

Youth marijuana use: a review of causes and consequences

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The legalization of medical and recreational marijuana has raised concerns about a potential increase in the availability and illegal use of marijuana by adolescent minors. To better understand the etiology, patterns, and consequences of adolescent marijuana use, this article reviews high quality, methodologically rigorous, longitudinal studies that focus on the role of personality factors such as sensation-seeking in the etiology of use, developmental trajectories of use and the effects of chronic use, potential gateway effects of marijuana on other illicit drugs, and its role in the onset of psychiatric disorders in adolescents and young adults. Implications are discussed in terms of mechanisms that account for initial and continued use of marijuana by adolescents, how use is associated with key developmental milestones and adult role socialization, and the potential of marijuana use during adolescence in furthering later drug involvement.

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Introduction

With medical and recreational marijuana use becoming more widespread, a concern has been whether increased availability of marijuana may have unintended consequences for young people who use marijuana before they become adults. To better understand the etiology, patterns, and consequences of adolescent marijuana use, this article reviews the scientific literature examining causes, trends, and consequences of youth marijuana use. Much of this research examines etiologic factors for adolescent marijuana use, including parent-child relations (i.e. attachment), parenting (i.e. discipline and monitoring) and the home environment (i.e. marital strife), peer social influences, and personality factors that contribute to use. We also review the large literature on patterns and

trajectories of youth marijuana use. Finally, we highlight key studies on the physical and mental health [1[•],2] consequences of marijuana use, including whether prolonged or excessive use interferes with psychosocial adjustment and disrupts adult role socialization. A careful review of the literature reveals that prominent areas of concern have included effects of chronic use on neuropsychological functioning (i.e. cognitive impairment), whether marijuana is a gateway drug and leads to other substance use, its contribution to psychiatric problems and also substance use disorders. In this paper we briefly review these different literatures with a special emphasis on evidence obtained from naturalistic longitudinal studies that monitor development over time.

Marijuana is quite popular worldwide and remains the most commonly used illicit drug by US youth. The latest annual US national surveillance data shows that 44% of high school seniors have used marijuana in their lifetime, more than one in three seniors used marijuana in the past year, and more than one in five used marijuana in the past 30 days [3[•]]. This proliferation in consumption is matched by the highest levels yet of past 30-day daily use (1.3%, 4.8% and 6.4% among 8th, 10th, and 12th grade youth, respectively); a trend paralleled by continued annual declines in perceived risks associated with use. There is also concern that many youths replace nicotine with marijuana (THC or hash oil) in battery-powered vaporizers [4,5], a pattern that has been noted with increasing frequency in both regional [6] and national surveys of youth vaping preferences [3[•],7].

Etiology of adolescent marijuana use

The linkages between personality and marijuana use has historical precedent stemming from the return of soldiers from Vietnam and a nationwide surge in activism and protest activity during the 1960s. The changing political climate and movement toward anti-establishment norms fostered interest in the role of alienation (i.e. sense of isolation), social criticism (i.e. anti-establishment sentiments), and tolerance for deviance as personality factors that interact to socialize problem behaviors [8[•]]. A consistent finding was that rebellious youth who decried conventional norms (i.e. church attendance), evidenced little academic motivation (i.e. poor grades) and who valued their independence (i.e. autonomy) were more likely to use marijuana [9]. This early work was then reinforced by a number of longitudinal studies examining factors contributing to marijuana use during adolescence including, in particular emphasizing the predictive role of personality when controlling for parenting, parent-child relations, and peer social influences [10–12].

The now classic Rocky Mountain longitudinal study implicated unconventional behavior and disaffection with society as contributors to problem behaviors [9,13] including among other deviant behaviors marijuana use [14]. Problem behavior theory suggests that poor motivation to comply with social regulation, low academic orientation, along with social criticism and alienation make youth deviance prone. Continued dissatisfaction with conventional institutions and poor performance in school encourages disaffected youth to violate social norms, act against authority, and adopt socially intolerant behaviors including smoking marijuana. The view that adolescents are immature, ‘fun-seeking’ rebellious creatures by nature encouraged researchers to focus on sensation seeking as one of several facets of personality contributing to marijuana use [15]. High sensation-seeking youth act more impulsively, take risks, lack behavioral control, and seek novelty in their environments [16]. As a result, these youth are more susceptible to acting on a whim, being adventuresome, thrill seeking, and engaging in dangerous behaviors with little forethought including using drugs like marijuana.

