic and cognitive functioning, social disadvantage, family functioning, personality, smoking) that account for much of the association between CU and later psychosocial problems, rather than, or in addition to, CU itself.

Keywords: Cannabis, psychosocial functioning, academic performance, employment, social relationships.

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Cannabis use is prevalent in Canada and around the world; for example, among Canadians aged 15 to 24, approximately one in three has used cannabis over the last 12 months (Statistics Canada, 2019). In addition, a growing number of countries have fully legalized recreational cannabis use for adults. This may lead to a decrease in the perceived risks and stigma of cannabis use and a possible increase in the number of people who use cannabis (Center for Behavioral Health Statistics and Quality, 2015; Johnston et al., 2016). This creates a sense of urgency to intensify research into the effects of cannabis on humans, and several questions remain regarding the real and long-term consequences of cannabis use.

Numerous studies have shown that cannabis use is associated with negative psychosocial correlates, including social and economic indicators of social standing and well-being such as lower academic achievement (e.g., Fergusson & Boden, 2008; Thompson et al., 2019), lower employment and economic prospects (e.g., Compton et al., 2014) as well as more interpersonal problems and a poorer quality of life (e.g., Choenni et al., 2017). However, some methodological problems have led researchers to question the evidence regarding a causal role of cannabis on these psychosocial consequences (e.g., Macleod, Oakes, Oppenkowski, et al., 2004; Meier, 2020). Notably, since randomized controlled trials, the gold standard for establishing causality, cannot be conducted because of ethical and legal constraints, it is difficult to eliminate alternative hypotheses, such as reverse causality (e.g., low academic achievement leads to cannabis use) or the influence

of a third variable (i.e., confounding variables that could explain both cannabis use and low academic achievement).

Accordingly, this article selectively reviews the literature (37 studies) on the associations between cannabis use and psychosocial functioning, operationalised here as academic success, employment, social relationships and quality of life (see table 1 for details of studies reviewed). To do this, we have included comprehensive systematic and narrative literature reviews that examined the effects of cannabis on psychosocial variables in the general population, as well as individual studies published since the year 2000 looking at questions about the effects of cannabis on (a) academic success; (b) employment and income; and (c) social relationships and quality of life. In selecting the literature, we prioritized studies that met the following criteria : (a) longitudinal and prospective studies where cannabis use preceded the psychosocial variables of interest; (b) repeated measurements of the variables of interest over time; (c) relatively large sample size; and (d) inclusion of socio-demographic control variables such as gender, age, family income and ethnicity, as well as other confounding variables associated with the variables of interest (e.g., academic performance in childhood, use of other substances). When possible, the effect sizes and the role of frequency of cannabis use, age of onset of use, as well as potential moderators will be clarified and discussed to highlight the implications for future studies, clinical policy and practice.

Academic success

Since 2000, two literature reviews have investigated the association between cannabis use and academic performance or success. In a review by Lynskey and Hall (2000), four prospective and longitudinal studies that examined the association between

cannabis use and academic success as well as associated variables such as absenteeism and academic motivation were included (Brook, Balka, et al., 1999; Ellickson et al., 1998; Fergusson & Horwood, 1997; Fergusson et al., 1996). All of the studies reported that there was a significant association between cannabis use in adolescence and truancy as well as dropping out of school. For example, in a longitudinal study of young people in New Zealand by Fergusson et al. (1996; Christchurch birth cohort), 22.5% of young people who used cannabis before age 15 had left school at 16, compared to only 2.5% of those who had not used cannabis. However, in all the studies, once the analyses had controlled for important confounding variables (e.g., delinquent and disruptive behavior, mental health, academic success, affiliation with deviant peers, family dysfunction), associations between cannabis use and school variables were significantly reduced, with the majority being no longer significant. The exception was dropping out of school; despite a decrease in association, it remained significant in the full sample (Brook, Balka, et al., 1999; Fergusson & Horwood, 1997; Fergusson et al., 1996), or for a subsample only, as in a study by Ellickson et al. (1998) conducted in the United States, where the association remained significant for Hispanic youth, but not for Asian, African American or Caucasian youth. The birth cohort from New Zealand (i.e., Christchurch birth cohort) was assessed again at age 30 and 35 years by Boden et al. (2020), with findings showing that participants who used cannabis weekly or more frequently, regardless of onset (i.e., 3 latent trajectories of high frequency users were modelled: adult-onset regular use, early-onset adult desisting and early-onset chronic use) had substantially reduced odds of attaining tertiary qualifications (beyond the high school level). The associations remained moderately strong after adjusting for a number of confounding variables representing individual and familial

childhood and adolescent factors, including adolescent tobacco use (but not other substance use).

In their systematic review, Macleod, Oakes, Copello, et al. (2004) identified eight high-quality longitudinal studies of the general population in which the effect of cannabis on academic achievement was examined, including the four studies reviewed by Lynskey and Hall (2000) and three other studies on academic outcome variables (Bray et al., 2000; Fergusson et al., 2002; Lynskey et al., 2003). Consistent with the previous review, MacLeod et al. (2004) reported that cannabis use was consistently associated with academic variables such as dropout, academic motivation and academic performance, but also noted that the strength of the association varied among reviewed studies, and when the appropriate control variables were included in the analyses (alcohol and other substance use, social class, ethnicity), the strength of the association decreased significantly, becoming non-significant in the majority of cases. However, it is interesting to note that when the association remained significant, it was the association between early cannabis use (i.e., at or before 15 years old; Brook, Balka, et al., 1999; Brook, Richter, et al., 1999; Fergusson et al., 1996; Lynskey et al., 2003) rather than any adolescent consumption that predicted academic outcomes.

In recent years, several studies have examined the association between cannabis use and school variables. However, several are not reviewed here, because they examined cannabis only in the context of poly-drug use or, because they did not control for important control variables, including academic success before cannabis use or consumption of other substances.

Arria et al. (2015) used growth charts to examine cannabis use and grade point average (GPA) during four years of university education as well as at graduation. They found that an increase in the frequency of cannabis use over the four years of university was associated with a decrease in GPA over the same period, but there were no longitudinal associations where cannabis use would have predicted GPA. This study also reported an indirect association where higher cannabis use in the first year of university was associated with missing more classes, which was associated with a lower GPA concurrently, which resulted in a lower GPA over the four years, and a longer time before graduating. However, despite this study controlling for several covariates (measured during the first university year), including academic engagement, it did not control for academic success before cannabis use, and accordingly bidirectional effects or reverse causation cannot be excluded.

Another longitudinal study conducted by Green and Ensminger (2006) with a sample of African Americans followed from age 6 to 32-33 years used a methodologically strong design (propensity score matching) to control for the confounding variables associated with family and individual factors in childhood, including academic success. This study found that high cannabis use during adolescence (20+ times prior to age 17) was associated with a higher risk of dropping out, with young people reporting high cannabis use being 20% more likely to drop out compared to other teens. Despite the methodological strengths of this study, a major limitation is that it did not control for the use of other substances, while several recent studies have shown that it is an important confounding variable (Pardini et al., 2015). This same cohort was later followed in mid-adulthood (age 42), with participants being assessed on health, substance use, criminal behavior and social integration, among other things (Green et al., 2017). This

study found that adolescent cannabis use was associated with dropping out of school, which in turn was associated with socioeconomic consequences (see next section) 25 years later (Green et al., 2017).

In addition, a study by (Pardini et al., 2015) found that cannabis use among adolescents was associated with more academic problems (school performance on reading, writing and arithmetic) as reported by parents, but when they controlled for time-varying covariates (particularly use of other substances and peer delinquency), the association between cannabis and academic problems was no longer significant. Similarly, McCaffrey et al. (2010) followed 4,500 adolescents for four years during high school and reported a positive association between cannabis use and dropping out in the following years, but this association was no longer significant after controlling for cigarette use.

