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Cannabis Use in Adolescents

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Abstract

As cannabis legalization expands across the United States, its use among adolescents remains a pressing public health concern. This analytic essay analyzes the current prevalence, patterns, and consequences of cannabis use in adolescents. While legalization has not substantially increased adolescent use, it has contributed to normalization and greater access, ultimately lowering perceived risk and complicating prevention efforts. Increasing product potency and diversified consumption methods (e.g., vaping, dabbing, edibles) add to these challenges. Adolescent cannabis use is associated with adverse outcomes in brain development, mental health, and physical health including its effects on the gastrointestinal, cardiovascular, respiratory and endocrine systems of body. Cannabis Use Disorder (CUD) is underdiagnosed and undertreated in youth, with no FDA-approved pharmacological treatments. Psychosocial interventions such as contingency management and cognitive behavioral therapy (CBT) show modest efficacy, particularly when involving families. This paper highlights the urgent need for targeted education, policy measures, and accessible evidence-based interventions specifically tailored to adolescent populations to address the evolving challenges of cannabis use and its long-term consequences.

Current State and Prevalence

Cannabis ranks as the most frequently used illicit drug and the third most common psychoactive substance, following alcohol and nicotine among adolescents.[1] As of 2024, cannabis use among middle and high school students in the United States remained at historically low levels compared to the previous three decades, with a significant decline during the period of the COVID-19 pandemic. According to the Monitoring the Future 2025 (MTF) report, despite the reduction, prevalence remains notable, with 26% of 12th graders, 16% of 10th graders, and 7% of 8th graders reporting marijuana use in the past year. Daily use (defined as use on 20 or more days in the past month) also remained low, particularly among younger students, with just 0.7% of 8th graders and 5.1% of 12th graders reporting such frequent use.[2] Notably, a higher prevalence of cannabis use has been observed among adolescents identifying as LGBTQ+ (30.9%), mixed race (27.1%), and Native Hawaiian or Pacific Islander (23.1%), and smoking cannabis was the most common method of consumption. Evidence indicates that coping-related motivations for cannabis use have become more prevalent among adolescents, with over half (53%) reporting its use to relax. Girls were more likely than boys to endorse coping reasons, and Black and Hispanic adolescents reported such motivations at higher rates than their White peers.[3]

Similarly, cannabis vaping, which had been increasing in previous years, has stabilized, with approximately 17.6% of 12th graders reporting past-year use.[2] The MTF 2025 report also highlighted the emergence of Delta-8 Tetrahydrocannabinol (THC), also known as “marijuana light” due to its intoxicating effects. Unlike adolescents, cannabis use has continued to rise among young adults aged 19–30, reaching record-high levels for both smoking and vaping cannabis.[2] According to a report from the Substance Abuse and Mental Health Services

Administration (SAMHSA), 10% of individuals who use marijuana develop a dependence, and this risk increases significantly for those who begin using marijuana before the age of 18, with approximately 16-17% becoming addicted.[4]

Cannabis is derived from the dried parts of the *Cannabis sativa* or *Cannabis indica* plant, including its leaves, flowers, stems, and seeds. While "cannabis" refers to the plant material itself, "cannabinoids" include both naturally occurring and synthetic compounds that interact with the body's endocannabinoid system. In recent years, the growing legalization of cannabis for medical use and the commercialization of recreational use have expanded access and led to a wider variety of available products.[5] These modern cannabis products, whether natural or synthetic, often contain much higher concentrations of THC than in the past, with average potency rising from about 1%–4% in the mid-20th century to over 19% today. This increase in potency has raised concerns about adverse health effects, especially among frequent or inexperienced users. New methods of consumption, such as vaping high-potency concentrates like wax and shatter or ingesting edibles, have further elevated these risks.[5–7] However, cannabis and cannabinoids also offer important therapeutic benefits. The FDA has approved specific cannabinoids for medical use; including, dronabinol and nabilone for chemotherapy-induced nausea and vomiting in 1985, dronabinol for appetite stimulation in wasting conditions such as HIV in 1992, and cannabidiol for treating seizures associated with Dravet syndrome and Lennox-Gastaut syndrome in 2018, as well as other seizure disorders in 2020.[5]

Legalization and Its Impact on Adolescent Cannabis Use

Policy Landscape

Despite cannabis's continued classification as a Schedule I drug under federal law, U.S. cannabis policies have undergone a significant shift from prohibition to broader acceptance over the last two decades. As of February 2025, 39 states and the District of Columbia have allowed the medical use of cannabis products. Additionally, 24 states, 3 territories, and the District of Columbia allow or regulate recreational use of cannabis for individuals aged 21 and older.[8–10] With cannabis legalization, potential benefits, such as reduced incarceration for drug-related offenses, reduced opioid-related harms in those with chronic pain, decreased racial disparities in law enforcement, and increased tax revenue generation, have been observed.[5,11,12]

Regulatory Challenges

Different states have implemented various safeguards to mitigate the exposure and use of cannabis in adolescents. For example, in the state of Colorado, cannabis regulations include strict advertising restrictions, prohibiting outdoor signage within 500 feet of schools, places of worship, and playgrounds. The use and possession of cannabis is banned on all school properties statewide. Local jurisdictions retain the authority to ban or limit retail cannabis businesses. Direct advertising to minors is prohibited, and media advertising via TV, radio, print, and the internet is permitted only when less than 30% of the audience is under 21 years old. Individuals under 21 are also not allowed inside dispensaries. Despite these safeguards, youth remain exposed to cannabis through adult normalization, media coverage, dispensary visibility near high-traffic venues like sports arenas, and a strong presence on social media.[8]Youth under 20 are required to be diagnosed with severe medical conditions by two independent physicians to qualify for the use of medical cannabis. Those with CUD are more likely to seek access,

especially in states without legal recreational use. Youth with chronic illnesses, such as inflammatory bowel disease or chronic pain, often use cannabis for symptom relief, primarily pain. However, many also met the criteria for CUD, highlighting the overlap between therapeutic use and misuse risk.[5,8,10]

Shifting Public Opinion

Public opinion has shifted markedly toward acceptance of cannabis use, influencing policy changes.[8] According to MTF 2025, the perceived risk of regular cannabis use among 12th graders has declined significantly from 58% in 2000 to 36% in 2024.[2] Despite this, evidence suggests that medical cannabis laws (MCLs) have had little to no effect on adolescent use overall. In contrast, cannabis use in adults has significantly risen. The effects on other substances such as alcohol, opioids, and tobacco vary, with some evidence that MCLs may reduce opioid-related harms, but inconclusive effects on alcohol and tobacco use. The impact of cannabis legalization on CUD is mixed; however, more permissive laws, such as those allowing dispensaries, are associated with higher rates of CUD among adults.