There is now considerable evidence linking sensation seeking and also trait impulsivity (acting rashly without reflection or deliberation) as precursors to adolescent marijuana use. This includes cross-sectional studies involving nationally representative data [17], general population studies prospectively tracking youth over time [18,19], laboratory behavioral assessments [20], case-control comparisons of users and non-users [21], at-risk groups [22], substance-use-naïve youth followed longitudinally [23] and genetically informed twin studies [24]. Two additional facets of sensation seeking, neurobehavioral disinhibition and behavioral undercontrol, have been implicated in marijuana use as risk phenotypes with neural underpinnings [25*,26,27]. Neural systems that regulate behaviors underlying disinhibition are tied to effortful control and incentive reactivity both responsive to novelty and reward motivational cues. Failure to invoke top down regulatory systems at the neural circuitry level weakens cognitive control functions making youth overly responsive to immediate reward cues (i.e. spontaneity) and cognitively aroused attending more to salient physiological cues and affective tone (i.e. emotional states). This diverts their attention from executive cognitive functions (i.e. response inhibition, strategic planning, and problem-solving) that would promote concerted decision-making skills, including, for instance, a consideration of potential future consequences of using marijuana [25*].

Developmental trajectories of adolescent marijuana use

Numerous longitudinal studies using person-centered strategies have identified discrete trajectories of marijuana use [28–31,32**]. Although the number and

composition of trajectory subgroups may vary from study to study, one consistent finding heralds a prototypical ‘chronic or persistent’ marijuana user group (usually encompassing only 5–10% of the total sample but with some noted exceptions [33,34]). Chronic users are characterized by early onset and continued increasing marijuana use across the lifespan. They have a greater preponderance of adverse outcomes including more criminal activity, stressful life events, drug-using friends, interpersonal problems (i.e. arguments with partner), lowered life satisfaction and work achievement, more depression, anxiety, school-related problems (i.e. lower grades, poorer academic performance, higher odds of dropping out of school, and lower educational attainment post-secondary) [35,36*], greater sexual risk behaviors, externalizing disorders, and prevalence of substance use disorders (SUDs) [31,32**,37**,38,39] including nicotine and alcohol dependence/abuse [30], compared to non-use or low use trajectory groups. Other notable problems include greater occupational stress and financial strain [40] and difficulty navigating psychosocial adjustment, the latter including failure to adopt adult roles such as marriage, pregnancy and parenting [33,34,41–44].

Consequences of adolescent marijuana use

Confusion over whether marijuana has long-term consequences has promoted considerable debate and led to a changing political landscape with regard to its legalization. In all but 11 US states marijuana remains a federally classified Schedule I substance under the Controlled Substance Act owing to its high potential for abuse [45,46**]. Notwithstanding, 33 states have responded to the popular ground swell urging legalization of marijuana based on its therapeutic potential including treating chronic pain [47,48], psychiatric conditions [49,50], and mitigating nausea and vomiting in patients undergoing chemotherapy [51] where conventional treatments may not work. The flowering tops of the *cannabis sativa* plant contain oils and resin that produce the psychoactive compound Δ^9 -tetrahydrocannabinol (THC). The effects of inhaling combustible marijuana joints (or using a hookah) are reported to produce a calming and relaxing sensation. Many users point to reduced inhibitions, the pleasant feeling of being ‘high,’ and a sense of euphoria that can be obtained with social recreational use [52–54]. The drug’s pharmacology and binding properties with endocannabinoid brain receptors (THC is a CB₁ agonist) has been well documented [55,56].

Marijuana and the gateway hypothesis

The gateway hypothesis suggests that drug use involvement proceeds in an invariant sequence beginning first with alcohol or cigarettes then involving marijuana followed by pills, psychedelics, cocaine and heroin, albeit not in a causal manner [57*]. The premise is built around interviews conducted with drug users asking them to recollect the various stages of drug use that characterized

their involvement [58,59]. Individuals whom reported use of cocaine, pills (amphetamines and tranquilizers) and heroin, had invariably commenced their drug use with alcohol or cigarettes before progressing to marijuana. Evidence supporting the progression model comes primarily from two sources, longitudinal studies monitoring development over time and behavior genetic twin studies. In both cases, investigators included statistical controls for theoretically relevant factors that could also account for progression. For the most part these included peer social influences, personality (i.e. risk-taking and nonconformist values), age of onset, family (i.e. poverty and marital conflict) and neighborhood contextual factors (i.e. illicit drug trafficking) that might independently account for developmental progression.