Some studies have suggested that it is early, frequent and/or persistent use of cannabis rather than any form of use that is associated with academic problems. Indeed, studies show that associations and effect sizes are stronger for early, frequent and/or persistent consumption (e.g., Brook, Balka, et al., 1999; Degenhardt et al., 2010; Fergusson & Boden, 2008; Horwood et al., 2010). However, even in studies examining these variables, the associations seem to decrease considerably or no longer be significant when the use of other substances is taken into account. For example, Mokrysz et al. (2016) analysed data from a prospective study of 2235 adolescents where 24% reported having used cannabis at or before age 15 years. They found that when they controlled for tobacco use and other confounding variables, even adolescents with high cannabis use (> 50 times) did not differ significantly from those who never used cannabis in terms of their academic performance at 16 years old. Degenhardt et al. (2010) followed a cohort of 1943 Australian

students from age 15 years to 24 years. They found that occasional, persistent and weekly users of cannabis were less likely to complete post-secondary education at 24 years compared to young people who had never used cannabis. However, the addition of confounding variables, including smoking, reduced the association. Similar results were found in a study by Meier et al. (2015), where persistent cannabis use from 14 to 18 years was associated with lower grades at 18 years in a high-middle class American sample, an association that became non-significant after controlling for persistent smoking and alcohol use. Finally, Maggs et al. (2015) found that 18-year-olds who used cannabis frequently (i.e., 6+ times in the past 30 days) were less likely to graduate from university, but this association was no longer significant after controlling for use of other substances.

Employment, income and social welfare

To our knowledge, no systematic reviews examining the link between adolescent cannabis use and employment outcomes exist. Cross-sectional results on the relationship between cannabis and employment are mixed. Significant associations were found between recent use of cannabis measured retrospectively and job loss in the last year (Compton et al., 2014) as well as a drop in wages (Van Ours, 2007), but not with employment status (Van Ours, 2006). Other studies have not found associations between lifetime cannabis use and unemployment (Degenhardt et al., 2007).

Despite mixed results, results of prospective and longitudinal studies are more consistent than the results of cross-sectional studies, with the most pronounced and consistent results concerning cannabis use dependence. For example, a longitudinal study of 947 participants (Cerdá et al., 2016) found that users who were dependent on cannabis had more financial difficulties (e.g., self-reported debt and cash flow issues, difficulty to

pay for basic expenses, being on welfare benefit, having low credit ratings) than non-users. Similarly, Boden et al. (2017) found that addiction to cannabis increased the risk of not having a job 3 to 5 years later, but the effects were bidirectional since unemployment was also associated with a higher risk of being addicted to cannabis 3 to 5 years later.

There is also support for the negative effects of cannabis use frequency on employment. For example, Fergusson and Boden (2008) conducted analyses on 1003 participants and found that an increase in the frequency of cannabis use between age 14 and 21 years was associated with a higher frequency of unemployment and dependence on social assistance as well as a lower income between 21 and 25 years, with a particularly high effect among the group consuming the most (400+ times between 14 and 21 years old). Danielsson et al. (2015) studied 42240 Swedish men enrolled in compulsory military service between ages 18 and 20 years in 1969-1970. They found a small effect where cannabis use before enrollment was associated with higher risks of dependence on social assistance (for all levels of consumption) and unemployment (only for the group reporting having consumed cannabis 50+ times) later between 1990 and 1995. In a longitudinal study of 2606 Norwegians, Pedersen (2011) found that the frequency of cannabis use between the ages of 21 and 28 increased the risk of receiving social assistance in the following two years, especially when consumption was high (50+ times in the past 12 months). However, after controlling for confounding variables including psychopathology and use of other substances, the strength of the association decreased substantially. A study by Arria et al. (2013) found that users of cannabis at university differed from non-users, with users more likely to be unemployed compared to employed

part-time. However, there was no difference between groups in terms of full-time employment.

Studies have also examined associations when cannabis use is modelled as longitudinal trajectories. Lee et al. (2015) followed 647 participants from 14 to 36 years of age and found that individuals reporting "chronic use" (use increasing between ages 14 and 24 and remaining high until age 36) and those reporting "quitting late" (use starting in adolescence and decreasing only after 29 years old) had a higher risk of unemployment compared to non-consumers. However, when control variables (demographic, educational and occupational expectations, physical health and prior unemployment status) were added to the model, the effect remained only for those reporting chronic use. Zhang et al. (2016) followed 548 participants from the same sample as Lee et al. (2015) from 14 to 43 years old. They found that, compared to non-users, chronic frequent but decreasing users (weekly use starting at age 14 and continuing in their twenties, then decreasing) and chronic occasional users (occasional use starting at age 16 years and continuing throughout the study until age 43 years) were at higher risk of being unemployed at age 43. However, after including confounding variables, including smoking and employment history, the association remained significant only for the group of chronic frequent but decreasing consumers, highlighting the importance of frequency of cannabis use. It is also interesting to note that there was no effect for the group with increased consumption (who reported experimenting at 16 years of age, with frequent use of several times a week in their thirties and forties), supporting the importance of the age of onset of consumption. Boden et al. (2020) also found that high-frequency users, even those with adult onset (i.e., adult-onset regular, early-onset adult desisting and early-onset chronic) had consistently poorer indices

of socioeconomic well-being including significantly reduced incomes, even after adjustment for confounders (but did not control for other substance use, beyond tobacco use at 15 years). Thompson et al. (2019) also provided support for the fact that the association between youth cannabis use and later employment outcomes is dependent on the frequency, stability and age of onset of cannabis use. That is, they showed that while early onset and persistent high or increasingly frequent cannabis use in the transition from adolescence to young adulthood was associated with lower occupational success, youth who used cannabis early but also quit early were not disadvantaged in terms of employment in adulthood.

Thus, the results of studies on the association between cannabis use and employment-related variables are mixed. To make sense of these results, it is important to note the type of cannabis use measured as well as the confounding variables included in the models. For example, some of the studies that found significant associations did not control for other substance use (Brook et al., 2011; Lee et al., 2015; Zhang et al., 2016) or psychopathology (Brook et al., 2011; Lee et al., 2015), and only a few of the reviewed studies (i.e., Cerdá et al., 2016; Lee et al., 2015; Thompson et al., 2019; Zhang et al., 2016) considered age of onset. This is important to highlight since some studies, such as the one conducted by Popovici and French (2014), suggest that the associations found between cannabis and employment-related variables could be overestimated given that important confounding variables were not controlled for. Popovici and French (2014) found that the observed relationships of cannabis use in early and mid-adulthood with employment and income four years later were no longer significant when using an analytical method that controls for inter-individual differences and is particularly well

suited to assess intra-individual effects. Similar results were found by Silins et al. (2014), whose results indicate that the association between cannabis use and subsequent dependence on social assistance was no longer significant after controlling for confounding variables at the participant level (cognition, behavior, use of other substances, mental health, demographic variables), parent level (adjustment, substance use, mental health, demographic variables) and peer level (affiliations with deviant peers). Finally, a recent study by Augustyn et al. (2020) that modelled trajectories of cannabis use spanning ages 14 to 30 in a sample of predominantly minorities (>80% minorities; 68% African American; i.e., Rochester Youth Development Study) and their association with probabilities of full-time employment in adulthood. Results showed that abstainers or rare cannabis users were more likely to have full-time employment compared with other cannabis use patterns users (early-onset-desistors, early-onset and late-onset persistors, and chronic users). However, it is interesting to note that in this study late onset persistors were more likely to be employed full-time compared to early onset persistors, again highlighting the potential important role of age of onset. That said, effects were small, with authors concluding that different patterns of cannabis use spanning adolescence to adulthood have limited impact on the ability to retain full-time employment once employed.

Other studies have highlighted the role of demographic factors on the relationship between cannabis use and employment variables not only as confounders, but also as moderating variables. For example, in a study of a sample of African Americans (Green & Ensminger, 2006), an association was found between frequent cannabis use (20+ times) in adolescence and unemployment at age 32-33 years among men, but not women. However, the association between adolescent cannabis use and unemployment does not seem to

extend later in the life course, and may be limited to aspects of work beyond employment (e.g., work quality; Green et al., 2017).

Similarly, Hara et al. (2013) found that cannabis use in early adulthood was associated with poorer post-university employment outcomes for men, but not women. They also found that having a job in early adulthood predicted lower cannabis use in subsequent years, similar to the results of Boden et al. (2017) reported above. As for ethnicity, Braun et al. (2000) found that cannabis use was negatively associated with occupational prestige 2-3 years later among Caucasian participants, but not among African American participants, and that cannabis use was associated with lower income among Caucasian participants and African American men, but not among African American women.

