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Co-use of cannabis, tobacco, and alcohol during adolescence: policy and regulatory implications

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Abstract

Legislative reforms have legalized use of cannabis for medical and recreational purposes. Efforts to evaluate the public health impact of these changes have predominantly focused on determining whether liberalizing cannabis policies has increased cannabis use patterns. Concurrent use of cannabis and other licit substances, namely tobacco and alcohol, is common during the developmental period of adolescence that is generally characterized by an increase in risk-taking and novelty-seeking. However, limited research has sought to evaluate the potential implications of reforms to medical and recreational cannabis laws on concurrent and simultaneous use of cannabis, tobacco, and alcohol during adolescence. The current report reviews the extant literature detailing the prevalence and outcomes associated with concurrent and simultaneous cannabis-tobacco and cannabis-alcohol use including recent work that has examined how concurrent and simultaneous use may be influenced by cannabis reform. We detail how the cannabis landscape and cannabis retail marketplace have evolved and briefly summarize the corresponding policy and regulatory challenges that have emerged. The report concludes with a focused cannabis co-use research agenda that adopts different strategies including behavioral economic, self-administration, and survey research methods.

Keywords

Cannabis; Marijuana; tobacco; alcohol; Co-Use; simultaneous use; adolescence; policy; reform

Introduction

Cannabis (marijuana, hashish) is one of the most widely used psychoactive drugs worldwide (Gowing et al., 2015; UNODC, 2014). In the United States, cannabis laws are rapidly evolving. Cannabis is classified as an illicit substance at the federal level, at the time of writing (March 2018), 29 states and the District of Columbia have passed medical marijuana laws (MML) permitting medicinal use of cannabis (ProCon.org, 2018). Nine states and the District of Columbia have passed recreational marijuana laws (RML) with heterogeneous provisions for possession and plant cultivation. The current era of cannabis legislative reform has experienced rapid expansion of a cannabis retail marketplace that includes a

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growing list of cannabis and cannabinoid products (e.g., edibles, cannabis concentrates) of varying potencies in addition to alternative drug delivery methods (e.g., vaporizers, dabbing). Attitudes toward cannabis use have changed; individuals' perceived risks and harms associated with cannabis use have significantly declined over the past decade (Compton, Han, Jones, Blanco, & Hughes, 2016; Patek, Mauro, & Martins, 2015) and most adults in the United States now favor cannabis legalization (Pew Research Center, 2018). The rate of cannabis legislative reforms has continued to outpace evidence-based regulatory efforts that seek to minimize potential public health harms. In turn, this has created a dire need for focused research to characterize the potential risks and benefits associated with increased access to cannabis. At present, one issue that has not been fully addressed is whether legalization of medical and/or recreational cannabis may increase the likelihood of co-use of cannabis with other licit and illicit drugs among adolescents and youth who are at heightened risk for experiencing the adverse consequences of co-use. It is well-documented that cannabis is seldom used in isolation; among cannabis users, co-use of tobacco and alcohol is highly prevalent (Agrawal, Budney, & Lynskey, 2012; Yurasek, Aston, & Metrik, 2017). In the United States alone, nearly 70% of adult cannabis users currently use tobacco and 75% of teens and adult cannabis users consume alcohol (Barrett, Darredeau, & Pihl, 2006; Schauer, Berg, Kegler, Donovan, & Windle, 2015). As will be discussed, co-use of cannabis with tobacco or alcohol during adolescence is associated with a series of elevated risks and adverse health outcomes (Jordan & Andersen, 2017). Co-use of cannabis and other substances is highly prevalent during this critical developmental period (Moss, Chen, & Yi, 2014), and adolescents are particularly vulnerable given the heightened propensity for risk-taking and sensation-seeking during adolescence when the critical brain structures that facilitate cognitive control are underdeveloped (Dahl, 2004; Steinberg, 2008). Consequently, cannabis-co use has deleterious effects on brain development and psychosocial functioning, both of which may increase the likelihood of developing substance use disorders. These adverse consequences may be further exacerbated depending on the frequency of co-use and whether substances are used concurrently (i.e. use of two or more substances on separate occasions) and/or simultaneously (i.e. two or more substances are administered at the same time or administered sequentially in close proximity).

The objectives of this narrative review are to summarize the extant literature and describe how changes in cannabis policy and the availability of new and increasingly potent cannabis products are impacting co-use of cannabis and tobacco/alcohol during adolescence. The first section of this report summarizes prevalence rates and current trends in adolescent use of cannabis, tobacco, and alcohol, followed by a detailed review of research that has examined prevalence rates and patterns of cannabis and tobacco/alcohol co-use. The second section reviews findings from studies examining how changes in cannabis policy and resulting availability of novel products may have a negatively impact on adolescent co-use of cannabis and tobacco/alcohol. The potential implications that the changing cannabis landscape may have on future cannabis co-use trends are also discussed. The review concludes with a summary discussion that presents recommendations for a research agenda that will focus on expanding the cannabis co-use literature base in order to maintain public health advances and to inform cannabis regulatory science.

Prevalence and trends in adolescent substance use and co-use

Prevalence and trends in use of cannabis, tobacco, and alcohol

Compared with other developmental periods, epidemiological data compiled over the past two decades have illustrated a persistent heightened prevalence of cannabis, alcohol, and tobacco use during adolescence (Banks et al., 2017; Johnston et al., 2018; Lanza et al., 2015; Miech et al., 2016; Palmer et al., 2009; Young et al., 2002). Among 8th graders participating in the 2017 Monitoring the Future (MTF) survey study, results indicated that 13.5% reported lifetime cannabis use, 23.1% reported lifetime alcohol use, and 9.4% reported lifetime cigarette use (Johnston et al., 2018). These rates increase with age as evidenced by the greater percentage of 12th graders who endorsed lifetime use of cannabis (45.0%), alcohol (61.5%), and cigarettes (26.6%) in the MTF survey.