Research on recreational cannabis laws (RCLs) is still emerging, but early findings indicate minimal changes in adolescent use, though some increase may occur among college students.[8,11,12] A national study of 149,383 adolescents aged 12–17, examining recreational marijuana law enactment between 2012 and 2015, found no significant increase in marijuana use or frequent use among adolescents, suggesting that legalization primarily increases cannabis use among adults who gain legal access. Notably, the study observed a small increase in CUD among adolescents who were already using marijuana, highlighting greater vulnerability among youth with psychiatric or familial risk factors and those exposed to more potent cannabis products after legalization.[11] Overall, the public health impact of cannabis legalization is complex and depends heavily on how specific laws are designed and implemented.[10]

Shifting cannabis policies have also contributed to lowered risk perception among vulnerable populations like pregnant women.[13,14] A systematic review found that cannabis legalization was associated with increased maternal cannabis use during pregnancy and postpartum, as well as greater parental use and approval of adult cannabis use.[15] The review noted an increase in unintentional pediatric cannabis exposures post-legalization, which has led to higher rates of emergency department visits and critical care admissions compared to other types of poisonings. The American Academy of Pediatrics (AAP) cautioned against adult cannabis use in the presence of minors; evidence remained inadequate to establish a causal relationship between legalization, parenting behavior, and child outcomes. Authors also emphasized that the impact of legalization might vary based on individual factors, such as genetic vulnerability to substance use, indicating that higher-risk families could be disproportionately affected.[5,15] Similarly, legalization of cannabis has been linked to higher rates of positive urine drug screens (16.2% vs 20.2%; OR, 1.3 (1.0-1.7); $p<.048$) in young women aged 12-22 years old which could have a detrimental impact on the prenatal development of babies.[16,17]

Potency Trends

Since legalization, cannabis products have become significantly more potent. This trend directly contradicts Cowan's "Iron Law of Prohibition," which predicted that tougher enforcement would increase potency while legalization would lower it. Instead, lower enforcement risks have

spurred innovation in extraction methods and expanded access to materials for producing high-THC products.[18]

Legal cannabis flower typically contains 20–25% THC, nearly double the THC concentration found in black-market flower before legalization. Even more concerning are cannabis concentrates like wax, shatter, and oils, which often range from 80–90% THC, making them about four times stronger than legal flower and more than seven times stronger than black-market flower.[18–20] Some state-level monitoring has found concentrates with THC levels as high as 95%.[20] Legalization and commercialization have increased the availability and diversity of these products, but research has not kept pace with their rapid evolution.[20]

The increase in THC levels raises public health concerns, particularly as new consumption methods like edibles, vaping, and dabbing now allow users to consume even higher doses of THC. A study done in 2019 in Colorado showed that about 24% of adolescents reported lifetime use of concentrate, which accounts for 72% of all adolescent cannabis users. Among these, 35.6% consumed edibles, 34.4% used dabbing, and 20.3% used vaping. With commercialization fueling rapid market growth, concentrate sales in Colorado increased by 480% between 2014 and 2017. Their market share nearly doubled from 17% to 32%.[20]

Traffic Safety

The impact of cannabis policies on traffic accidents has shown mixed results. In the first three states to legalize recreational cannabis, there was a combined 5.2% increase in police-reported traffic crashes and a 6% rise in auto insurance collision claims compared to neighboring states where cannabis remains illegal. Between 2012 and 2017, the number of drivers involved in fatal crashes who tested positive for THC more than doubled in Washington State. It was unclear whether cannabis impairment caused these accidents. In contrast, Colorado experienced a decline in cannabis-impaired traffic fatalities, dropping from 12% in 2016 to 8% in 2017.[21–23]

Cannabis Use Disorder

The Diagnostic and Statistical Manual (DSM) of Mental Health Disorders, fifth edition, defines criteria for CUD as cannabis use with at least 2 or more of 11 specific symptoms within a 12-month period, encompassing four main categories:

1. Impaired control such as using larger amounts or longer than intended, unsuccessful efforts to cut down and spending excessive time related to use, and cravings
2. Social impairments such as failure to fulfill major roles, continued use despite interpersonal problems, and giving up important activities.
3. Risky use including the use of cannabis in physically hazardous situations and continuing use despite known physical or psychological problems
4. Pharmacological criteria for tolerance and withdrawal symptoms.

The disorder's severity is specified as mild (2–3 symptoms), moderate (4–5), or severe (6 or more).[24]

Regular cannabis use before age 17 is linked to an increased risk of developing CUD in young adulthood.[20] A significant risk factor for developing CUD is early age of initiation, particularly

before age 16. This is likely related to the fact that the brain, including the endocannabinoid system, is actively developing during adolescence and is more vulnerable to environmental exposures at this time.[13] Other risk factors include high frequency of use, male gender, and concurrent tobacco or alcohol use.[8]

Although males are more frequently diagnosed with CUD, when the frequency of cannabis use is controlled, the rates of CUD are similar between both sexes. Females may develop CUD more rapidly (a phenomenon known as "telescoping"), experiencing more intense withdrawal symptoms, and showing higher rates of comorbid anxiety or mood disorders. The gender gap is narrowing, potentially due to the increased use and use of higher-potency products among females.[20]

Cannabis Withdrawal Syndrome

Cannabis Withdrawal Syndrome (CWS) particularly affects heavy and regular cannabis users. Symptoms typically begin within 24 hours of cessation, peak during the first week, and may last up to a month.[19] To meet DSM-5 criteria, individuals must exhibit at least three of seven symptoms, developing within seven days of stopping or significantly reducing use. These symptoms include irritability, anger or aggression; nervousness or anxiety; sleep difficulties such as insomnia or vivid dreams; decreased appetite or weight loss; restlessness; depressed mood; and at least one physical symptom causing discomfort (e.g., headaches, sweating, nausea, vomiting, or abdominal pain).[25]