Quality of life and social relationships

Quality of life

A systematic literature review (Goldenberg et al., 2017) recently reviewed studies of associations between cannabis use and quality of life, defined as a subjective and multidimensional concept that measures physical, psychological, emotional and social well-being. Overall, studies on the topic show that in the general population, recreational cannabis use was weakly associated with a lower quality of psychological life (e.g., self-efficacy, social adjustment, life satisfaction), but the results were inconclusive for physical quality of life (e.g., physical health, pain, motor ability, handicaps). In addition, a high frequency of cannabis use was associated with a lower quality of psychological life compared to occasional use (Goldenberg et al., 2017). A study examining the trajectories of cannabis use from the first year at university over seven years also found that chronic

cannabis users (who had a high frequency of use across the seven years) and late increase cannabis users (who consumed little at the start of the study, but had a high frequency of use by the end of the study) had a lower psychological and physical quality of life at the end of the study compared to the other cannabis use groups (which included non-users, low-stable users, those with early but declining use and those who used cannabis through college but not later (Caldeira et al., 2012)). In individuals meeting cannabis use disorder criteria, overall quality of life decreased with increasing dose (quantity) of cannabis used (Goldenberg et al., 2017). However, again, since most of the studies listed were cross-sectional or did not control for quality of life before the start of cannabis use, the direction of the relationship as well as the causality cannot be determined. One longitudinal study did examine the effect of remission from a cannabis use disorder on the quality of psychological life, and found that the change in the level of psychological quality of life did not differ between participants in remission and participants who still had a cannabis use disorder (Rubio et al., 2013).

Interpersonal Relationships

Some studies reported an association between cannabis use and interpersonal relationships using outcomes like marriage, relationship quality, parent-child relationship and marital harmony. For example, a longitudinal study on cannabis use and adverse life-course outcomes among African-American and Puerto Rican frequent cannabis users found that, regardless of age of onset or whether they matured out of cannabis use, these users experienced marital issues including being less likely to be married, and when married being less satisfied with their partner or experiencing less marital harmony overall (Brook et al., 2011). Green et al. (2017) reported similar findings, with adolescents who used

cannabis heavily being more likely to be unmarried in mid-life. A more recent longitudinal study also supports this association by reporting that participants with heavier use (i.e., adult-onset regular, adult desisting and early-onset chronic) were less likely to be in a relationship and have dependent children (biological or adopted child) at the age of 35 (Boden et al., 2020). In terms of relationships with other family members, a longitudinal study by (Stormshak et al., 2019) found that participants who reported increasing cannabis use across middle school and those who initiated cannabis use in young adulthood reported lower relationship quality with their parents compared to low-risk users (normative initiation trajectory). As these results were not found for young-adult alcohol use, the authors explained that it is possible that the social acceptability or norm of alcohol use played a role in this discrepancy between cannabis and alcohol use (Stormshak et al., 2019).

Family violence

A recent systematic literature review examined studies on the association between cannabis use and domestic violence (Choenni et al., 2017). Despite some exceptions, the majority of studies find a positive association between cannabis use and domestic violence, both in the general population and in clinical samples. However, the majority of the studies listed were cross-sectional. A prospective study found no association between high school cannabis use and domestic violence in early adulthood (Melander et al., 2010). A longitudinal study also examined the association between cannabis use between 15 and 21 years of age and domestic violence at 26 years. Any use of cannabis between the ages of 15 and 21 was associated with higher risks of being a victim or perpetrator of domestic violence, the greatest effect being for participants who used cannabis throughout the developmental period (Reingle et al., 2012). However, domestic violence (passive or

active exposure) was not measured before the start of cannabis use. One longitudinal study did examine bidirectional associations between cannabis use and domestic violence between the ages of 23 and 29 years in a sample of young adult women. The use of cannabis at 23 years was concurrently associated with domestic violence perpetration, compared with non-users. However, no longitudinal (cross-lagged) effect was found between the two variables, i.e. cannabis use at 23 did not predict the occurrence of domestic violence at 29, and domestic abuse at 23 did not predict cannabis use at 29 (Martino et al., 2005). One last study reported that frequent cannabis use (i.e., weekly or more) from ages 15-35 years was associated with increased odds of experiencing intimate partner physical violence compared to abstainers and occasional users, after adjusting for individual and familial factors in childhood and adolescence, including adolescent tobacco use (but no other substance use; Boden et al., 2020).

Finally, studies on the association between cannabis use and child maltreatment have also been listed in a systematic literature review. Despite some studies showing an association between cannabis use and child maltreatment, too few studies have been conducted on the topic to make reliable conclusions, and no study listed was longitudinal (Choenni et al., 2017).

Discussion

This article reviewed recent literature (mostly published since 2000) examining associations between cannabis use and outcomes related to education, employment, social relationships and quality of life. Despite mixed results, what seems to emerge is that when important confounding variables (including demographic, environmental and individual differences as well as time-varying factors, including use of other substances) are

controlled for, the results of prospective and longitudinal studies suggest that the impact of cannabis use on psychosocial variables is generally small or non-significant. These results remind us that any influence of cannabis use on psychosocial factors occurs within a complex system of individual and environmental risk and protective factors and suggest that the specific impact of cannabis use may be minimal from an ecological perspective. Furthermore, these results illustrate the importance of controlling for intra- and inter-individual differences to examine whether cannabis use leads to a significant, observable and persistent deterioration in psychosocial functioning. Nevertheless, some studies have found that even after controlling for several confounding variables, an association between cannabis use and psychosocial variables remained, particularly for chronic, dependent or early cannabis use, suggesting that the frequency of use and the age of onset of consumption may be necessary elements to detect persistent, however small, psychosocial consequences. This is consistent with findings showing that an earlier onset of cannabis use during adolescence (e.g.,<16 years), but not a later onset, is associated with cortical thickness and white matter alterations (Gruber et al., 2014; Jacobus et al., 2014), as well as poor neurocognitive function by early adulthood (Castellanos-Ryan et al., 2017).

Nevertheless, even for studies showing a significant association between cannabis use and psychosocial variables, the causal nature of these associations is far from clear. Some would suggest that these associations meet at least some of the traditional criteria for establishing causation (Hill, 1965); the effects are fairly consistent (at least for dependence and early use), the cause seems to precede the effect in some studies (but many others did not control for pre-substance use levels of the outcome or confounding factors), and a plausible mechanism for these effects may be proposed (e.g., early cannabis use will

increase the risk of truancy, which will increase the risk of dropping out; Roebuck et al., 2004). However, it is clear from the reviewed studies that the association's specificity criterion is not always satisfied. In several studies, tobacco and alcohol use show similar associations to cannabis use with psychosocial variables (see Stormshak et al., 2019, for an exception), and once these variables are controlled for, the associations between cannabis use and psychosocial variables decrease in effect size or become non-significant. These results do not suggest a causal mechanism through drug-specific neurophysiological effects or involvement in the criminal trade, since tobacco and alcohol have distinct neurophysiological effects and are also illegal for adolescents in most states and countries. In addition, cannabis use in the context of polysubstance use is prevalent, and is an important factor to consider in analyses. Unfortunately, the effects of polysubstance use versus single-substance use cannot be clarified with the studies reviewed, as the analyses included do not allow to fully disentangle the effects of cannabis use alone versus cannabis use in conjunction with other substance use. That is, while "specific effects" of cannabis use (controlling for other substance use) help us get closer to clarifying whether the effects observed are uniquely associated with cannabis use, when other substance use is held at a constant (or at a mean level), it does not inform us on the effect of cannabis use when other substance use is zero. Most cannabis users also drink alcohol and a considerable number use tobacco or other drugs; thus, although studying cannabis use in the context of poly-substance use versus single-substance use may be challenging in certain samples, it should be made a priority in future research. Also, it is interesting to note that tobacco use, more than other forms of substance use, seemed to decrease the effect cannabis use had on psychosocial outcomes. Further studies are needed to clarify the associations between

cannabis use, tobacco use and psychosocial functioning and some of the mechanisms that explain these associations.

Another criteria to confirm causality is the existence of a dose-response relationship, where the magnitude of the consequences varies with the magnitude of exposure to cannabis. This criteria is often mentioned, but in several studies, the existence of such a relationship was impossible to assess since only binary categories of exposure were examined. Although the results examining dependence and chronic cannabis use were more consistent than those examining cannabis use in general, a linear association ranging from lower exposure to higher exposure to cannabis is difficult to establish from the current literature. The interpretation of a dose-response relationship is also complicated by the fact that the amount of cannabis consumed is difficult to measure accurately, which means that in almost all studies, the frequency of consumption was measured rather than the dose. However, some studies have shown that the amount of cannabis consumed was significantly associated with the frequency of consumption (e.g., Cuttler & Spradlin, 2017).