Changes in the prevalence of current (past 30-day) use of cannabis, tobacco, and alcohol over the last decade (i.e., 2007–2017) have illustrated several emerging trends that are seemingly relevant for cannabis co-use (Johnston et al., 2018). First, the prevalence of past 30-day cannabis use has remained relatively stable over the past decade across youth age groups (8th, 10th, and 12th grades combined) while past 30-day use of cigarettes and alcohol declined substantially (8% for cigarettes, 10% for alcohol). However, while rates of cigarette and alcohol use are decreasing, use of other products that permit consumption of cannabis and tobacco are on the rise. Findings from the 2017 MTF survey also demonstrated that alternative tobacco products, primarily flavored little cigars and cigarillos, were just as prevalent as cigarette smoking (5.4% for both products). Growing use of alternative tobacco products (e.g., cigars, cigarillos) has significant implications for co-use, especially in the United States, where these products are regularly consumed with cannabis (i.e., blunts; Schauer, Rosenberry, & Peters, 2017). 2017 MTF survey data also revealed a subset of adolescents who reported use of electronic vaporizers to consume other substances (Johnston et al., 2017); the prevalence of past 30-day vaporizer use, for any substance, was 12.0% across all grade levels; 7.5% vaporized nicotine and 3.6% vaporized cannabis. Notably, the 2017 MTF survey was the first year that included questions about vaping specific substances; consequently, data from subsequent years will be necessary to fully characterize emerging trends in the vaporization of specific psychoactive substances.

Prevalence and trends in co-use of cannabis, tobacco, and alcohol

Although rates of adolescent cannabis use has remained relatively stable over the past decade (Johnston et al., 2018), it is quite possible that co-use of cannabis with tobacco/alcohol may be increasing during this developmental period, which would incur deleterious effects at greater magnitudes than use of each substance individually. Cannabis-alcohol and cannabis-tobacco co-use are the most prevalent and the most studied concurrent substance use patterns. In a nationally representative sample of adolescent substance users, Banks et al. (2017) used multinomial logistic regression to classify substance use profiles, and in contrast to the large percentage of individuals that were categorized as alcohol-only users (37.8%), a smaller percentage were characterized as concurrent cannabis-alcohol users (13.4%) and concurrent cannabis-tobacco users (5.1%). For cannabis and tobacco, co-use appears to be more prevalent than use of each substance in isolation, which is supported by recent analyses

of National Survey on Drug Use and Health (NSDUH) data where 5.4% of adolescents (ages 12–17) reported past-month co-use of cannabis and tobacco, which exceeded independent use of cannabis (2.2%) and tobacco (3.9%) (Schauer & Peters, 2018). Moreover, the prevalence of tobacco use among co-users has remained stable over the past 10 years despite declining rates of tobacco use. Simultaneous use was also highly prevalent among co-users; 85.5% reported cigar/blunt use and 34.1% reported blunt use exclusively.

An emerging literature has also detailed the prevalence of simultaneous use of cannabis and alcohol among adolescents in the United States and adolescents abroad (Pape, Rossow, & Storvoll, 2009). In the National Alcohol Survey, Subbaraman and Kerr (2015) found that 3.9% of individuals identified themselves as cannabis-alcohol co-users while 7.5% identified as simultaneous users of cannabis and alcohol. Terry-McElrath et al. (2013) documented the prevalence of simultaneous cannabis-alcohol use among 12th graders and found that among those who endorsed past-year cannabis use, roughly 70% reported any simultaneous cannabis-alcohol use and 18% indicated a highly frequent pattern of simultaneous cannabis-alcohol use. More recently, Patrick et al.'s analysis of MTF survey revealed that 20% of 12th graders endorsed past-year simultaneous cannabis-alcohol use and the risk for simultaneous cannabis-alcohol use increased as a function of the cannabis and alcohol use frequency (Patrick et al., 2017).

Risks and health implications of co-use

The concerns related to co-use are wide-ranging. For example, tobacco use is associated with a greater probability of cannabis use initiation (Ramo, Liu, & Prochaska, 2012) and is a significant predictor of cannabis relapse (Budney, Hughes, Moore, & Novy, 2001; Haney et al., 2013) and cannabis use disorder (CUD) (Agrawal & Lynskey, 2009; Hindocha et al., 2015; Peters, Budney, & Carroll, 2012). Conversely, cannabis use predicts the onset and escalation of tobacco smoking (Patton, Coffey, Carlin, Sawyer, & Lynskey, 2005; Rubinstein, Rait, & Prochaska, 2014), and cannabis use among tobacco smokers predicts poorer tobacco cessation outcomes (Amos, Wiltshire, Bostock, Haw, & McNeill, 2004; Ford, Vu, & Anthony, 2002). Simultaneous use of cannabis and tobacco (e.g., mixing tobacco and cannabis in blunts or spliffs) leads to further risks. Cigar smoking is associated with ingestion of greater levels of toxicants and carcinogens than cigarettes; however, many young people might not consider a cigar or blunt wrapper to be a tobacco product (e.g., Wackowski & Delnevo, 2015), which might reduce or eliminate perceived harms of blunt use and decrease motivation to quit. Simultaneous co-users have cannabis-related problems of greater severity (Cohn et al., 2015; Fairman, 2015; Ream, Benoit, Johnson, & Dunlap, 2008), lesser motivation to quit tobacco (Hindocha, Freeman, Ferris, Lynskey, & Winstock, 2016), and increased odds of initiating cigarette smoking and later development of nicotine dependence (Hu, Muthén, Schaffran, Griesler, & Kandel, 2008; Timberlake, 2009) compared with non-simultaneous users. Cannabis and tobacco co-use is associated with a greater likelihood for meeting diagnostic criteria for both cannabis and nicotine dependence in addition to heavier cannabis use patterns (Rubinstein et al., 2014; Schauer & Peters, 2018). Quantity and frequency of alcohol use, including binge drinking, is also greater among cannabis and tobacco co-users (Schauer & Peters, 2018).