Studies estimate that approximately 47% of regular or dependent cannabis users experience withdrawal symptoms, with higher prevalence in clinical populations and those with concurrent tobacco or other drug use disorders. The biological basis involves the downregulation of CB1 receptors due to chronic cannabis use, leading to neurotransmitter disruptions during withdrawal. CWS symptoms often overlap with anxiety and depression, which many users attempt to manage by resuming cannabis use, thereby complicating cessation and treatment efforts. Recognizing CWS is crucial because its symptoms interfere with daily functioning and act as negative reinforcers that contribute to relapse and continued cannabis use.[26]

Routes of Consumption

The rise in CUD and cannabis withdrawal reflects broader shifts in how cannabis is consumed, highlighting the need to examine the expanding variety of high-potency cannabis products and routes of administration. Dabbing refers to the practice of vaporizing high-potency cannabis concentrates such as wax or shatter at high temperatures (typically between 400–600°F) using a device called a dab rig. Common cannabis products include dried flower, oils, solid concentrates like hash and shatter, edibles such as gummies or baked goods, and topicals like creams and balms applied to the skin. These products are consumed using a range of devices, including joints, blunts, bongs, vape pens, and dab rigs.[12]

The route of administration and the type of product used have a significant impact on the health effects and psychoactive experience. Smoking and vaping generally produce rapid but short-lived effects, while edibles result in a slower onset with longer-lasting effects. High-potency concentrates, such as those used for dabbing, tend to produce more intense psychoactive effects than lower-potency forms. Although smoking dried cannabis flower remains the most common method of consumption in the United States and Canada, the popularity of other forms, such as

edibles and concentrates, continues to rise, especially in areas where recreational cannabis is legally available.[12]

Electronic cigarettes (e-cigarettes), initially developed for nicotine delivery, are now frequently modified by adolescents to vaporize cannabis products like hash oil, THC-infused wax, and dried buds or leaves. This method of consumption is particularly attractive to youth due to its discreet nature, with a less pungent odor than smoking. A 2014 study conducted in five high schools in Connecticut revealed, through an anonymous survey, that 27.9% of lifetime e-cigarette users and 29.2% of cannabis users reported using e-cigarettes to vape cannabis. Notably, the use of e-cigarettes to vape cannabis was 27 times more common among high school students than among adults, again likely due to its discreet nature. Although these findings are based on self-reported data, and thus may be underestimated, they highlight a concerning trend in adolescent cannabis consumption. Moreover, school-specific factors like cannabis culture and anti-vaping policies may also play a more significant role in influencing cannabis.[26]

Cannabis Use and Brain Development

Adolescents who initiate cannabis use early tend to consume it in greater amounts and with greater frequency than those who begin later in life. Specifically, initiating cannabis use before the age of 16 has been associated with more pronounced short- and long-term detrimental effects on brain development, including higher dependence compared to individuals who begin using cannabis in adulthood.[5,27]

The human endocannabinoid system regulates a variety of physiological processes through endogenous cannabinoids that interact with two primary G-protein-coupled receptors known as Cannabinoid receptors (CB-Rs): CB1 and CB2. CB1 receptors are mainly located in the brain, while CB2 receptors are found on peripheral immune cells and dopaminergic terminals in the striatum. Tetrahydrocannabinol (THC), the psychoactive component of cannabis, acts as a partial agonist at both CB1 and CB2 and is associated with euphoria, psychosis, and motor and cognitive dysfunction, along with therapeutic properties such as analgesia and anti-inflammatory effects. In contrast, cannabidiol (CBD) demonstrates a more complex pharmacology. It antagonizes CB1, negatively modulates CB2, and activates TRPV1 and 5-HT1A receptors, producing therapeutic anxiolytic, antipsychotic, and anti-inflammatory effects. CBD also inhibits GPR55 signaling via modulation of calcium and adenosine signaling, a mechanism linked to antiepileptic and antipsychotic activity.[28–30]

Several studies have implicated both acute and chronic impairments in memory, learning, attention, motor skills, and executive functioning associated with cannabis use. These cognitive effects are believed to result from the direct activation of CB1 receptors, which are in key brain regions such as the prefrontal cortex, globus pallidus, substantia nigra, hippocampus, striatum, and cerebellum leading to poor academic outcomes. These impairments tend to be more pronounced in younger individuals who use cannabis regularly.[31–33] Another longitudinal study of 799 adolescents found a dose-dependent association between cannabis use over five years and neurodevelopmental abnormalities, including accelerated cortical thinning, particularly in the prefrontal regions of the brain.[26] Early exposure to THC during the prenatal and adolescent periods has been associated with impaired neural connectivity in the hippocampus, explaining the link between early and regular cannabis exposure with decreased IQ.[34,35]

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Cannabis Use and Psychiatric Comorbidities

Psychosis

Adolescent cannabis use has an established association with an increased risk of psychotic disorders, particularly among those with early-onset and heavy use.[36,37] Although acute cannabis-induced psychosis is relatively rare in adolescents, up to 75% of individuals who experience these brief episodes go on to develop chronic psychotic disorders.[38] The risk is highest for those with a pre-existing vulnerability to psychosis, such as those with a family history of schizophrenia, high-potency THC product use, and daily or near-daily cannabis use.[19] Studies have suggested that cannabis use increases the risk of developing a psychotic disorder by approximately 2 to 4-fold.[38,39] Early-onset users also have an increased risk of developing symptoms of psychosis earlier than those who do not use cannabis.[38]

Although the lifetime prevalence of psychosis has remained stable in recent years, cannabis use has increased. This suggests that lifetime prevalence may not be a sensitive enough measure to detect the impact of adolescent cannabis consumption on the development of psychosis. Additionally, because CUD is significantly underdiagnosed, the true overlap between CUD and psychosis may be underestimated.[38]

Internalizing and Externalizing Disorders

The psychological effects of cannabis use, specifically internalizing and externalizing disorders, are highlighted in *Table 1*. A systematic review and meta-analysis of 11 studies involving 23,317 individuals found that adolescent cannabis use was associated with an increased risk of developing depression and suicidal behaviors in later life, even in individuals without preexisting mental health conditions. Furthermore, younger adolescents aged 14-15 were at a significantly higher risk of developing suicidal behaviors. This risk was prominent in girls as compared to boys with an additional impact on academic performance and delinquency.[42] Individuals who were using cannabis before age of 18 experienced markedly reduced odds of high-school completion (adjusted odds ratio AOR = 0.37, 95% CI 0.20–0.66) and lower odds of achieving a university degree (AOR = 0.38, 95% CI 0.22–0.66) when compared to those who had never used cannabis along higher odds of suicide attempt (6·83, 2·04-22·90).[53]