Even if the traditional criteria for establishing causation were all met, studies have shown that associations can meet these criteria and not be causal (Davey Smith et al., 1992). Indeed, alternative explanations of reverse causality and of confounding variables must be excluded to support causality, which was not the case in the studies reviewed. Indeed, these studies did not use a methodological and statistical estimate capable of excluding these alternative explanations. Thus, it is clear that studies that use appropriate methodological approaches that go beyond correlation and regression analyses applied to observational data are needed to inform public policy decisions and to help understand the real consequences that may be associated with legalization

of recreational cannabis use. Methodological approaches such as propensity scores matching (Butelman et al., 2018), Mendelian randomization (Gage et al., 2017) and those examining intra-individual change and bidirectional effects between psychosocial and cannabis use (e.g., Random Intercept Cross-lagged Panel Model; (Hamaker et al., 2015)) have shown promise in clarifying temporality and specificity of associations between substance use and psychosocial outcomes.

Despite mixed results and the possibilities of reverse causality and confounding variables, this literature review highlights several clinical and policy implications. Since bidirectional effects between cannabis use and psychosocial variables are plausible (and have been found in some studies, e.g., Boden et al., 2017), psychosocial factors should be considered as important risk factors for cannabis use. Indeed, several studies show that poor academic success and poor cognitive functioning in childhood, which are associated with several psychosocial outcomes, are also associated with an increased risk of initiating cannabis use earlier or using cannabis more frequently during adolescence (Castellanos-Ryan et al., 2017; Duncan et al., 1998; Henry et al., 2007; Newcomb & Bentler, 1986). Early cannabis use is associated with several risk factors such as early social disadvantage, family problems, trauma, family conflicts, alcohol and drug use problems among parents and individual factors including impulsivity and negative affect, which are also associated with a variety of psychosocial consequences later in life (Castellanos-Ryan, O'Leary-Barrett, et al., 2013; Fergusson & Horwood, 1997; Rioux et al., 2018).

Cannabis legalization offers an opportunity to better examine populations at risk and social and environmental causation, and to thus identify the best targets for prevention and early intervention. For example, a study in Oregon reported that while legalization of

recreational cannabis did not increase cannabis use for youth who did not use cannabis before legalization (i.e., did not increase onset or experimentation), it did increase use in youth who were already using prior to legalization (i.e., increased frequency of use in users; Rusby et al., 2018). This suggests that as legalization becomes more widespread, prevention campaigns should not only focus on preventing the initiation of cannabis use in adolescents, but also target highly frequent cannabis use (e.g., daily or near daily use) in current users, especially considering the results of the studies reviewed suggesting that chronic use and dependence may be associated with more psychosocial problems.

Overall, all of this suggests that policy and prevention programs may want to aim at delaying the onset of cannabis use, as well as chronic or highly frequent use (daily or near daily use). Universal prevention or campaigns focusing on delaying onset (see Fischer et al. (2017) for a review of promising intervention approaches that encourage adolescents to "just wait" and not initiate cannabis use until the age of 16) and providing parents with resources to promote dialogue about cannabis use with their children should be implemented before adolescents start using cannabis and thus may need to be implemented by the end of elementary school rather than in middle or high school. This said, results suggest that the impact of interventions delaying onset and chronic cannabis use may only have small effects in preventing future psychosocial problems, and thus, other approaches should be considered. A promising approach may be to target some of the individual and environmental factors (e.g., early academic and cognitive functioning, social disadvantage, family functioning, personality, smoking) that account for much of the association between cannabis use and later psychosocial problems, rather than cannabis use itself. Such targeted or selective prevention strategies focusing on early risk factors could be an effective

method to prevent both early and chronic cannabis use and later psychosocial problems. Indeed, prevention programs targeting early risk factors can prevent early onset or frequent use without explicitly addressing cannabis use. Recent results show that interventions targeting early risk factors (e.g., relating to early disruptive behaviours or temperament and personality traits) are effective in preventing substance use and co-occurring or associated psychosocial problems (Castellanos-Ryan, Seguin, et al., 2013; Conrod et al., 2013; Hawkins et al., 1999; Mahu et al., 2015).

In conclusion, the prospective and longitudinal studies reviewed in the present paper suggest that the impact of cannabis use on psychosocial variables is generally small or non-significant, but is more robust, albeit still small, for chronic, dependent or early cannabis use. However, studies were limited methodologically, and longitudinal studies using strong methodological approaches, and especially controlling for pre-cannabis use outcomes and other substance use, are needed. Such studies will allow for a better evidence base for prevention programs, but evidence to date suggests that they should start early and target early risk factors for cannabis use in addition to addressing early and chronic cannabis use directly.

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Table 1. Results of prospective and longitudinal studies examining cannabis use in the prediction of (1) Academic outcomes, (2) Employment, income and social welfare, (3) Quality of life, (4) Interpersonal relationships, and (5) Family violence

Authors, year (n and Country)	Cannabis variable	Outcome	OR (95% CI) or other± with minimal controls	OR (95% CI) or other± controlling for confounders	Nature of association tested	Follow-up	Covariates entered in to 1st step of analyses (controls) and 2nd step of analyses (confounders)
1. Academic Outcomes							
Arria et al., 2015 (n=1117 college students; US)	CUFr during 1st y (intercept) and across college (5y; slope):	GPA and Time to graduation:			Longitudinal	6y	Controlling for confounders: Sociodemographics, academic expectations and/or achievement, personality, externalizing problems <13y and >13y, personality, mental health and inadaptation, other drug use and alcohol use, and other social factors.
	CU 1st y (Intercept)	GPA 1st y (intercept)		n.s.			
		GPA across college (slope)		n.s.			
	CU across college (slope)	GPA across college (slope)		B=-0.051 (.024)*			
	CU 1st y (Intercept)	Time to graduation		n.s.			
	CU across college (slope)	Time to graduation		n.s.			
Boden et al.,2020 (n=1065; New Zealand)	CUFr trajectories from 15-35y	Attainment of tertiary-level qualification (by 35y)			Longitudinal	1-20y	Minimal controls: none Controlling for confounders: Sociodemographics, family history of substance use, family history of mental health problems

Authors, year (n and Country)	Cannabis variable	Outcome	OR (95% CI) or other± with minimal controls	OR (95% CI) or other± controlling for confounders	Nature of association tested	Follow-up	Covariates entered in to 1st step of analyses (controls) and 2nd step of analyses (confounders)
	Adult onset (>18y) regular vs non-users		0.19(0.09-0.41)***	0.20 (0.09-0.43)***			and inadaptation, family structure and functioning, child sexual or physical abuse, academic expectations and/or achievement, cognitive performance, externalizing problems <13y and >13y, personality, mental health and inadaptation, substance use and delinquency in peers, cigarette use.
	Early onset, Adult desisting vs non-users		0.27 (0.15-0.49)***	0.39(0.18-0.84)*			
	Early-onset chronic vs non-users		0.22(0.11-0.47)***	0.37(0.13-1.05)			
Bray et al., 2000 (n= 1392; US)	CU prior to school drop-out vs no CU	School drop-out by 18y	2.97 (CIs not available)**	2.31(CIs not available)**	Longitudinal	4y	Minimal controls: Sociodemographics, Family structure, other social factors, and academic expectations and/or achievement. Controlling for confounders: alcohol, tobacco and other drug use.
Brook, Balka, et al., 1999 (n=1336; n=695 African American; n=637 Puerto Rican; US)	CU at 14y: >monthly use vs less frequent use	Low academic attainment (non-attainment of a high school diploma)	1.91 (1.05-347)*	2.00 (1.09-3.66)*	Longitudinal	5y	Minimal controls: Sociodemographics. Controlling for confounders: academic expectations and/or achievement, externalizing problems <14y, substance use and delinquency in peers (and siblings) and substance use attitudes.
Degenhardt et al., 2010	Adolescent (14-17y) CUFr	Post-school qualifications by 24y			Longitudinal	7y	Minimal controls: Sex.