Likewise, simultaneous use of cannabis and alcohol is also significantly associated with increased risk for health, legal, academic, and interpersonal problems, intoxicated driving, developing alcohol use disorder (AUD), and higher rates of binge-drinking and heavier cannabis consumption (Brière, Fallu, Descheneaux, & Janosz, 2011; Green et al., 2016; Lipperman-Kreda, Gruenewald, Grube, & Bersamin, 2017; Patrick, Veliz, & Terry-McElrath, 2017; Peters, Schwartz, Wang, O'Grady, & Blanco, 2014; Subbaraman & Kerr, 2015; Weinberger, Platt, & Goodwin, 2016; Yurasek et al., 2017). Co-users of cannabis and alcohol were also found to be at heightened risk of having AUD and CUD in the past year (Winters & Lee, 2008).

Liberalization of cannabis policies and resulting impact on use and co-use

Epidemiological survey data remains the richest source of information for examining whether the passage of MML and/or RML influence adolescent and adult cannabis use patterns (D'Amico, Tucker, Pedersen, & Shih, 2017; Harper, Strumpf, & Kaufman, 2012; Hasin et al., 2017; Hasin et al., 2015; Shi, Lenzi, & An, 2015). However, the impact of MML and RML on adolescent cannabis co-use has received less attention (Levy & Weitzman, 2016), and this sizeable gap in research is cause for concern (Hopfer, 2014).

Impact on cannabis use alone

To date, research examining the effects of MML and RML on adolescent cannabis use has yielded equivocal results (Hasin et al., 2015) and we refer the interested reader to excellent expert reviews and commentaries that discuss the myriad challenges and complexities researchers encounter while evaluating cannabis use patterns prior to and following the passage of MML and RML (Budney & Borodovsky, 2017; Choo & Emery, 2017; Pacula, Powell, Heaton, & Sevigny, 2015; Pacula & Sevigny, 2014). Using NSDUH survey data from 2002 to 2011, Stolzenberg et al. (2016) found that, compared to adolescents living in states without a MML, adolescents residing in MML states reported greater past-month use of non-medical ("recreational") cannabis. Similarly, Wen et al. (2015) used pooled NSDUH survey data to examine the impact of MML on cannabis, alcohol, and other drug use in both adolescents and adults. Among adolescents, Wen et al. (2015) reported that the probability of past-year initiation of cannabis attributed to MML increased by 5%. After combining 8th, 10th, and 12th grade MTF survey cohorts, Keyes et al. (2016) found no evidence of an increase in adolescent cannabis use after the passage of MML. Focusing on four states (Delaware, Michigan, Montana, Rhode Island) in the Youth Risk Behavior Survey (YRBS), Lynne-Landsman et al. did not observe a significant effect of MML on lifetime or past 30-day cannabis use (Lynne-Landsman, Livingston, & Wagenaar, 2013). Similarly, Wall and colleagues analyzed NSDUH data from 2002 to 2008 and found that higher rates of adolescent cannabis use in MML states predated the passage MML (Wall et al., 2011). Ammerman et al. (2015) reported on changes in cannabis use among 12th graders as a function of pre-post MML passage on the YRBS in 11 states; a significant increase in cannabis use was only observed in one state (New Mexico). Understandably, research efforts have continued to evaluate the nature and extent to which legalizing use of cannabis for medical recreational purposes has influenced adolescent cannabis use.

Impact on co-use

Wen et al. (2015) also assessed the impact of MML on adolescent use of licit and illicit drugs using pooled NSDUH data from 2004 to 2012. Among 12–20-year-olds, Wen found no evidence of a change in past-month binge drinking or quantity of alcohol consumption that could be attributed to the passage of MML. Stolzenberg et al. (2016) used NSDUH data from 2002 to 2011 to assess the impact of MML on adolescent cannabis use in addition to use of other licit and illicit drugs and found that MML increased adolescent cannabis use; however, the passage of MML was not significantly associated with an increase in alcohol use. Mason et al. (2016) observed substitution effects in a study of two adolescent cohorts in Washington State, where the second cohort, but not the first, was exposed to RML and accompanying decriminalization of cannabis. Interestingly, only the RML-exposed cohort reported a reduction in past 30-day cigarette use, but both cohorts reported reductions in past 30-day alcohol use at follow-up. It is important to note that use of alternative tobacco products (e.g. cigars, cigarillos, e-cigarettes) were not evaluated in the Mason et al. study, but may have produced differential findings in contrast to the decrease in cigarette smoking in the second cohort, especially when considering the recent increase in use of these products among youth (Johnston et al., 2018; Schauer, Rosenberry, & Peters, 2017). Finally, Cerdá et al. (2018) analyzed difference-in-difference models of MTF data to probe for changes in adolescent use of cannabis, alcohol, cigarettes, prescription medications and illicit drugs. After the passage of MML, past 30-day cigarette use significantly increased only among 12th graders (Cerdá et al., 2018).