Table 1: Adverse Effects of Cannabis

Body System	Associated Effects
Neurological	Impairment in memory, learning, attention, motor skills, and executive functioning[31–33] Reduced gray matter density[40] Accelerated cortical thinning[41]
Psychiatric	Major Depressive Disorder[39,42] Generalized Anxiety Disorder[42] Attention deficit hyperactivity disorder[43] Psychosis[36–39] Increased suicide risk[39,42]

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	Decreased stress reactivity[44]
Respiratory	Chronic bronchitis[45,46] Cough, wheezing, phlegm production, sore throat[45,46] Lung cancer[47] E-cigarette or Vaping Product Use–Associated Lung Injury[48]
Cardiovascular	Potentially increased risk of cardiovascular disease: Myocardial Infarction, Acute coronary syndrome, arrhythmias[49] Increased Heart Rate, increased Blood Pressure[46]
Gastrointestinal	Cannabis Hyperemesis Syndrome (CHS)[50]
Endocrine	Decreased morning cortisol[44] Increased evening cortisol levels[44]
Sleep	Insomnia Decreased rapid eye movement sleep (REM) sleep Decreased total sleep time Frequent nocturnal awakenings Decreased slow-wave sleep (SWS) [45,51,52]

The overall relationship between depression and cannabis use is still unclear. Some studies suggest cannabis may provide symptom relief for certain individuals with depression, while others indicate it can worsen symptoms by causing emotional blunting and anhedonia. Cannabis use may interact with the brain's reward system, potentially playing a role in the development of Major Depressive Disorder (MDD). This conflicting evidence is especially concerning given the possible link between cannabis use and increased risk of suicidal behaviors in young people, warranting more nuanced research.[39]

CUD is a commonly found comorbidity in individuals with Attention Deficit Hyperactivity Disorder (ADHD), with an estimated prevalence of 33%-38%.[43] Both CUD and ADHD are associated with academic challenges including disruptive behaviors and difficulties with time management, which often result in poor grades.[54] Although less intuitive than other stimulating drugs such as cocaine, cannabis's role in the dopaminergic pathway may be potentially why individuals with ADHD are more prone to use cannabis.[55]

Individuals with childhood ADHD not only tend to initiate cannabis use earlier but may also follow distinct usage trajectories compared to their non-ADHD peers. Whereas adolescents without ADHD who engage in cannabis and alcohol use often show a decline in substance use as they transition into adulthood, individuals with a history of childhood ADHD exhibit sustained

or increasing patterns of use into adulthood.[56] These findings suggest that ADHD may be a risk factor for prolonged or escalating substance use.

Cannabis Use and Physical Health

With the most common method of cannabis consumption being smoking, with vaping gaining more popularity among adolescents, the effects of cannabis use on the respiratory system are of particular interest. Several studies suggest an increased prevalence of respiratory symptoms, even when nicotine use was controlled for, as highlighted in *Table 1*.

Existing literature on asthma is primarily from adult studies and reports a significant association between cannabis use and asthma; for instance, one study found that emerging adult cannabis users had a 1.71-fold increased odds of filling prescriptions for asthma medications, even after adjusting for confounding factors such as body mass index and tobacco use. These findings underscore the need for further investigation, particularly in adolescent populations, to clarify causal relationships and long-term pulmonary outcomes.[45]

Furthermore, there is some evidence linking cannabis use with cancer. A longitudinal study following over 49,00 men in Sweden for 40 years starting in 1969-1970 found that “heavy” cannabis smoking, defined as over 50 uses over a lifetime, was significantly associated with more than a twofold risk of developing lung cancer (hazard ratio 2.12, 95% CI 1.08-4.14) over the 40-year follow-up period, even after statistical adjustment for baseline tobacco use, alcohol use, respiratory conditions, and socioeconomic status.[47]

Low doses of cannabis are antiemetic and have been FDA-approved for chemotherapy-induced nausea, but chronic high doses can paradoxically cause hyperemesis. Cannabis Hyperemesis Syndrome (CHS) is a functional gut-brain disorder marked by episodic nausea and vomiting. Considered a variant of cyclical vomiting syndrome (CVS) in cannabis users, CHS is uniquely associated with compulsive hot bathing or showers for symptom relief and has been linked to heavy cannabis use, with symptoms improving after sustained cessation. First reported in 2004, the incidence of CHS cases has increased in parallel with increasing global cannabis use and legalization.[50]

Notably, in 2019, there was a multistate E-cigarette or Vaping product use-associated Lung Injury (EVALI) outbreak, with a report of approximately 2,506 hospitalized cases reported to the CDC. Of these, over 859 were young adults (18-24) and 360 were adolescents.[48] Approximately 77-80% of these adolescents reported using THC-containing products.[8,48] Common pulmonary symptoms in EVALI include shortness of breath, chest pain, cough, and rarely hemoptysis, with lung images showing ground glass opacities.[57] Many of these cases involved acute lung injuries requiring intensive care/intubation. Adolescents with EVALI more frequently have a history of asthma and mental, emotional, or behavioral disorders, such as ADHD, compared with adults.[48]

Studies have shown adverse cardiac effects stemming from THC, including increased heart rate and moderate increases in blood pressure.[46] While there are several documented case studies in young adults, as documented in *Table 1*, many of which are without prior cardiovascular risk factors,[49] reports are rare in adolescents. One case report documents a 16-year-old who experienced an MI shortly after acutely inhaling cannabis. Extensive toxicology had confirmed the presence of a THC metabolite and ruled out exposure to other substances. One month after the event, an MRI showed a severely dilated left ventricle and moderately to severely depressed

global systolic function, indicating there may be long-term effects of cannabis use on the cardiovascular system.[58]

Studies of the endocrine effects of cannabis use in adolescents are limited. The *Tracking Adolescents' Individual Lives Survey* (TRAILS), a non-clinical cohort study, provided some insight into the relationship between cannabis use and stress reactivity in adolescents. Adolescents with a history of lifetime cannabis use demonstrated reduced physiological stress reactivity compared to non-users, even after adjusting for sociodemographic variables. Additionally, early-onset cannabis users (ages 9–12) exhibited lower morning cortisol levels relative to non-users and those with later-onset use (ages 13–14). Furthermore, adolescents who had used cannabis at least once showed elevated evening cortisol levels compared to never-users. These findings suggest that adolescent cannabis use, especially with early initiation, may dysregulate diurnal cortisol patterns, causing potential disruption of the hypothalamic-pituitary-adrenal (HPA) axis.[44]