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(n=1943; Australia)	Occasional use (<weekly) vs no-use		0.63 (0.47-0.83)***	0.98 (0.71-1.3)			Controlling for confounders Sociodemographics, mental health and inadaptation, alcohol use and tobacco use.
	Weekly+ CU vs no-use		0.41 (0.29-0.58)***	0.84 (0.55-1.3)			
Ellickson et al., 1998 (n=4,390 adolescents; US)	CU vs no-use in 7th grade	School drop-out by 12th grade	1.68 (no CIs available)***	1.13 (no CIs available)	Prospective	5y	Minimal controls: None. Controlling for confounders: Sociodemographics, family structure, academic expectations and/or achievement, externalizing problems and school environment.
Fergusson et al., 1996 (n=1265; New Zealand)	CU<15y vs no use	Truancy Frequency 15 to 16y	9.3 (5.4-16.0)***	2.0 (1.0-4.2)	Longitudinal	1y	Minimal controls: None. Controlling for confounders: Sex, Family structure and functioning, Family history of Substance use, externalizing problems<13y, cognitive functioning, mental health and inadaptation, academic expectations and achievement, substance use and delinquency in peers and alcohol use.
	CU<15y vs no use	Dropping out by 16y	8.1 (4.3-15.0)***	3.1 (1.2-7.9)*	Longitudinal		
Fergusson & Boden, 2008 (n=1003; New Zealand)	CUFr 14-21y	University degree by 25y			Longitudinal	11y	Minimal controls: none Controlling for confounders: Sociodemographics, child sexual or physical abuse, family structure and functioning, family
	1-99 times vs never		27% vs. 36%	0.75 (0.62-0.92)			

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	100-199 times vs never		18% vs. 36%	0.57 (0.38-0.85)			history of substance use, family history of mental health problems and inadaptation, externalizing problems >13y, substance use and delinquency in peers, cognitive performance, academic expectations and/or achievement, mental health and inadaptation, alcohol use, cigarette use, other drug use
	200-299 times vs never		11% vs. 36%	0.43 (0.23-0.78)			
	300-399 times vs never		9% vs. 36%	0.32 (0.14-0.72)			
	400+ times vs never		2% vs. 36%	0.24 (0.09-0.66)			
			Linear trend***	Linear trend***			
Fergusson & Horwood, 1997 (n=935; New Zealand)	CUFr 15-16y: used 1-9 times vs no-use	School dropout by 18y	2.66 (1.74-4.06)***	1.62 (1.05-2.50)*	Longitudinal	2y	Minimal controls: None. Controlling for confounders: Sex, Family structure and functioning, Family history of Substance use and offending, child sexual abuse, externalizing problems by15y, cognitive functioning, personality, mental health and inadaptation, academic expectations and achievement, substance use and delinquency in peers and alcohol and tobacco use.
	CUFr 15-16y: used 10+ times vs no-use	School dropout by 18y	7.24 (3.96-13.23)***	2.66 (1.43-4.95)**			
Green & Ensminger, 2006 (n=274 African Americans; US)	Heavy adolescent CU (20+ times by 16y) vs. other	High-school diploma vs dropout (school records) by 32-33y	Males: 0.21 (0.07-0.35)* Females: 0.20 (0.02-0.38)*		Longitudinal	17y	Propensity score matching used: Groups matched on sociodemographics, family history of drug use, personality, mental health and inadaptation and externalizing problems <13y.

Authors, year (n and Country)	Cannabis variable	Outcome	OR (95% CI) or other± with minimal controls	OR (95% CI) or other± controlling for confounders	Nature of association tested	Follow-up	Covariates entered in to 1st step of analyses (controls) and 2nd step of analyses (confounders)
Green et al. 2017 (n=330 African Americans; US)	Heavy adolescent CU (20+ times by 16y) vs others	College dropout vs degree completion High-school diploma	3.11 (1.31-7.39)* 0.49 (0.26-0.93)*		Longitudinal	16-26y	Propensity score matching used: Groups matched on sociodemographics, family structure and functioning, family history of substance use and mental health problems and inadaptation, cognitive performance, academic expectations and/or achievement, personality, externalizing problems <13y and >13 years.
Horwood et al., 2010 (n~6000; 3 cohorts Australia and New Zealand);	CUAO: Never used vs CU<15y	High school completion by 21y (one cohort) or by 24/25y	3.6 (2.6-4.9)***	2.9 (1.8-4.6)***	Longitudinal	1-10y	Minimal controls: None. Controlling for confounders: Socio-demographics, family structure and functioning, cognitive function, academic aspirations and achievement, externalizing problems <13 years.
Lynskey et al., 2003 (n=1601; Australia)	Weekly or more frequent CU vs no/less CU:	Early school leaving (assessed at 21y)			Prospective	3-6y	Minimal controls: none. Controlling for confounders: Sociodemographics, tobacco and alcohol use, externalizing problems and mental health and inadaptation.
	Weekly CU in grade 10 (15/16y)		6.8 (2.8–16)*	5.6 (2.0-15.0)*			
	Weekly CU in grade 11 (16/17y)		3.2 (1.4–7.3)*	2.2 (0.91–6.0)			
	Weekly CU in grade 12 (17/18y)		1.8 (0.69–4.6)	1.1 (0.40-2.9)			
	CUFr over last 30 days at 19/20y:				Longitudinal	4y	

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Maggs et al., 2015 (n=4925; US)	no use vs infrequent use (1-5 times)	Post-secondary degree attainment (bachelors) by 23/24y	Z=-1.38	Z=-1.01			Minimal controls: Sociodemographics, family structure and functioning, academic aspirations and achievement and other social factors.
	No use vs frequent use (6+ times)		Z= 3.36***	Z=1.24			Controlling for confounders: substance use at 18 years.
McCaffrey et al., 2010 (n=4,375; US)	CU consistently over grades 9 and 10 (<3 times/y)	High School dropout (staff and student reports)	5.59 (CIs not available)***	1.27 (CIs not available)	Longitudinal	3y	Propensity score matching used: sociodemographic, family structure and functioning, substance use expectancies. Controlling for confounders: time varying alcohol use, cigarette use and grades.
Meier et al., 2015 (n=254; US)	Persistent CU (using 10+ over 1y) across 4y (14/15 to 17/18y)	GPA at 17/18y	β=-0.13*	β=-0.06	Longitudinal	4y	Minimal controls: Sociodemographics, externalizing problems, mental health and inadaptation, and academic expectations and achievement. Controlling for confounders: persistent alcohol and tobacco use.
Mokrysz et al., 2016 (n=2235; UK)	CU >50 times at 15y vs non users	Educational performance (% GCSE points) at 16y	-11.6%***	-2.2%	Longitudinal	1y	Minimal controls: None. Controlling for confounders: Sociodemographics, academic expectations and achievement, externalizing problems, mental health and inadaptation, and alcohol, cigarette and other substance use.
	CUFr over 11-16y:				Longitudinal	1-5y	

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Pardini et al., 2015 (2 cohorts: Pittsburgh	CU <monthy in past 12 months vs no use;	Academic problems (average ordinal score) 11-16y	Females: B=0.13 (0.09); males: B=-0.05 (0.19)	Females: B=0.02 (0.15); males: B=-0.08 (0.31)			Minimal controls: Sociodemographics, academic expectations and achievement, externalizing problems, mental health and inadaptation, substance use and delinquency in peers.
Youth Study n=479 males; Pittsburgh Girls Study n=2296 females; US).	CU >monthly in past 12 months vs no use		Females: B=0.24 (0.12)*; males: B=0.30 (0.27)	Females: B=0.23 (0.25); males: B=-0.32 (0.56)			Controlling for confounders: Cannabis use abstinence 12 months prior to outcome.
	CU 15-17y vs CU<15y		1.9 (1.2-2.2)**	1.7 (1.4-2.1)**			
2. Employment, income and social welfare							
Arria et al., 2013 (n=620; US)	CU and other drug use 18-21y				Prospective	6y	Minimal controls: none.
	CU only vs no use	Unemployed vs employed full-time 23 y	3.70 (0.79-17.28)	4.14 (0.87-19.80)			Controlling for confounders: Sociodemographics, other social factors, personality, externalizing problems >13y, college graduation, alcohol use.
	Sporadic other drug use vs no use		2.78 (0.61-12.68)	3.23 (0.68-15.29)			
	Persistent other drug use vs no use		6.64 (1.41-31.24)*	8.10 (1.61-40.76)*			
	CU only vs no use	Unemployed vs employed part-time 23y	6.00 (1.13-31.73)*	6.36 (1.19-33.92)*			
	Sporadic other drug use vs no use		4.00 (0.80-20.04)	4.15 (0.81-21.20)			

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	Persistent other drug use vs no use		5.62 (1.07-29.61)*	5.49 (1.01-29.81)*			
	CU only vs no use	Employed part-time vs full-time 23y	0.62 (0.30-1.29)	0.90 (0.41-1.98)			
	Sporadic other drug use vs no use		0.70 (0.37-1.32)	1.18 (0.56-2.47)			
	Persistent other drug use vs no use		1.18 (0.56-2.47)	2.53 (1.03-6.26)*			
Bears Augustyn et al., 2020 (n=705; US)	CUFr trajectories from 14 to 30y:				Prospective	16y	Minimal control: none.
	Abstainer	Employment stability 29-30y	χ^2 = 8.46, n.s.				
	Early-onset desistor						
	Late-onset persistor						
	Early-onset persistor						
	Increasing chronic						
	Abstainer vs all user groups	Full-time employment 27-30y	significantly higher				