Impact of the changing cannabis landscape

Potency and novel cannabis products

Over the past 30 years, researchers have documented the increasing concentration (potency) of Δ^9 -tetrahydrocannabinol (THC) in cannabis plant material, both domestically in the United States and in international markets (ElSohly et al., 2016). Given that THC is the primary psychoactive constituent of the cannabis plant and produces feelings of euphoria and a heightened sense of well-being, rising THC levels continue to increase public health concerns. Results of a survey study conducted by Freeman and Winstock (2015) indicated that severity of cannabis dependence scores were significantly related to the frequency by which adult cannabis users consumed high-potency, but not low-potency cannabis. Expansion of the cannabis retail marketplace has also witnessed the introduction of novel alternatives to traditional smoked self-administration of cannabis flowers and plant material, which includes products with extremely high THC concentrations (e.g., wax, dabs, shatter, butane hash oil). Though controlled scientific investigations are lacking, especially in youth populations, the results of online survey studies examining adult use of high-potency concentrates is concerning. Loflin and Earleywine (2014) found that use of dabs resulted in significant increases in both physiological tolerance and withdrawal compared with traditional cannabis products (i.e., cannabis flowers), however, differences in the frequencies of problems and negative consequences arising from the use of dabs compared to those resulting from the use of cannabis plant material were not statistically significant. Converging with findings reported by Loflin and Earleywine, Meier (2017) surveyed a large sample of college students and found that 40% of individuals who endorsed past-year

cannabis use reported past-year use of butane hash oil (BHO), and compared to those who denied use of BHO, users of BHO used cannabis more frequently and BHO use was significantly associated with greater dependence and a greater number of cannabis-related problems.

Alternative drug delivery devices

Expansion of the cannabis retail market has benefited from technological advances that now provide consumers with an increasing array of alternative drug delivery devices that include vaporizers, vape pens, and vaporizing accessories (e.g., vape cartridges, etc., Budney, Sargent & Lee, 2015), which are widely perceived to be safer and more discreet alternatives to smoking cannabis (Etter, 2015; Lee, Crosier, Borodovsky, Sargent & Budney, 2016; Malouff, Rooke, & Copeland, 2014). Vaporizers heat cannabis flowers and plant material or liquids and concentrates containing THC below the point of combustion (230°C), which is thought to provide an efficient method for self-administering THC and other phytocannabinoids and terpenoids while reducing the adverse health effects associated with the inhalation of smoke toxins produced via combustion (Abrams et al., 2007; Gieringer, 2001). In addition, vape pens afford cannabis users the ability to consume cannabis and cannabinoid products discreetly in public places and other settings where smoking is prohibited (e.g. indoors). Estimates of lifetime adult use of electronic vaporizers is on the rise (Russell, Rueda, Room, Tyndall, & Fischer, 2018; Schauer, King, Bunnell, Promoff, & McAfee, 2016). Among youth, data from the MTF survey (described in detail in the preceding section) has provided initial evidence that vaporization is increasing in prevalence. Similarly, a recent survey of high school students found that many dual users of e-cigarettes and cannabis reported using e-cigarettes to consume cannabis and other cannabinoid products (Morean, Kong, Camenga, Cavallo, & Krishnan-Sarin, 2015).

Policy and regulatory implications

Cannabis reform, marketplace expansion, and industry growth have introduced a number of scenarios, many of which are currently unknown, that may affect adolescent rates of cannabis co-use with alcohol and/or tobacco. Importantly, regulatory agencies must consider how commercial/industry, economic, policy, and public health variables may directly/indirectly affect cannabis co-use.

Like alcohol and tobacco, the legal for-profit cannabis industry will likely aim to maximize product consumption to increase annual revenues (e.g., Rolles & Murkin, 2016). Indeed, researchers have already commented on how the cannabis industry has adopted marketing strategies that resulted in successful outcomes for the alcohol and tobacco industries that targeted youth and young adults with innovative marketing strategies and prioritized research and product development (Barry & Glantz, 2016; Hall & Kozlowski, 2017; Richter & Levy, 2014; Subritzky, Lenton, & Pettigrew, 2016). Additionally, the cannabis industry's accelerated growth is responsible for declining rates of alcohol consumption in states with MMLs (Baggio, Chong, & Kwon, 2017) and alcohol companies have strategically established commercial partnerships with cannabis manufacturers (Maloney & George-Cosh, 2017). Current restrictions on advertising and marketing in Colorado, Washington

State, Alaska, and Oregon are variable, but in general, do not prohibit retail sales within 1,000 feet of areas frequented by vulnerable populations, which is a common policy for retail sales and marketing of alcohol and tobacco products (Barry & Glantz, 2016).

Economic variables (i.e., product prices and taxes) may also exert direct or indirect effects on co-use of cannabis with alcohol and/or tobacco. From a regulatory perspective, state and authorized officials that review and monitor the price of cannabis and cannabinoid products must also jointly consider the price of alcohol and tobacco given that price shifts in one may influence consumption rates for the other, and whether changes in legalization and price for retail sales in adults have spillover effects related to adolescent co-use rates. (Carnevale, Kagan, Murphy, & Esrick, 2017; Guttmanova et al., 2016; Rolles & Murkin, 2016; Subbaraman, 2016).

Current policies and regulations in states that have legalized recreational cannabis do not meet accepted public health standards for other recreational substances, which has potential impacts on co-use. Specific provisions in cannabis laws may have differential effects on rates of co-use. For example, a recent survey study found that states with provisions allowing for home cultivation of cannabis were associated with a lower age of cannabis edible use in adolescents (Borodovsky et al., 2017). Close monitoring of specific provisions in cannabis laws are needed to understand how provisions can impact co-use. In addition, product testing in legalized markets has revealed dose information labeled incorrectly for edibles and cannabidiol extracts (i.e. Vandrey et al., 2015; Bonn-Miller et al., 2017), and little information exists to inform testing of other substances, such as nicotine, in various cannabis products.