Studies on chronic cannabis users have also noted detrimental effects on sleep architecture, as highlighted in *Table 1*. Notably, one study demonstrated a temporal shift in how cannabis use is associated with sleep patterns in adolescents over time. At initial assessment (mean age of 15), cannabis use correlated with weekend oversleeping, whereas at follow-up (mean age of 17), it was associated with reduced weekend sleep duration.[59] Evidence suggests a bidirectional relationship: early sleep disturbances and an evening chronotype may predict future cannabis use, while early cannabis use is linked to later sleep problems such as reduced sleep duration, poor sleep quality, and insomnia.[45]

Treatment of CUD

Cannabis use can lead to impairment, addiction, and other serious consequences, yet treatment rates for CUD remain low. Despite rising use overall, there was no increase in the percent of substance use treatment admission where cannabis was the primary drug between 2003 and 2013. Data from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) shows that only a small proportion of individuals with CUD received cannabis-specific interventions; just 7.2% with current cannabis abuse and 13.7% with lifetime use in NESARC-III (2012–2013).[19]

Despite increasing cannabis use and CUD prevalence, treatment options remain inadequate. To date, no pharmacological treatments have received FDA approval for use in managing CUD in either adolescents or adults. There is also limited success of off-label psychotropic medications particularly in relapse prevention.[60] In several studies, N-acetylcysteine (NAC) has shown promise. A youth-focused randomized controlled trial found that NAC doubled the odds of abstinence when paired with contingency management (CM), but NAC alone (without CM) was not effective in a more recent trial. CM is a robust behavioral approach providing extrinsic motivation, which is important in youth where treatment motivation may be limited or fleeting. This suggests CM may be essential for NAC's efficacy, particularly in adolescents.[61] Miranda and colleagues conducted a randomized controlled trial to test the potential efficacy of topiramate plus motivational enhancement therapy (MET) for treating cannabis use among adolescents. Topiramate was titrated over 4 weeks and continued at 200 mg for 2 weeks. Greater reductions in cannabis use was seen in topiramate groups suggesting it is a promising treatment intervention.[62] Gabapentin, oxytocin and chronic dosing of naltrexone have also similarly shown reductions in CUD or prevention of relapse in small or targeted patient samples but have not yet

shown efficacy in larger samples.[25] Cannabinoid replacement therapies such as nabilone, nabiximols, or dronabinol have not yet proven consistently effective, adding to the challenge of finding reliable pharmacological treatments for CUD.[26]

Current treatments, especially in youth, rely on psychosocial and behavioral interventions. Evidence suggests adolescents benefit most from externally reinforced, family-involved interventions like CM, MET, and CBT compared to other age groups. Brief motivational interviewing and family-based programs significantly improve abstinence outcomes. Emerging evidence also suggests gender may moderate response to treatment. Personalized feedback interventions have reduced cannabis-related problems among women but not men, suggesting sex-specific tailoring may enhance outcomes.[60]

Overall, medications aimed at treating CUD show promise, especially when combined with behavioral interventions. However, as noted above, their success has been limited and currently no FDA-approved medications exist for CUD in adolescents or adults. As seen in tobacco cessation, combining medications with behavioral counseling may offer more effective treatment outcomes.[25]

In contrast, current placebo-controlled trials for CUD suggest that certain medications may help manage withdrawal symptoms. For withdrawal management, mirtazapine and quetiapine show some efficacy for withdrawal symptoms, while zolpidem and benzodiazepines may help with sleep disturbances. Cannabinoid-based treatments like oral THC, nabiximols, and nabilone appear promising for addressing withdrawal globally; however, further research is needed. These medications may reduce discomfort during cessation but are generally insufficient for achieving abstinence or reducing long-term use.[25]

Conclusion

The evolving landscape of cannabis legalization, increasing product potency, and diversified modes of consumption present complex challenges to adolescent health and public policy. In contrast to adults, cannabis legalization has not led to a dramatic increase in adolescent cannabis use. However, it has resulted in greater social acceptance and reduced perceived risk in adolescents. While cannabis offers therapeutic potential for certain medical conditions, there is overwhelming evidence to demonstrate significant health risks associated with its consumption in adolescents. Early and frequent use, particularly with access to high-potency products, has been associated with various adverse outcomes, including detrimental effects on brain development, mental health, and physical health in adolescents. Effective prevention strategies require targeted education, robust policy measures, and continued research into adolescent vulnerability. Likewise, current treatment options for CUD are limited, emphasizing the urgent need for evidence-based interventions specifically tailored to adolescents.

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References

1. Ross, J. A., & Levy, S. (2023, June). The impact of cannabis use on adolescent neurodevelopment and clinical outcomes amidst changing state policies. *Clinical Therapeutics*, *45*(6), 535–540. https://doi.org/10.1016/j.clinthera.2023.03.009 PubMed

2. Miech, R. A., Johnston, L. D., Patrick, M. E., & O'Malley, P. M. (2025). Monitoring the Future national survey results on drug use, 1975–2024: Overview and detailed results for secondary school students. Monitoring the Future Monograph Series. Institute for Social Research, University of Michigan. https://monitoringthefuture.org/results/annual-reports

3. Patrick, M. E., Peterson, S. J., Terry-McElrath, Y. M., Rogan, S. E. B., & Solberg, M. A. (2024, January). Trends in coping reasons for marijuana use among U.S. adolescents from 2016 to 2022. *Addictive Behaviors*, *148*, 107845. https://doi.org/10.1016/j.addbeh.2023.107845 PubMed

4. SAMHSA. (2024, November). Know the effects, risks and side effects of marijuana. https://www.samhsa.gov/marijuana

5. Hill, K. P., Gold, M. S., Nemeroff, C. B., McDonald, W., Grzenda, A., Widge, A. S., . . . Carpenter, L. L. (2022, February). Risks and benefits of cannabis and cannabinoids in psychiatry. *The American Journal of Psychiatry*, *179*(2), 98–109. https://doi.org/10.1176/appi.ajp.2021.21030320 PubMed

6. Chandra, S., Radwan, M. M., Majumdar, C. G., Church, J. C., Freeman, T. P., & ElSohly, M. A. (2019, December). Correction to: New trends in cannabis potency in USA and Europe during the last decade (2008-2017). *European Archives of Psychiatry and Clinical Neuroscience*, *269*(8), 997–997. https://doi.org/10.1007/s00406-019-01020-1 PubMed

7. Hall, W., & Degenhardt, L. (2008). Cannabis use and the risk of developing a psychotic disorder. *World Psychiatry*, *7*(2), 68–71. https://doi.org/10.1002/j.2051-5545.2008.tb00158.x PubMed

8. Hinckley, J., Bhatia, D., Ellingson, J., Molinero, K., & Hopfer, C. (2024, March). The impact of recreational cannabis legalization on youth: the Colorado experience. In *European Child and Adolescent Psychiatry* (Issue 3, pp. 637–650). Springer Science and Business Media Deutschland GmbH.