Even with controls for confounding, there is conflicting evidence with some studies asserting that marijuana consistently precedes use of other drugs [60,61], while other studies provide limited evidence to support this hypothesis [62]. In some cases, effects fade with inclusion of statistical controls for 'life course' measures and in other cases alternative sequences underscore the lack of temporal precedence from marijuana to other illicit drugs [63–66]. Studies providing evidence of progression hinge on a dose-response relationship conveying the influence of age of onset and regularity of marijuana use [67]. Also, selective recruitment is an important consideration as marijuana users differ from non-users or users of other drugs like alcohol and cigarettes in key ways that could make them more vulnerable to progression.

Genetically informed studies can shed some light on the progression argument by examining twins who vary in the age of onset to marijuana (<17 versus older). This discordant twin design teases apart the contribution of the shared environment from genetic liability as both twins are raised in the same home subject to a consistent set of child-rearing practice and a similar home context. Differences in behavior that are not attributed to the home environment thus reflect either nonshared characteristics of the individual (i.e. sensation seeking) or genetic liability, the latter which is stronger in monozygotic compared to dizygotic twins. Rejection of both shared environment and genetics as explanations would then attribute developmental progression to perhaps pharmacological sensitization by marijuana that triggers further drug involvement. A study of Australian [68] adolescent male twins showed that the twin commencing marijuana use before age 17 showed much higher odds of progressing to other drug use (2.3–5.2 higher), alcohol dependence (1.85), and drug abuse/dependence (1.98) compared to the twin with a later onset (adjusted for known risk factors). A similar study of Dutch [69] twins showed that for the marijuana-using twin unadjusted odds ranged from 6.8 for recreational party drug use to 14 for hard drug use, but became nonsignificant when models were adjusted for control

factors (i.e. age of onset, tobacco, alcohol use, aggressive and rule breaking behavior). A third general population study that culled discordant adolescent twin pairs (monozygotic and dizygotic and sibling pairs) showed that the marijuana using twin was 83% more likely to use hard drugs as a young adult than the non-using twin [70]. One other twin study used the magnitude of within-pair differences rather than discordant age of onset to predict within-pair hard drug use differences in same-sex twin pairs. The authors concluded that marijuana's role in drug escalation is more than likely genetically influenced rather than reflecting other spurious sources of influence. This is because the gateway effect held for dizygotic but not monozygotic twins [71].

Marijuana use and the risk of psychiatric disorders

Considerable evidence implicates marijuana use in the development of psychiatric disorders. The strength of this evidence is based on both epidemiological [72] and population-based longitudinal studies that link age of onset and chronic use with a wide range of mental health problems. With few exceptions [73,74], systematic reviews [75–79,80*] and meta-analyses point toward marijuana use as contributing to depression [81,82,83*,84], psychotic disorders [85–88], and in some cases even suicidal behavior [89–92] independent of confounding. Compiled across studies, odds ratios for psychotic disorders ranged from 1.17 for comparing users to non-users to 1.67 comparing heavy to light users. This increases to 2.58 using pooled data in meta-analysis [78]. A consistent finding across studies is a dose-response effect with more pronounced adverse outcomes at higher levels of consumption [76–79,80*,81,82].

Birth cohort studies that track youth longitudinally from before marijuana onset also reinforce that early onset and chronic marijuana use is associated with greater risk of psychiatric disorders [73,88]. In the Dunedin birth cohort study, weekly marijuana use, by age 15, quadrupled the odds of schizophreniform diagnosis at age 26 [93]; however, this effect was no longer significant when the model was adjusted for childhood psychotic symptoms. Marijuana was also implicated as a risk factor for externalizing disorders [83*] from age 18–21 but for males only (OR = 1.56). Other cohort studies also show that daily marijuana use is a risk factor for psychosis [89], marijuana dependence in late adolescence is a risk factor for psychotic symptoms (OR = 2.3) at age 21 [86], daily marijuana use assessed at age 14–15 increases the risk for depression and anxiety seven years later (OR = 5.6) and weekly marijuana use increases the risk almost twofold for the same outcomes (OR = 1.9) compared to non-users; however, this latter finding was for females only [84]. In all of these studies, individuals were tracked from before marijuana onset and models controlled for prodromal symptoms at baseline, family factors (household climate and socioeconomic disadvantage), and behaviors (smoking and alcohol

use) at earlier ages that may also predispose individuals to heavy marijuana use as well as mental health problems. Interestingly, a US birth cohort study found no evidence of a causal relationship between adolescent (< age 17) onset of marijuana problems (dependence or abuse) and having a depressive episode (age 19–24) in the past year using propensity score adjusted models to control covariate differences [94].