In the context of adolescent cannabis and tobacco co-use, a pressing concern is restricting marketing and use of appealing products for consuming cannabis that might have implications for simultaneous tobacco co-use. At the present time, it is uncertain whether the popularity of e-cigarettes and electronic vaporizers will suppress or reverse the consistent linear reduction in adolescent cigarette smoking rates, and likewise increase prevalence rates of cannabis use. A significant and immediate challenge that policymakers face is developing effective regulations for the rapidly expanding cannabis retail market while negotiating challenges associated with a poorly-regulated e-cigarette market and burgeoning online e-cigarette retailers with limited ability to successfully restrict underage access to these products (Mackey, Miner, & Cuomo, 2015). A second pressing concern related to cannabis and tobacco co-use is restricting marketing and sale of products for smoking cannabis which may include nicotine, such as flavored rolling papers and blunt wraps, which can increase exposure to nicotine and other tobacco constituents and exacerbate longitudinal tobacco use patterns (Cooper and Haney, 2009; Peters et al., 2016).

Concerns related to co-use of cannabis and alcohol include both short- and long-term physical and behavioral health outcomes and psychosocial functioning (e.g. Macleod et al., 2004; Volkow et al., 2016). Acute intoxication and impairment attributed to co-use of cannabis and alcohol is a significant public health concern. As discussed earlier, co-use of cannabis and alcohol significantly increases the likelihood of driving while intoxicated and is associated with a myriad of negative health outcomes and adverse psychosocial

consequences (Subbaraman & Kerr, 2015). From a policy and public health perspective, parents, teachers, healthcare providers, and scientists must integrate cannabis into the discussion of driving while under the influence of alcohol (Rolles & Murkin, 2016) and provide psychoeducation on the acute and long-term behavioral, cognitive, physiological, psychological effects of consuming cannabis alone or in combination with alcohol. Public health guidelines, print and online media, and in-person discussions of cannabis-alcohol interactions will likely have a stronger impact by directly addressing the heterogeneity that exists relative to the varying levels of potency, the range of available cannabinoid products, and differences in the time course of drug effects between the smoked/inhaled and oral routes of administration (Fischer et al., 2017).

Discussion

The landscape of legal medical and recreational cannabis use has drastically changed over the past two decades. Considerable public support for cannabis reform exists and is partly reflected by significant reductions in the perceived risks and consequences of cannabis use. Findings from national and smaller-scale survey studies have continued to document national trends in adolescent licit and illicit substance use, and similar research strategies have been used to examine the potential impact that the passage of laws legalizing medical and recreational cannabis use have on rates of adolescent cannabis use. Substance co-use, operationally defined as the use of more than one substance in a set period, is highly common during adolescence, and carries a unique set of risks including negative health outcomes. Considerable research has explored trends and patterns in adolescent cannabis-tobacco and cannabis-alcohol co-use, yet a major limitation of national surveillance data is a clear lack of depth; the contents of annual epidemiological survey studies seldom extend beyond the collection of simple quantity and frequency data. Consequently, current surveillance strategies are unable to adequately characterize adolescent cannabis-tobacco and cannabis-alcohol co-use, which introduces several public health concerns. In addition, co-use of cannabis and other illicit drugs, while impacting a smaller subset of individuals, warrants greater detailed surveillance. To maintain and ensure the safety and health of the public and to preserve significant public health achievements, including the linear decline in adolescent cigarette smoking rates, research teams comprised of scientists, public health and policy experts, and healthcare practitioners are needed to help answer critical questions that focus on examining the impact of cannabis reform on adolescent cannabis use in isolation, and importantly, adolescent cannabis-tobacco and cannabis-alcohol co-use.

Developing a cannabis co-use research agenda

Ongoing reforms legalizing medical and recreational cannabis use have presented cannabinoid scientists with the challenge of quickly filling an extensive research gap that limits the ability to inform public health, policy, and regulatory initiatives. In the context of adolescent cannabis-tobacco and cannabis-alcohol co-use, a detailed research agenda provides a blueprint for addressing noticeable limitations of the extant literature to enhance regulatory and policy guidelines for medical and recreational cannabis legalization. Accordingly, we provide a concise set of recommendations for advancing this area of research.

1. Surveillance research

Close continued monitoring of adolescent substance use is clearly required to determine the impact of changing laws and products available for cannabis consumption on the prevalence and patterns of adolescent cannabis co-use. Nationally representative epidemiological data sets (i.e., Monitoring the Future, Youth Risk Behavior Survey) continue to play an instrumental role in tracking prevalence rates and patterns of illicit and licit substance use. However, these national surveillance systems have clear limitations; understandably, nationally representative surveys ask a limited number of questions about concurrent substance use, product types, and routes of administration (Burdzovic Andreas & Bretteville-Jensen, 2017). This is a clear limitation for cannabis, especially given the number of options available for consuming cannabis. Smaller investigations conducted in targeted samples of cannabis users can supplement nationally-representative surveys by providing detailed information about the growing list of cannabis and cannabinoid products, methods of self-administration, positive and negative outcomes of various methods of administration, health consequences, and other related problems arising from cannabis use. Aside from survey research, other observational approaches such as ecological momentary assessment (EMA) may provide valuable high resolution data to document patterns of co-use and determine environmental and situational antecedent factors underlying co-use in the natural environment (e.g. Schuster, Mermelstein, & Hedeker, 2016; McQuoid, Thrul, & Ling, 2018). These studies will be integral for understanding risks associated with distinct patterns of co-use (e.g. simultaneous vs. concurrent use) and underlying mechanisms to inform public health and regulatory efforts to prevent an increase in adolescent use.

In addition to understanding prevalence and patterns of co-use, there is a clear need for detailed surveillance of the emerging cannabis marketplace. In particular, compared to the alcohol and tobacco industries, advances in online commerce and global communication networks predated the emergence of the legal cannabis industry. Consequently, the cannabis industry has the capacity to market its products to any individual online (Richter & Levy, 2014), including individuals living in regions without legal access to cannabis, and may also potentially reach vulnerable populations such as youth and young adults. Indeed, recent work has illustrated how the cannabis industry and cannabis enthusiasts already enjoy a strong presence on the Internet on popular social media sites (e.g., Facebook, Twitter, Instagram), video-sharing sites (YouTube), cannabis resource sites (Leafly), and online communities (e.g., Weedmaps, Reddit) (Bierut, Krauss, Sowles, & Cavazos-Rehg, 2017; Krauss et al., 2017). However, researchers can learn from the information contained on these Internet websites and possibly data disseminated by retailers themselves (Kilmer & Pacula, 2017) to complement national data acquired via traditional epidemiological survey methods (Levy & Weitzman, 2016).