9. Hoffmann, D. E., & Weber, E. (2010, April 22). Medical marijuana and the law. *The New England Journal of Medicine*, *362*(16), 1453–1457. https://doi.org/10.1056/NEJMp1000695 PubMed

10. Smart, R., & Pacula, R. L. (2019). Early evidence of the impact of cannabis legalization on cannabis use, cannabis use disorder, and the use of other substances: Findings from state policy evaluations. *The American Journal of Drug and Alcohol Abuse*, *45*(6), 644–663. https://doi.org/10.1080/00952990.2019.1669626 PubMed

11. Cerdá, M., Mauro, C., Hamilton, A., Levy, N. S., Santaella-Tenorio, J., Hasin, D., . . . Martins, S. S. (2020, February 1). Association between recreational marijuana legalization in the United States and changes in marijuana use and cannabis use disorder from 2008 to 2016. *JAMA Psychiatry*, *77*(2), 165–171. https://doi.org/10.1001/jamapsychiatry.2019.3254 PubMed

12. Wadsworth, E., Craft, S., Calder, R., & Hammond, D. (2022, June). Prevalence and use of cannabis products and routes of administration among youth and young adults in Canada and the United States: A systematic review. *Addictive Behaviors*, *129*, 107258. https://doi.org/10.1016/j.addbeh.2022.107258 PubMed

13. Volkow, N. D., Baler, R. D., Compton, W. M., & Weiss, S. R. B. (2014, June 5). Adverse health effects of marijuana use. *The New England Journal of Medicine*, *370*(23), 2219–2227. https://doi.org/10.1056/NEJMra1402309 PubMed

14. Volkow, N. D., Han, B., Compton, W. M., & McCance-Katz, E. F. (2019, July 9). Self-reported medical and nonmedical cannabis use among pregnant women in the United States. *JAMA*, *322*(2), 167–169. https://doi.org/10.1001/jama.2019.7982 PubMed

15. Wilson, S., & Rhee, S. H. (2022, March). Causal effects of cannabis legalization on parents, parenting, and children: A systematic review. *Preventive Medicine*, *156*, 106956. https://doi.org/10.1016/j.ypmed.2022.106956 PubMed

16. Gunn, J. K. L., Rosales, C. B., Center, K. E., Nuñez, A., Gibson, S. J., Christ, C., & Ehiri, J. E. (2016, April 5). Prenatal exposure to cannabis and maternal and child health outcomes: A systematic review and meta-analysis. *BMJ Open*, *6*(4), e009986. https://doi.org/10.1136/bmjopen-2015-009986 PubMed

17. Rodriguez, C. E., Sheeder, J., Allshouse, A. A., Scott, S., Wymore, E., Hopfer, C., . . . Metz, T. D. (2019, November). Marijuana use in young mothers and adverse pregnancy outcomes: A retrospective cohort study. *BJOG*, *126*(12), 1491–1497. https://doi.org/10.1111/1471-0528.15885 PubMed

18. Smart, R., Caulkins, J. P., Kilmer, B., Davenport, S., & Midgette, G. (2017, December). Variation in cannabis potency and prices in a newly legal market: Evidence from 30 million cannabis sales in Washington state. *Addiction (Abingdon, England)*, *112*(12), 2167–2177. https://doi.org/10.1111/add.13886 PubMed

19. Hasin, D. S. (2018, January). US epidemiology of cannabis use and associated problems. *Neuropsychopharmacology*, *43*(1), 195–212. https://doi.org/10.1038/npp.2017.198 PubMed

20. Hinckley, J. D., Ferland, J. M. N., & Hurd, Y. L. (2024, May). The developmental trajectory to cannabis use disorder. In *American Journal of Psychiatry* (Issue 5, pp. 353–358). American Psychiatric Association.

21. Monfort, S. (2018). Effect of recreational marijuana sales on police-reported crashes in Colorado, Oregon, and Washington (pp. 1–24). Insurance Institute for Highway Safety, Highway Loss Data Institute. https://www.iihs.org/topics/bibliography/ref/2183

22. Reed, J. K. (2021). Impacts of marijuana legalization in Colorado. Colorado Division of Criminal Justice. https://cdpsdocs.state.co.us/ors/docs/reports/2021-SB13-283Report.pdf

23. Tefft, B., & Arnold, L. (2020). Cannabis use among drivers in fatal crashes in Washington State before and after legalization. AAA Foundation for Traffic Safety. https://aaafoundation.org/cannabis-use-among-drivers-in-fatal-crashes-in-washington-state-before-and-after-legalization/

24. Hasin, D. S., O'Brien, C. P., Auriacombe, M., Borges, G., Bucholz, K., Budney, A., . . . Grant, B. F. (2013, August). DSM-5 criteria for substance use disorders: Recommendations and rationale. *The American Journal of Psychiatry*, *170*(8), 834–851. https://doi.org/10.1176/appi.ajp.2013.12060782 PubMed

25. Brezing, C. A., & Levin, F. R. (2018, January). The current state of pharmacological treatments for cannabis use disorder and withdrawal. *Neuropsychopharmacology*, *43*(1), 173–194. https://doi.org/10.1038/npp.2017.212 PubMed

26. Morean, M. E., Kong, G., Camenga, D. R., Cavallo, D. A., & Krishnan-Sarin, S. (2015, October). High school students' use of electronic cigarettes to vaporize cannabis. *Pediatrics*, *136*(4), 611–616. https://doi.org/10.1542/peds.2015-1727 PubMed