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	Late onset persistor vs early onset persistor		significantly higher				
	All other group comparisons		n.s.				
Boden et al., 2017 (n=1011; New Zealand)	Cannabis dependence within 3-5y periods between ages 18-35y	Periods of unemployment of 3+ months within 3-5y periods between ages 18-35y	3.57 (2.55-4.97)***	2.83 (1.98-4.02)**	Longitudinal	17y	Minimal controls: none. Controlling for confounders: Previous unemployment and cannabis use, mental health and inadaptation, stressful life events, alcohol use.
Boden et al., 2020 (n=1065; New Zealand)	CUFr trajectories from 15-35y:				Longitudinal	20y	Minimal controls: none. Controlling for confounders: Sociodemographics, family history of substance use, family history of mental health problems and inadaptation, family structure and functioning, child sexual or physical abuse, academic expectations and/or achievement, cognitive performance, externalizing problems <13y and >13y, personality, mental health and inadaptation, substance use and delinquency in peers, cigarette use.
	Adult-onset (>18y) regular vs non-users	Weekly income 35y	Mean difference = -192 (-344,-38.9)*	Mean difference = -384 (-554,-215)***			
	Early onset, Adult desisting vs non-users		Mean difference = -72.5 (-248,104)	Mean difference = -303 (-516,-89)**			
	Early-onset chronic vs non-users		Mean difference = -135 (-372,103)	Mean difference = -273 (-540,-5.3)*			

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	Adult-onset (>18y) regular vs non-users	Welfare dependence 30-35y	2.6 (1.3-5.2)**	2.4 (1.1-5.2)*			
	Early onset, Adult desisting vs non-users		2.9 (1.6-5.2)***	2.8 (1.5-5.6)**			
	Early-onset chronic vs non-users		5.7 (3.0-10.9)***	3.7 (1.7-8.3)***			
	Adult-onset (>18y) regular vs non-users	Unemployment 30-35y	1.8 (0.9-3.6)	1.6 (0.7-3.5)			
	Early onset, Adult desisting vs non-users		1.5 (0.8-2.7)	1.7 (0.9-3.4)			
	Early-onset chronic vs non-users		2.7 (1.4-5.3)**	2.4 (1.1-5.0)*			
Braun et al., 2000 (n=5115; US)	Past-month CU vs. no use within 5 assessments	Employment within 5 assessments between ages 25-35y		Black 1.04 (0.86-1.26); white 0.89 (0.78-1.03)	Longitudinal	10y	Controlling for confounders: Sociodemographics, participant marital or parental status, academic expectations and/or achievement.

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	between ages 25-35y	Occupational prestige 25-35y		Black unit difference = -0.3 (-0.9,0.4); white = -0.9 (-1.6,-0.2)*			
		Income 25-35y		Black male difference = -2142 (-4271,-13)*; black female = 373 (-1950, 2696); white male = -4389 (-6813,-1965)*; white female = -3100 (-5919, -281)*			
Brook et al., 2011	CUFr trajectories from 13-29y				Longitudinal	16y	Minimal controls: Sociodemographics, academic expectations and/or achievement.
(n=837; n=460 African American; n=377 Puerto Rican; US)	Maturing-out vs nonuse/low-use	Unemployment 29y	1.0 (0.5-2.0)				
	Late-onset vs nonuse/low-use		2.4 (1.4-4.3)**				
	Chronic vs nonuse/low-use		1.7 (0.9-3.1)				
Cerda et al., 2016 (n=947; New Zealand)	Persistence of cannabis dependence 18-38y	Financial difficulties 38y	r=.31***	r=.19***	Prospective	20y	Minimal controls: none. Controlling for confounders: Sociodemographics, family history of substance use, personality, cognitive performance, mental

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							health and inadaptation, participant marital or parental status, CU dependence age of onset.
Danielsson et al., 2015 (n=42240; Sweden)	Lifetime CUFr 19y				Longitudinal		Minimal controls: none.
	1-10 times vs never	Unemployment 40-45y	RR 1.11 (1.01-1.21)*	RR 1.05 (0.96-1.15)			Controlling for confounders: Sociodemographics, family structure and functioning, cognitive performance, mental health and inadaptation, academic expectations and/or achievement, alcohol use, cigarette use, other drug use.
	11-50 times vs never		RR 1.27 (1.08-1.51)*	RR 1.07 (0.89-1.29)			
	> 50 times vs never		RR 1.72 (1.49-1.98)*	RR 1.26 (1.04-1.53)*			
	1-10 times vs never	Social assistance 40-45y	RR 1.52 (1.39-1.66)*	RR 1.16 (1.06-1.26)*			
	11-50 times vs never		RR 2.12 (1.84-2.44)*	RR 1.22 (1.04-1.42)*			
	> 50 times vs never		RR 3.13 (2.82-3.48)*	RR 1.39 (1.19-1.62)*			
Fergusson & Horwood, 1997 (n=935; New Zealand)	CUFr 15-16y: used 1-9 times vs no-use	Unemployment 16-18y	2.97 (1.89-4.65)***	1.14 (0.66-1.96)	Longitudinal	4y	Minimal controls: All at <=16yr; Sociodemographics, family structure and functioning, family history of mental health problems and inadaptation, child sexual or physical abuse, cognitive performance, externalizing problems <13yr and >13yr, personality, mental health and inadaptation,
	used 10+ times vs no-use	Unemployment 16-18y	5.44 (2.89-10.23)***	1.23 (0.54-2.82)			

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							substance use and delinquency in peers, alcohol use, cigarette use. Controlling for confounders: all previous + academic expectations and/or achievement, sociodemographics, substance use and delinquency in peers at 16-18y.
Fergusson & Boden, 2008 (n=1003; New Zealand)	CUFr 14-21y				Longitudinal	11y	Minimal controls: none. Controlling for confounders: Sociodemographics, child sexual or physical abuse, family structure and functioning, family history of substance use, family history of mental health problems and inadaptation, externalizing problems >13y, substance use and delinquency in peers, cognitive performance, academic expectations and/or achievement, mental health and inadaptation, alcohol use, cigarette use, other drug use.
	Never used	Income 25y	*M* = 31.7 (000$)	*M* = 33.2 (31.4-34.9)			
	1-99 times		*M* = 34.0	*M* = 31.6 (30.4-32.8)			
	100-199 times		*M* = 27.1	*M* = 30.0 (28.6-31.5)			
	200-299 times		*M* = 27.6	*M* = 28.5 (26.2-30.7)			
	300-399 times		*M* = 27.5	*M* = 26.9 (23.7-30.1)			
	400+ times		*M* = 26.1	*M* = 25.3 (21.2-29.4)			
			Linear trend**	Linear trend**			
	1-99 vs never	Welfare dependence 21-25y	32% vs. 25%	1.37 (1.23-1.54)			
	100-199 vs never		41% vs. 25%	1.89 (1.51-2.37)			
	200-299 vs never		53% vs. 25%	2.60 (1.85-3.65)			
	300-399 vs never		55% vs. 25%	3.57 (2.27-5.61)			
	400+ vs never		58% vs. 25%	4.90 (2.79-8.63)			

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			Linear trend***	Linear trend***			
	1-99 vs never	Unemployment 21-25y	23% vs. 21%	1.27 (1.06-1.51)			
	100-199 vs never		25% vs. 21%	1.61 (1.13-2.29)			
	200-299 vs never		42% vs. 21%	2.04 (1.20-3.47)			
	300-399 vs never		41% vs. 21%	2.59 (1.28-5.24)			
	400+ vs never		52% vs. 21%	3.28 (1.36-7.94)			
			Linear trend***	Linear trend**			
Green & Ensminger, 2006 (n=274 African Americans; US)	CU 20+ times by 15-16y vs. other	Employed 32-33y	Marginal effect male = -.19 (-.32, -.05)**; female = -.18 (-.38, .02)	Marginal effect male = -.15 (-.30,-.16)*; female = -.12 (-.33, .09)	Longitudinal	17y	Minimal control: Propensity score matching used: Groups matched on sociodemographics, family history of drug use, personality, mental health and inadaptation and externalizing problems <13y. Controlling for confounders: Addition of high school drop out.
Green et al., 2017 (n=330 African Americans; US)	CU 20+ times by 16y vs. other	Employed 42y		0.93 (0.51-1.69)	Longitudinal	26y	Propensity score matching used: Groups matched on sociodemographics, family structure and functioning, family history of substance use and mental health problems and inadaptation, cognitive performance, academic expectations and/or achievement, personality, externalizing problems <13y and >13 years, alcohol use, cigarette use.
		Income 42y		B = -1.43 (-2.61,-0.25) n.s.			