Conclusions

A consistent body of evidence suggests that early initiation and sustained chronic use of marijuana conveys numerous deficits including impaired well-being, negative health effects, impairment to cognitive functioning, and increased risk of psychiatric problems. For the most part, these findings hold up even with the addition of important control measures capturing different facets of interpersonal and intrapersonal functioning. Importantly, studies using a longitudinal developmental perspective, and tracking youth from adolescent to emerging adulthood, consistently find deficits in various forms of psychosocial functioning, fostering problems in psychosocial adjustment that can be tied to earlier and continued use of marijuana. These deficits arise from failure to navigate certain developmental tasks considered essential to adult role socialization [95]. Included are finishing school, establishing a sense of identity, finding a career vocation, and forming intimate bonds that are a prelude to marriage and parenting [34,41,96**]. The fact that a large body of this work used general population samples suggests that, when maintained for prolonged periods of time, social recreational marijuana use, if left unabated, conveys debilitating effects across the lifespan.

The bulk of the evidence seems to suggest that adolescence represents a critical period of development during which time neuromaturation reaches new heights particularly in brain regions (i.e. prefrontal networks) that control decision-making and inhibitory control [97]. Harm to these brain structures from excessive marijuana (or other drug) use, specifically disruption of neuromaturation [98*], can hinder development of important higher cognitive functions that facilitate the transition to adult thinking [99]. Of concern is the current potency of marijuana and the new strains being cultivated along with new route of administration (i.e. vaping) and how these changes affect functioning. This brings to mind the possibility that extant knowledge regarding health effects may be dominated by historical uses of marijuana. A new wave of mental, physical, and social complications may arise from both exposure through legalization and the deleterious pharmacological effects associated with more potent marijuana.

Even given the considerable weight of evidence suggesting adverse effects, there are several methodological concerns that should be considered. For instance,

methodological variation between studies can hinder determining whether marijuana is the main contributor to deficits. Regardless of focus, sample sizes varied considerably between studies, as well as did the time frame studied, the length of time used to track individuals, and recruitment strategies. Moreover, studies varied considerably in what confounders were statistically controlled, and in many cases, there was tremendous variation in the operational definition used to gauge ‘heavy’ consumption.

Similar concerns surface with regard to the role of marijuana elevating risk for psychiatric illness. Discussion revolves around confounder control, diagnostic heterogeneity, concerns over reverse causation and the observation that marijuana use and psychological problems can share causal etiological pathways. In this respect, prospective longitudinal studies help to disentangle the contribution of premorbid conditions that may also predispose youth to later mental health problems independent of early marijuana use [100]. In addressing the proverbial chicken versus the egg conundrum, there is the potential that youth susceptible to mental health disorders are more likely to use marijuana to mask symptoms of psychiatric illness [101]. Such a self-medication view reinforces that some individuals may be predisposed to marijuana use as a means of regulating mood [102,103*]. This is consistent with studies that find high rates of cannabis use disorders in children with a history of conduct disorders and likewise among youth with internalizing disorders (i.e. anxiety and depression) who encounter a wide range of biological, personality, and contextual factors that may contribute to both their marijuana use and mental health problems [100,81].

Not discussed at length in this review are the plausible etiological mechanisms that instigate initial involvement and maintain continued use across the lifespan. The ‘amotivational syndrome,’ [104,105] has been suggested as a broad catchall to capture the lack of initiative, apathy, and motivational deficits that characterizes disaffected youth [106]. Early onset users that continue their drug involvement pull away from the social bonds that would normally allow them to introject conventional values, adopting instead nonconformist behaviors that put them at odds with prosocial role models. This is a mainstay of social control theory, suggesting the importance adopting mainstream conformist attitudes [107,108]. In essence, conventional institutions are socializing agents, encouraging youth to refrain from norms transgression and rules violation as these activities are incommensurate with assuming adult work and family roles [109].

Social interactional continuity [110] suggests that differential association guides marijuana-using youth to socially engage with like-minded peers who also use drugs, feel alienated and engage in social criticism [111]. Once their behaviors become deeply enmeshed into deviant social-

interactional pathways, it is hard to shift into new behavior patterns without reorganization of the self. Still, the processes that link early involvement with later outcomes needs to be further explored using both methodological designs and statistical approaches capable of modeling developmental phenomenon. There is myriad of ways for youth to engage in drug-using behavior as part of identity exploration, numerous factors that can amplify their use, and multiple ways they can mature out as they transition to adulthood [112,113].

Conflict of interest statement

Nothing declared.

CRedit authorship contribution statement

Lawrence M Scheier: Conceptualization, Methodology, Writing - original draft, Visualization, Supervision. **Kenneth W Griffin:** Investigation, Writing - review & editing.

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