27. Chen, C.-Y., Storr, C. L., & Anthony, J. C. (2009, March). Early-onset drug use and risk for drug dependence problems. *Addictive Behaviors*, *34*(3), 319–322. https://doi.org/10.1016/j.addbeh.2008.10.021 PubMed

28. Iffland, K., & Grotenhermen, F. (2017, June 1). An update on safety and side effects of cannabidiol: A review of clinical data and relevant animal studies. *Cannabis and Cannabinoid Research*, *2*(1), 139–154. https://doi.org/10.1089/can.2016.0034 PubMed

29. Moehle, M. S., & Conn, P. J. (2019, August). Roles of the M_4 acetylcholine receptor in the basal ganglia and the treatment of movement disorders. *Mov Disord*, *34*(8), 1089–1099. https://doi.org/10.1002/mds.27740 PubMed

30. Sylantyev, S., Jensen, T. P., Ross, R. A., & Rusakov, D. A. (2013, March 26). Cannabinoid- and lysophosphatidylinositol-sensitive receptor GPR55 boosts neurotransmitter release at central synapses. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(13), 5193–5198. https://doi.org/10.1073/pnas.1211204110 PubMed

31. Casey, J. L., & Cservenka, A. (2020, January 28). Effects of frequent marijuana use on risky decision-making in young adult college students. *Addictive Behaviors Reports*, *11*, 100253. https://doi.org/10.1016/j.abrep.2020.100253 PubMed

32. Crean, R. D., Tapert, S. F., Minassian, A., Macdonald, K., Crane, N. A., & Mason, B. J. (2011, March). Effects of chronic, heavy cannabis use on executive functions. *Journal of Addiction Medicine*, *5*(1), 9–15. https://doi.org/10.1097/ADM.0b013e31820cdd57 PubMed

33. Gruber, S. A., Dahlgren, M. K., Sagar, K. A., Gönenc, A., & Killgore, W. D. S. (2012, March 9). Age of onset of marijuana use impacts inhibitory processing. *Neuroscience Letters*, *511*(2), 89–94. https://doi.org/10.1016/j.neulet.2012.01.039 PubMed

34. Meier, M. H., Caspi, A., Ambler, A., Harrington, H., Houts, R., Keefe, R. S. E., . . . Moffitt, T. E. (2012, October 2). Persistent cannabis users show neuropsychological decline from childhood to midlife. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(40), E2657–E2664. https://doi.org/10.1073/pnas.1206820109 PubMed

35. Zalesky, A., Solowij, N., Yücel, M., Lubman, D. I., Takagi, M., Harding, I. H., . . . Seal, M. (2012, July). Effect of long-term cannabis use on axonal fibre connectivity. *Brain*, *135*(Pt 7), 2245–2255. https://doi.org/10.1093/brain/aws136 PubMed

36. Chadwick, B., Miller, M. L., & Hurd, Y. L. (2013, October 14). Cannabis use during adolescent development: Susceptibility to psychiatric illness. *Frontiers in Psychiatry*, *4*, 129. https://doi.org/10.3389/fpsyt.2013.00129 PubMed

37. Englund, A., Morrison, P. D., Nottage, J., Hague, D., Kane, F., Bonaccorso, S., . . . Kapur, S. (2013, January). Cannabidiol inhibits THC-elicited paranoid symptoms and hippocampal-

dependent memory impairment. *Journal of Psychopharmacology (Oxford, England)*, *27*(1), 19–27. https://doi.org/10.1177/0269881112460109 PubMed

38. Levine, A., Clemenza, K., Rynn, M., & Lieberman, J. (2017, March). Evidence for the risks and consequences of adolescent cannabis exposure. *Journal of the American Academy of Child \&. Journal of the American Academy of Child and Adolescent Psychiatry*, *56*(3), 214–225. https://doi.org/10.1016/j.jaac.2016.12.014 PubMed
39. Urits, I., Gress, K., Charipova, K., Li, N., Berger, A. A., Cornett, E. M., . . . Viswanath, O. (2020, May 19). Cannabis use and its association with psychological disorders. *Psychopharmacology Bulletin*, *50*(2), 56–67. PubMed
40. Abush, H., Ghose, S., Van Enkevort, E. A., Clementz, B. A., Pearlson, G. D., Sweeney, J. A., . . . Ivleva, E. I. (2018, June 30). Associations between adolescent cannabis use and brain structure in psychosis. *Psychiatry Res Neuroimaging*, *276*, 53–64. https://doi.org/10.1016/j.pscychresns.2018.03.008 PubMed
41. Albaugh, M. D., Ottino-Gonzalez, J., Sidwell, A., Lepage, C., Juliano, A., Owens, M. M., ... Garavan, H., & the IMAGEN Consortium. (2021, June 16). Association of cannabis use during adolescence with neurodevelopment. *JAMA Psychiatry, 78*(9), 1–11. https://doi.org/10.1001/jamapsychiatry.2021.1258 PubMed
42. Gobbi, G., Atkin, T., Zytynski, T., Wang, S., Askari, S., Boruff, J., . . . Mayo, N. (2019, April 1). Association of cannabis use in adolescence and risk of depression, anxiety, and suicidality in young adulthood. *JAMA Psychiatry*, *76*(4), 426–434. https://doi.org/10.1001/jamapsychiatry.2018.4500 PubMed
43. Zaman, T., Malowney, M., Knight, J., & Boyd, J. W. (2015, Jul-Aug). Co-occurrence of substance-related and other mental health disorders among adolescent cannabis users. *Journal of Addiction Medicine*, *9*(4), 317–321. https://doi.org/10.1097/ADM.0000000000000138 PubMed
44. van Leeuwen, A. P., Creemers, H. E., Greaves-Lord, K., Verhulst, F. C., Ormel, J., & Huizink, A. C. (2011, August). Hypothalamic-pituitary-adrenal axis reactivity to social stress and adolescent cannabis use: The TRAILS study. *Addiction (Abingdon, England)*, *106*(8), 1484–1492. https://doi.org/10.1111/j.1360-0443.2011.03448.x PubMed
45. Tuvel, A. L., Winiger, E. A., & Ross, J. M. (2023, January). A review of the effects of adolescent cannabis use on physical health. *Child and Adolescent Psychiatric Clinics of North America*, *32*(1), 85–105. https://doi.org/10.1016/j.chc.2022.07.005 PubMed
46. Bechtold, J., Simpson, T., White, H. R., & Pardini, D. (2015, September). Chronic adolescent marijuana use as a risk factor for physical and mental health problems in young adult men. *Psychol Addict Behav*, *29*(3), 552–563. https://doi.org/10.1037/adb0000103 PubMed
47. Callaghan, R. C., Allebeck, P., & Sidorchuk, A. (2013, October). Marijuana use and risk of lung cancer: A 40-year cohort study. *Cancer Causes Control*, *24*(10), 1811–1820. https://doi.org/10.1007/s10552-013-0259-0 PubMed
48. Adkins, S. H., Anderson, K. N., Goodman, A. B., Twentyman, E., Danielson, M. L., Kimball, A., ... Wiltz, J. L., & the Lung Injury Clinical Task Force and the Lung Injury Epidemiology/Surveillance Task Force. (2020, July 1). Demographics, substance use