Authors, year (n and Country)	Cannabis variable	Outcome	OR (95% CI) or other± with minimal controls	OR (95% CI) or other± controlling for confounders	Nature of association tested	Follow-up	Covariates entered in to 1st step of analyses (controls) and 2nd step of analyses (confounders)
Hara et al., 2013 (n=3677 males, 3984 females ; US)	CU rate at 23 yr (intercept)	Employment at 23y (intercept)	Males r = -34.03* Females r = -43.12**		Longitudinal	17y	Minimal control: none.
		Employment from 23 to 39y (slope)	Males r = -4.17** Females r = -2.81				
	CU rate from 23 to 39y (slope)	Employment from 23 to 39y(slope)	Males r = 0.18 Female r = 0.30				
	Early quitters vs nonusers		1.53 (0.44-5.36)	1.30 (0.33-5.15)			
Pedersen, 2011 (n=2606; Norway)	Past-year CUFr 21y	Social welfare assistance 21-23y			Longitudinal	2y	Minimal controls: none. Controlling for confounders: Sociodemographics, family structure and functioning, family history of substance use, academic expectations and/or achievement, mental health and inadaptation, substance use and delinquency in peers.
	1-10 times vs never		2.5 (1.6-3.8)*	2.1 (1.3-3.4)*			
	11-50 times vs never		5.4 (2.6-11.2)*	3.5 (1.5-8.1)*			
	>50 times vs never		9.7 (5.1-18.6)*	5.0 (2.4-10.4)*			
	Past-year CUFr 28y	Social welfare assistance 28-30y					

Authors, year (n and Country)	Cannabis variable	Outcome	OR (95% CI) or other± with minimal controls	OR (95% CI) or other± controlling for confounders	Nature of association tested	Follow-up	Covariates entered in to 1st step of analyses (controls) and 2nd step of analyses (confounders)
	1-10 times vs never		3.9 (2.3-6.5)*	2.6 (1.5-4.7)*			
	11-50 times vs never		4.2 (1.6-11.1)*	2.2 (0.7-6.9)			
	>50 times vs never		23.1 (12.3-43.4)*	9.3 (4.3-20.1)*			
Popovici & French, 2014 (n=7077 females, 7199 males; US)	CUFr in the last 1y (43y for minimal controls, 40y for controlling for confounders)				Longitudinal	3y	Minimal controls: Sociodemographics, participant marital or parental status, academic expectations and/or achievement, mental health and inadaptation, alcohol use, cigarette use, other drug use.
	<weekly vs no use	Employed 43y	Females = 0.60 (0.44-0.83)***; males = 0.72 (0.54-1.04)*	Females = 0.79 (0.49-1.29); males = 1.05 (0.66-1.68)			Controlling for confounders: Time-varying sociodemographics, participant marital or parental status, academic expectations and/or achievement, mental health and inadaptation, alcohol use, cigarette use, other drug use.
	<daily vs no use		Females = 0.56 (0.32-0.99)**; males = 0.65 (0.44-0.98)**	Females = 0.48 (0.19-1.18); males = 0.65 (0.36-1.18)			
	daily vs no use		Females = 0.25 (0.10-0.62)***; males = 0.22 (0.11-0.43)***	Females = 0.78 (0.27-2.24); males = 0.81 (0.24-2.79)			
	>weekly vs no use	Income 43y	Females B = 1.13 (-2.08,4.34); males B = -2.55 (-5.95, 8.50)	Females B = 3.66 (-1.88, 2.61); males B = -1.17 (-3.65, 1.32)			

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	>daily vs no use		Females B = -5.61 (-9.51,-1.72); males B = -7.52 (-11.37,-3.67)***	Females B = -2.26 (-6.59,2.07); males B = -2.29 (-5.26, 6.84)			
	daily vs no use		Females B = -6.94 (-13.10,-7.85)**; males B = -12.17 (-18.45, -5.88)***	Females B = -4.61 (-12.73, 3.51); males = 4.15 (-3.53, 4.36)			
Silins et al., 2014 (n= 3284; Australia and New Zealand)	Max CUFr before 17y	Welfare dependence 27-30y				12-16y	Minimal controls: none. Controlling for confounders: Sociodemographics, externalizing problems <13y, mental health and inadaptation, family history of substance use, family history of mental health problems and inadaptation, family structure and functioning, substance use and delinquency in peers, academic expectations and/or achievement, cigarette use, alcohol use, other drug use.
	<monthly vs never		1.17 (1.04-1.32)	1.04 (0.84-1.28)			
	Monthly vs never		1.37 (1.07-1.75)	1.08 (0.71-1.63)			
	Weekly vs never		1.61 (1.11-2.32)	1.12 (0.60-2.09)			
	Daily vs never		1.88 (1.15-3.07)	1.16 (0.50-2.66)			
			Group-wise*	Group-wise n.s.			
Thompson et al., 2019 (n=662; Canada)	CUFr trajectories from 15-28y					10y	Minimal controls: none. Controlling for confounders: Sociodemographics, academic expectations and/or achievement, adolescent externalizing problems, mental health and inadaptation, baseline alcohol use, cigarette use.
	Occasional vs abstainers	Occupational prestige 22-29y	d = -.19 (-.40, .02)	d = -.05 (-.26, .16)			
	Decreasers vs abstainers		d = -.13 (-.38, .13)	d = .01 (-.25, .26)			

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	Increasers vs abstainers		d = -.58 (-.82, -.35)	d = -.16 (-.38, .07)			
	Chronic vs abstainers		d = -.83 (-1.11, -.54)	d = -.14 (-.42, .13)			
	Occasional vs abstainers	Income 22-29y	d = -.09 (-.30, -.12)	d = -.02 (-.23, .19)			
	Decreasers vs abstainers		d = .25 (-.01, .50)	d = .10 (-.16, .35)			
	Increasers vs abstainers		d = -.08 (-.30, .15)	d = -.11 (-.33, .12)			
	Chronic vs abstainers		d = -.22 (-.50, .06)	d = 0 (-.28, .27)			
	Occasional vs abstainers	Full-time employment 22-29y	0.84 (0.55-1.30)	0.63 (0.41-0.99)			
	Decreasers vs abstainers		1.38 (0.80-2.38)	7.39 (2.70-20.21)			
	Increasers vs abstainers		0.88 (0.55-1.40)	0.54 (0.33-0.87)			
	Chronic vs abstainers		0.96 (0.54-1.70)	1.05 (0.56-1.96)			

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Zhang et al., 2016 (n=548; US)	CUFr trajectories 14-43y	Unemployment 43y			Longitudinal	29y	Minimal controls: none. Controling for confounders: Sociodemographics, participant marital or parental status, mental health and inadaptation, physical health, academic expectations and/or achievement, previous unemployment, cigarette smoking.
	Chronic/decreasing vs nonusers		3.49 (1.34-9.05)*	3.51 (1.13-10.91)*			
	Occasional vs nonusers		2.66 (1.23-5.75)*	1.92 (0.80-4.58)			
	Increasing vs nonusers		2.02 (0.56-7.21)	1.31 (0.31-5.55)			
	Quitters vs nonusers		0.99 (0.35-2.82)	1.16 (0.36-3.71)			
3. Quality of life							
Caldeira et al., 2012 (n=973; US)	CUFr trajectory groups from 18-23y:				Longitudinal	7y	Controlling for confounders: Sociodemographics, physical health, alcohol use, cigarette use.
	Non-use	Physical quality of life 24y		*M*=84.08			
	Low-stable			*M*=83.73			
	Early-decline			*M*=83.06			
	Late-increase			*M*=81.89			
	College-peak			*M*=85.99			
	Chronic			*M*=79.11			

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				All means significantly different			
	Non-use	Psychological quality of life 24y		*M*=74.09			
	Low-stable			*M*=72.13			
	Early-decline			*M*=72.48			
	Late-increase			*M*=70.88			
	College-peak			*M*=75.49			
	Chronic			*M*=67.98			
				All means except Low-stable vs. Early-decline significantly different			
Rubio et al., 2013 (n=10 367 adults with CUD; US)	Non-remitted CUD vs remitted CUD	Change in psychological quality of life		β=1.18, n.s.	Longitudinal	3y	Controlling for confounders: Sociodemographics, academic expectations and/or achievement, participant marital and parental status, mental health and adaptation, alcohol use, cigarette use.
4. Interpersonal relationships							
Boden et al., 2020	CUFr trajectories from 15-35y:				Longitudinal	20y	Minimal controls: none.