2. Experimental research

Systematic evaluation of the relationship between cannabis-tobacco and cannabis-alcohol co-use using controlled experimental conditions in preclinical and clinical laboratories are needed to understand the neurobiological, pharmacological, and behavioral mechanisms underlying co-use, and potential negative effects of exposure to multiple substances. The most pressing need in this domain is to fully characterize effects related to cannabis potency

at dose ranges relevant to what is currently available in the market. Specific to co-use, systematic evaluation of cannabis potency and nicotine/tobacco content, alcohol content, and route of administration are clearly needed and would provide valuable information on subjective drug effect ratings, resulting behavioral and cognitive impairment, and pharmacokinetic profiles.

Although the ability to conduct experimental studies with drug administration directly in adolescent human populations is limited, laboratory research in preclinical models and adult cannabis users would provide valuable data that can be translated to adolescents to inform risks that present the most salient need for targeted prevention/early interventions in adolescent co-users. While experimental research on cannabis and tobacco/alcohol dose-related effects is not possible in adolescent populations, other experimental approaches can be utilized to examine factors related to co-use. For example, hypothetical behavioral economic purchase task paradigms could be used to examine the influence of the availability and price of cannabis, alcohol, and tobacco on respective consumption patterns to model potential spillover effects related to increased availability of cannabis in locations with medical/recreational legalization. Experimental studies are also needed to identify marketing/advertising practices that may influence perceptions related to risks/harms and expectancies of cannabis use and related changes in perceptions in other substances.

3. Health risks and harm reduction

Legalization of cannabis for medical and recreational purposes has created a challenge for focused prevention campaigns and responding to individuals presenting for treatment who use cannabis alone or in combination with tobacco, alcohol, or other drugs. In the U.S., there is no set of uniform cannabis use guidelines that healthcare providers can disseminate to patients. An expert panel of scientists and physicians in Canada recently conducted a literature review and refined 10 recommendations for using cannabis and cannabinoid products in a manner that attempts to mitigate health risks and cannabis-related harms (Fischer et al., 2017). One clear and common-sense recommendation is that individuals younger than 18 should refrain from using cannabis, when the magnitude of risks for long-term adverse effects are arguably the highest. However, while a minimum age of 18 (or 21) might be a clear guideline for recreational cannabis use, the question of whether minors should be granted approval for medical use of cannabis presents additional challenges. Careful consideration by medical professionals and policymakers to balance the potential benefits and harms of medical cannabis for specific physical and mental health conditions in adolescents is clearly warranted, with a clear need for research to provide a foundation for consistent evidence-based guidelines.

Regardless of evidence-based recommendations for adolescents to refrain from using cannabis for recreational purposes, adolescent cannabis use and co-use of cannabis with other substances is a critical public health concern and continued area of focus. One benefit of medical/recreational legalization of cannabis for adults is a potential shift from law enforcement to public health strategies to prevent early use. An example of this shift is in the state of Washington, where proposals have been created to utilize tax revenues from cannabis sales to implement empirically-supported prevention and early intervention

programs (i.e. Roffman, 2016), which might not strictly result in a reduction in cannabis use, but may also have positive benefits on co-use of tobacco, alcohol and other psychoactive substances.

Conclusion

The current era of cannabis reform has been accompanied by increasing concerns that the legalization of cannabis for medical and recreational purposes will ultimately lead to an increase in cannabis use alone, and concurrent use of cannabis with other licit substances, such as tobacco and alcohol. While studies evaluating the impact of medical and recreational cannabis laws have yielded equivocal findings, results of national epidemiological surveys indicate that a substantial number of adolescents endorse concurrent use of cannabis with tobacco or alcohol. Co-use of cannabis with other licit and illicit drugs of abuse has serious consequences, and future research examining cannabis co-use is needed to inform the public, policymakers, public health officials, healthcare providers, and parents as well as to guide cannabis regulatory science.

Disclosure statement

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References

- Abrams DI, Vizoso HP, Shade SB, Jay C, Kelly ME, & Benowitz NL (2007). Vaporization as a smokeless cannabis delivery system: a pilot study. *Clinical Pharmacology and Therapeutics*, 82, 572–578. [CrossRef][10.1038/sj.clpt.6100200][TQ1][TQ2] [PubMed: 17429350]
- Agrawal A, Budney AJ, & Lynskey MT (2012). The co-occurring use and misuse of cannabis and tobacco: a review. *Addiction*, 107, 1221–1233. [CrossRef][10.1111/j.1360-0443.2012.03837.x] [PubMed: 22300456]
- Agrawal A, & Lynskey MT (2009). Tobacco and cannabis co-occurrence: does route of administration matter?. *Drug and Alcohol Dependence*, 99, 240–247. [CrossRef][10.1016/j.drugalcdep.2008.08.007] [PubMed: 18926646]
- Ammerman S, Ryan S, & Adelman WP (2015). The impact of marijuana policies on youth: clinical, research, and legal update. *Pediatrics*, 135, e769–e785. [PMC][10.1542/peds.2014-4147] [25624385] [PubMed: 25624385]
- Amos A, Wiltshire S, Bostock Y, Haw S, McNeill A (2004). ‘You can’t go without a fag... you need it for your hash’—a qualitative exploration of smoking, cannabis and young people. *Addiction*, 99, 77–81. [CrossRef][10.1111/j.1360-0443.2004.00531.x] [PubMed: 14678065]
- Baggio M, Chong A, & Kwon S (2017). Helping settle the marijuana and alcohol debate: evidence from scanner data. Available at SSRN: 10.2139/ssrn.3063288
- Banks DE, Rowe AT, Mpofu P, & Zapolski TC (2017). Trends in typologies of concurrent alcohol, marijuana, and cigarette use among US adolescents: An ecological examination by sex and race/ethnicity. *Drug and Alcohol Dependence*, 179, 71–77. [CrossRef][10.1016/j.drugalcdep.2017.06.026] [PubMed: 28756102]
- Barrett SP, Darredeau C, & Pihl RO (2006). Patterns of simultaneous polysubstance use in drug using university students. *Human Psychopharmacology: Clinical and Experimental*, 21, 255–263. [CrossRef][10.1002/hup.766] [PubMed: 16783813]
- Barry RA, & Glantz S (2016). A public health framework for legalized retail marijuana based on the US experience: Avoiding a new tobacco industry. *PLoS Medicine*, 13, e1002131. [CrossRef] [10.1371/journal.pmed.1002131] [PubMed: 27676176]