behaviors, and clinical characteristics of adolescents with e-cigarette, or vaping, product use–associated lung injury (EVALI) in the United States in 2019. *JAMA Pediatrics, 174*(7), e200756. https://doi.org/10.1001/jamapediatrics.2020.0756 PubMed

49. Ladha, K. S., Mistry, N., Wijeysundera, D. N., Clarke, H., Verma, S., Hare, G. M. T., & Mazer, C. D. (2021, September 7). Recent cannabis use and myocardial infarction in young adults: A cross-sectional study. *CMAJ*, *193*(35), E1377–E1384. https://doi.org/10.1503/cmaj.202392 PubMed
50. Perisetti, A., Gajendran, M., Dasari, C. S., Bansal, P., Aziz, M., Inamdar, S., . . . Goyal, H. (2020). Cannabis hyperemesis syndrome: An update on the pathophysiology and management. In *Annals of Gastroenterology* (Issue 6, pp. 571–578). Hellenic Society of Gastroenterology.
51. Schierenbeck, T., Riemann, D., Berger, M., & Hornyak, M. (2008, October). Effect of illicit recreational drugs upon sleep: Cocaine, ecstasy and marijuana. *Sleep Medicine Reviews*, *12*(5), 381–389. https://doi.org/10.1016/j.smrv.2007.12.004 PubMed
52. Hasler, B. P., Franzen, P. L., de Zambotti, M., Prouty, D., Brown, S. A., Tapert, S. F., . . . Clark, D. B. (2017, June). Eveningness and later sleep timing are associated with greater risk for alcohol and marijuana use in adolescence: Initial findings from the National Consortium on Alcohol and Neurodevelopment in Adolescence Study. *Alcoholism, Clinical and Experimental Research*, *41*(6), 1154–1165. https://doi.org/10.1111/acer.13401 PubMed
53. Silins, E., Horwood, L. J., Patton, G. C., Fergusson, D. M., Olsson, C. A., Hutchinson, D. M., ... Mattick, R. P., & the Cannabis Cohorts Research Consortium. (2014, September). Young adult sequelae of adolescent cannabis use: An integrative analysis. *The Lancet. Psychiatry, 1*(4), 286–293. https://doi.org/10.1016/S2215-0366(14)70307-4 PubMed
54. Hogue, A., Evans, S. W., & Levin, F. R. (2017). A clinician's guide to co-occurring ADHD among adolescent substance users: Comorbidity, neurodevelopmental risk, and evidence-based treatment options. *Journal of Child \& Adolescent. Journal of Child & Adolescent Substance Abuse*, *26*(4), 277–292. https://doi.org/10.1080/1067828X.2017.1305930 PubMed
55. Loflin, M., Earleywine, M., Leo, J. D., & Hobkirk, A. (2014). Subtypes of attention deficit-hyperactivity disorder (ADHD) and cannabis use. *Substance Use \& Misuse, 49*(4), 427–434. https://doi.org/https://doi.org/10.3109/10826084.2013.841251
56. Kennedy, T. M., Howard, A. L., Mitchell, J. T., Hoza, B., Arnold, L. E., Hechtman, L. T., . . . Molina, B. S. G. (2019, December). Adult substance use as a function of growth in peer use across adolescence and young adulthood in the context of ADHD: Findings from the MTA. *Addictive Behaviors*, *99*, 106106. https://doi.org/10.1016/j.addbeh.2019.106106 PubMed
57. Thakrar, P. D., Boyd, K. P., Swanson, C. P., Wideburg, E., & Kumbhar, S. S. (2020, March). E-cigarette, or vaping, product use-associated lung injury in adolescents: A review of imaging features. *Pediatric Radiology*, *50*(3), 338–344. https://doi.org/10.1007/s00247-019-04572-5 PubMed

58. Toce, M. S., Farias, M., Powell, A. J., Daly, K. P., Vargas, S. O., & Burns, M. M. (2019, Jan-Feb). Myocardial infarct after marijuana inhalation in a 16-year-old adolescent boy. *Pediatr Dev Pathol*, *22*(1), 80–86. https://doi.org/10.1177/1093526618785552 PubMed

59. Pasch, K. E., Latimer, L. A., Cance, J. D., Moe, S. G., & Lytle, L. A. (2012, September). Longitudinal bi-directional relationships between sleep and youth substance use. *Journal of Youth and Adolescence*, *41*(9), 1184–1196. https://doi.org/10.1007/s10964-012-9784-5 PubMed

60. Ghafouri, M., Correa da Costa, S., Zare Dehnavi, A., Gold, M. S., & Rummans, T. A. (2024, February 28). Treatments for cannabis use disorder across the lifespan: A systematic review. *Brain Sciences*, *14*(3), 227. https://doi.org/10.3390/brainsci14030227 PubMed

61. Gray, K. M., Tomko, R. L., Baker, N. L., McClure, E. A., McRae-Clark, A. L., & Squeglia, L. M. (2025, April). N-acetylcysteine for youth cannabis use disorder: Randomized controlled trial main findings. *Neuropsychopharmacology*, *50*(5), 731–738. https://doi.org/10.1038/s41386-025-02061-y PubMed

62. Miranda, R., Jr., Treloar, H., Blanchard, A., Justus, A., Monti, P. M., Chun, T., . . . Gwaltney, C. J. (2017, May). Topiramate and motivational enhancement therapy for cannabis use among youth: A randomized placebo-controlled pilot study. *Addiction Biology*, *22*(3), 779–790. https://doi.org/10.1111/adb.12350 PubMed