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(n=1065; New Zealand)	Adult-onset (>18y) regular vs non-users	With dependent children by 35y	0.49 (0.27-0.87)*	0.42 (0.22-0.79)**			Controlling for confounders: Sociodemographics, family history of substance use, family history of mental health problems and inadaptation, family structure and functioning, child sexual or physical abuse, academic expectations and/or achievement, cognitive performance, externalizing problems <13y and >13y, personality, mental health and inadaptation, substance use and delinquency in peers, cigarette use.
	Early onset, Adult desisting vs non-users		0.57 (0.35-0.95)*	0.47 (0.25-0.88)*			
	Early-onset chronic vs non-users		0.63 (0.34-1.16)	0.51 (0.25-1.04)			
	Adult-onset (>18y) regular vs non-users	Cohabiting partner by 35y	0.48 (0.26-0.88)*	0.38 (0.19-0.75)**			
	Early onset, Adult desisting vs non-users		0.48 (0.28-0.81)**	0.42 (0.23-0.80)**			
	Early-onset chronic vs non-users		0.57 (0.30-1.09)	0.46 (0.21-0.97)*			
Brook et al., 2011	CUFr trajectories from 13-29y				Longitudinal	16y	Minimal controls: Sociodemographics.
(n=460 African American; n=377	Maturing-out vs nonuse/low-use	Divorce or separated by 29y	1.8 (0.6-4.9)				

Authors, year (n and Country)	Cannabis variable	Outcome	OR (95% CI) or other± with minimal controls	OR (95% CI) or other± controlling for confounders	Nature of association tested	Follow-up	Covariates entered in to 1st step of analyses (controls) and 2nd step of analyses (confounders)
Puerto Rican; US)	Late-onset vs nonuse/low-use		1.2 (0.3-4.1)				
	Chronic vs nonuse/low-use		0.4 (0.1-2.9)				
	Maturing-out vs nonuse/low-use	Married and living together by 29y	0.6 (0.3-1.1)				
	Late-onset vs nonuse/low-use		0.3 (0.1-0.6)**				
	Chronic vs nonuse/low-use		0.3 (0.1-0.7)**				
	Maturing-out vs nonuse/low-use	Arguments with partner 29y	3.1 (1.7-5.4)***				
	Late-onset vs nonuse/low-use		1.9 (0.9-3.5)				
	Chronic vs nonuse/low-use		4.4 (2.5-7.6)***				
	Maturing-out vs nonuse/low-use	Low marital harmony	2.8 (1.6-5.0)***				
	Late-onset vs nonuse/low-use		1.3 (0.7-2.6)				

Authors, year (n and Country)	Cannabis variable	Outcome	OR (95% CI) or other± with minimal controls	OR (95% CI) or other± controlling for confounders	Nature of association tested	Follow-up	Covariates entered in to 1st step of analyses (controls) and 2nd step of analyses (confounders)
	Chronic vs nonuse/low-use		1.8 (0.9-3.3)				
	Maturing-out vs nonuse/low-use	Low satisfaction with partner	2.5 (1.4-5.4)**				
	Late-onset vs nonuse/low-use		2.2 (1.2-3.9)**				
	Chronic vs nonuse/low-use		1.7 (0.9-3.3)				
Green et al., 2017 (n=633; US)	Heavy adolescent CU (20+ times by 16y) vs others	Unmarried by 42y		1.79 (1.01-3.17)*	Longitudinal	26y	Controlling for confounders: Sociodemographics, family history of substance use, family history of mental health problems and inadaptation, family structure and functioning, academic expectations and/or achievement, cognitive performance, personality, externalizing problems >13y, alcohol use, cigarette use.
Stormshak et al., 2019 (n=593; US)	CUFr trajectory from 12 to 15y:				Longitudinal	8y	
	Normative vs no use	Relation quality with parents	n.s. (*M* = .05 vs -.01)				Minimal controls: none.
	High risk vs no use		n.s. (*M* = -.08 vs -.01)				

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	High risk vs normative		significantly lower (*M* = -.08 vs .05)				
	CU initiation between 15 and 20y	Relation quality with parents		β = -.27***			Controlling for confounders: Sociodemographics, alcohol use.
5. Family violence							
Boden et al., 2020 (n=1065; New Zealand)	CUFr trajectories from 15-35y:	Intimate partner violence 35y			Longitudinal	20y	Minimal controls: none. Controlling for confounders: Sociodemographics, family history of substance use, family history of mental health problems and inadaptation, family structure and functioning, child sexual or physical abuse, academic expectations and/or achievement, cognitive performance, externalizing problems <13y and >13y, personality, mental health and inadaptation, substance use and delinquency in peers, cigarette use.
	Adult-onset (>18y) regular vs non-users		2.6 (1.1, 5.8)*	1.6 (0.6, 4.1)			
	Early onset, Adult desisting vs non-users		5.2 (2.8, 9.6)***	3.4 (1.6, 7.2)**			
	Early-onset chronic vs non-users		3.9 (1.8, 8.5)**	1.8 (0.7, 4.3)			
Martino et al., 2005 (n=509; US)	Past month cannabis use 23y	Intimate partner violence			Longitudinal	6y	Minimal controls: none.
		Perpetrator 29y	B=0.59 (0.22)**	n.s.			

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		Victim 29y	B=0.64 (0.21)**	n.s.			Controlling for confounders: Sociodemographics, alcohol use, other drug use, previous violence.
		Perpetrator 23y	B=0.72 (0.23)**	n.s.			
		Victim 23y	B=0.60 (0.24)**	n.s.			
Melander et al., 2010 (n= 6563; US)	Past-month cannabis use 16y	Intimate partner violence 23y			Prospective	7y	Minimal controls: none.
		Perpetration only vs no violence	0.92 (0.55-1.55)				
		Bidirectional vs no violence	1.28 (0.89-1.85)				
		Victimization only vs no violence	0.85 (0.48-1.51)				
		Bidirectional vs perpetration only	1.39 (0.81-2.41)				
		Bidirectional vs victimization only	1.51 (0.82-2.81)				
Reingle et al., 2012 (n= 9421; US)	CU trajectories 15y-21y	Intimate partner violence at 26y			Longitudinal	11y	Minimal controls: none.
	Desisted vs. no use	Victim only	0.99 (0.78, 1.24)	1.10 (0.80, 1.52)			Controlling for confounders: Sociodemographics, substance use and delinquency in peers, family history of
	Initiated vs. no use		1.14 (0.86, 1.50)	1.99 (0.78, 1.26)			

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	Consistent vs. no use		1.28 (0.98, 1.69)	1.24 (0.89, 1.73)			substance use, family structure and functioning, mental health and inadaptation, alcohol use.
	Desisted vs. no use	Perpretator only	1.27 (0.93, 1.75)	1.33 (0.83, 2.14)			
	Initiated vs. no use		1.28 (0.80, 2.06)	1.40 (0.95, 2.05)			
	Consistent vs. no use		1.84 (1.18, 2.86)**	1.85 (1.04, 3.28)*			
	Desisted vs. no use	Victim and perpretator	1.27 (1.05, 1.54)*	1.37 (0.96, 1.96)			
	Initiated vs. no use		1.54 (1.12, 2.11)**	1.39 (1.12, 1.73) **			
	Consistent vs. no use		2.36 (1.89, 2.94)***	2.08 (1.53, 2.85)***			

Note: CUAO: Cannabis Use age of onset or Early onset (<16y); CUFr: Canabis Use Frequency; CUD: Cannabis use disorder diagnosis or symptoms. *p<.05. **p<.01. ***p<.001. ±If not OR and 95%CI, other coefficient or comparison stated within table: B=Unstandardized beta, β = Standardized beta (with values in parenthesis representing standard errors or CIs); r = correlation; OR= Odds Ratios; RR=Relative Risk Ratio; M= Mean; y = year(s); n.s. = non-significant (entered when no p value is provided in the study). Guidelines for the interpretation of effect sizes vary, but based on Ferguson 2009, coefficients can be interpreted as follows: RR or OR<2.00 trivial, RR or OR=2.0-2.9 small, RR or OR=3.0-3.9 moderate and RR or OR≥4.0 large; Mean differences: .41= small, 1.15= moderate and 2.70= large; r and β: .2=small, .5=moderate, and .8=large.