- Bierut T, Krauss MJ, Sowles SJ, & Cavazos-Rehg PA (2017). Exploring marijuana advertising on Weedmaps, a popular online directory. *Prevention Science*, 18, 183–192. [CrossRef][10.1007/s11121-016-0702-z] [PubMed: 27534665]
- Bonn-Miller MO, Loflin MJ, Thomas BF, Marcu JP, Hyke T, & Vandrey R (2017). Labeling accuracy of cannabidiol extracts sold online. *Jama*, 318, 1708–1709. [CrossRef][10.1001/jama.2017.11909] [PubMed: 29114823]
- Brière F, Fallu J-S, Descheneaux A, & Janosz M (2011). Predictors and consequences of simultaneous alcohol and cannabis use in adolescents. *Addictive Behaviors*, 36, 785–788. [PMC][10.1016/j.addbeh.2011.02.012] [21429672] [PubMed: 21429672]
- Budney AJ, & Borodovsky JT (2017). The potential impact of cannabis legalization on the development of cannabis use disorders. *Preventive Medicine*, 104, 31–36. [CrossRef][10.1016/j.ypmed.2017.06.034] [PubMed: 28668544]
- Budney AJ, Hughes JR, Moore BA, & Novy PL (2001). Marijuana abstinence effects in marijuana smokers maintained in their home environment. *Archives of General Psychiatry*, 58, 917–924. [CrossRef][10.1001/archpsyc.58.10.917] [PubMed: 11576029]
- Budney AJ, Sargent JD, & Lee DC (2015). Vaping cannabis (marijuana): Parallel concerns to e-cigs? *Addiction*, 110, 1699–1704. [PMC][10.1111/add.13036] [26264448] [PubMed: 26264448]
- Burdzovic Andreas J, & Bretteville-Jensen AL (2017). Consideration of use opportunities, novel products, and user modes in cannabis monitoring, research, and policy: a response to the commentary. *Addiction*, 113, 575–576. [CrossRef][10.1111/add.14108] [PubMed: 29282781]
- Carnevale JT, Kagan R, Murphy PJ, & Esrick J (2017). A practical framework for regulating for-profit recreational marijuana in US states: lessons from Colorado and Washington. *Int. J. Drug Policy*, 42, 71–85. [PMC][10.1016/j.drugpo.2017.03.001] [28366598] [PubMed: 28366598]
- Cerdá M, Sarvet AL, Wall M, Feng T, Keyes KM, Galea S, & Hasin DS (2018). Medical marijuana laws and adolescent use of marijuana and other substances: Alcohol, cigarettes, prescription drugs, and other illicit drugs. *Drug and Alcohol Dependence*, 183, 62–68. [CrossRef][10.1016/j.drugalcdep.2017.10.021] [PubMed: 29227839]
- Choo EK, & Emery SL (2017). Clearing the haze: the complexities and challenges of research on state marijuana laws. *Annals of the New York Academy of Sciences*, 1394, 55–73. [CrossRef][10.1111/nyas.13093] [PubMed: 27723946]
- Cohn A, Villanti A, Richardson A, Rath JM, Williams V, Stanton C, & Mermelstein R (2015). The association between alcohol, marijuana use, and new and emerging tobacco products in a young adult population. *Addictive Behaviors*, 48, 79–88. [CrossRef][10.1016/j.addbeh.2015.02.005] [PubMed: 26042613]
- Compton WM, Han B, Jones CM, Blanco C, & Hughes A (2016). Marijuana use and use disorders in adults in the USA, 2002–14: analysis of annual cross-sectional surveys. *The Lancet Psychiatry*, 3, 954–964. [CrossRef][10.1016/S2215-0366(16)30208-5] [PubMed: 27592339]
- Cooper ZD, & Haney M (2009). Comparison of subjective, pharmacokinetic, and physiological effects of marijuana smoked as joints and blunts. *Drug Alcohol Depend*, 103, 107–113. doi:10.1016/j.drugalcdep.2009.01.023 [CrossRef][10.1016/j.drugalcdep.2009.01.023] [PubMed: 19443132]
- D'Amico EJ, Tucker JS, Pedersen ER, & Shih RA (2017). Understanding rates of marijuana use and consequences among adolescents in a changing legal landscape. *Current Addiction Reports*, 4, 343–349. [CrossRef][10.1007/s40429-017-0170-y] [PubMed: 29201592]
- Dahl RE (2004). Adolescent brain development: a period of vulnerabilities and opportunities. Keynote address. *Annals of the New York Academy of Sciences*, 1021, 1–22. [CrossRef][10.1196/annals.1308.001] [PubMed: 15251869]
- Eggers ME, Lee YO, Jackson K, Wiley JL, Porter L, & Nonnemaker JM (2017). Youth use of electronic vapor products and blunts for administering cannabis. *Addictive Behaviors*, 70, 79–82. [CrossRef][10.1016/j.addbeh.2017.02.020] [PubMed: 28214740]
- ElSohly MA, Mehmedic Z, Foster S, Gon C, Chandra S, & Church JC (2016). Changes in cannabis potency over the last 2 decades (1995–2014): analysis of current data in the United States. *Biological Psychiatry*, 79, 613–619. [CrossRef][10.1016/j.biopsych.2016.01.004] [PubMed: 26903403]

- Etter JF (2015). Electronic cigarettes and cannabis: an exploratory study. *European Addiction Research*, 21, 124–130. [CrossRef][10.1159/000369791] [PubMed: 25613866]
- Fairman BJ (2015). Cannabis problem experiences among users of the tobacco–cannabis combination known as blunts. *Drug and Alcohol Dependence*, 150, 77–84. [CrossRef][10.1016/j.drugalcdep.2015.02.014] [PubMed: 25746234]
- Fischer B, Russell C, Sabioni P, van den Brink W, Le Foll B, Hall W, ... Room R (2017). Lower-risk cannabis use guidelines: a comprehensive update of evidence and recommendations. *American Journal of Public Health*, 107, e1–e12. [CrossRef][10.2105/AJPH.2017.303818a]
- Ford DE, Vu HT, & Anthony JC (2002). Marijuana use and cessation of tobacco smoking in adults from a community sample. *Drug and Alcohol Dependence*, 67, 243–248. [PMC][12127195] [PubMed: 12127195]
- Freeman T, & Winstock A (2015). Examining the profile of high-potency cannabis and its association with severity of cannabis dependence. *Psychological Medicine*, 45, 3181–3189. [CrossRef][10.1017/S0033291715001178] [PubMed: 26213314]
- Gieringer DH (2001). Cannabis “Vaporization”. a Promising Strategy for Smoke Harm Reduction. *Journal of Cannabis Therapeutics*, 1, 153–170. [CrossRef][10.1300/J175v01n03_10]
- Giroud C, de Cesare M, Berthet A, Varlet V, Concha-Lozano N, & Favrat B (2015). E-cigarettes: a review of new trends in cannabis use. *International Journal of Environmental Research and Public Health*, 12, 9988–10008. [CrossRef][10.3390/ijerph120809988] [PubMed: 26308021]
- Gowing LR, Ali RL, Allsop S, Marsden J, Turf EE, West R, & Witton J (2015). Global statistics on addictive behaviours: 2014 status report. *Addiction*, 110, 904–919. [PMC][10.1111/add.12899] [25963869] [PubMed: 25963869]
- Green KM, Musci RJ, Johnson RM, Matson PA, Reboussin BA, & Ialongo NS (2016). Outcomes associated with adolescent marijuana and alcohol use among urban young adults: A prospective study. *Addictive Behaviors*, 53, 155–160. [CrossRef][10.1016/j.addbeh.2015.10.014] [PubMed: 26517712]
- Guttmannova K, Lee CM, Kilmer JR, Fleming CB, Rhew IC, Kosterman R, & Larimer ME (2016). Impacts of changing marijuana policies on alcohol use in the United States. *Alcoholism: Clinical and Experimental Research*, 40, 33–46. [CrossRef][10.1111/acer.12942]
- Hall W, & Kozlowski LT (2017). The diverging trajectories of cannabis and tobacco policies in the United States: reasons and possible implications. *Addiction*, [TQ3]
- Haney M, Bedi G, Cooper ZD, Glass A, Vosburg SK, Comer SD, & Foltin RW (2013). Predictors of marijuana relapse in the human laboratory: robust impact of tobacco cigarette smoking status. *Biological Psychiatry*, 73, 242–248. [CrossRef][10.1016/j.biopsych.2012.07.028] [PubMed: 22939992]
- Harper S, Strumpf EC, & Kaufman JS (2012). Do medical marijuana laws increase marijuana use? Replication study and extension. *Annals of Epidemiology*, 22, 207–212. [CrossRef][10.1016/j.annepidem.2011.12.002] [PubMed: 22285867]
- Hasin DS, Sarvet AL, Cerdá M, Keyes KM, Stohl M, Galea S, & Wall MM (2017). US adult illicit cannabis use, cannabis use disorder, and medical marijuana laws: 1991–1992 to 2012–2013. *JAMA Psychiatry*, 74, 579–588. [CrossRef][10.1001/jamapsychiatry.2017.0724] [PubMed: 28445557]
- Hasin DS, Wall M, Keyes KM, Cerdá M, Schulenberg J, O’Malley PM, ... Feng T (2015). Medical marijuana laws and adolescent marijuana use in the USA from 1991 to 2014: results from annual, repeated cross-sectional surveys. *The Lancet Psychiatry*, 2, 601–608. [CrossRef][10.1016/S2215-0366(15)00217-5] [PubMed: 26303557]
- Hindocha C, Freeman TP, Ferris JA, Lynskey MT, & Winstock AR (2016). No smoke without tobacco: a global overview of cannabis and tobacco routes of administration and their association with intention to quit. *Frontiers in Psychiatry*, 7, 1–9. [CrossRef][10.3389/fpsy.2016.00104] [PubMed: 26903886]
- Hindocha C, Shaban ND, Freeman TP, Das RK, Gale G, Schafer G, ... Curran HV (2015). Associations between cigarette smoking and cannabis dependence: a longitudinal study of young cannabis users in the United Kingdom. *Drug and Alcohol Dependence*, 148, 165–171. [CrossRef][10.1016/j.drugalcdep.2015.01.004] [PubMed: 25622777]

- Hopfer C (2014). Implications of marijuana legalization for adolescent substance use. *Substance Abuse*, 35, 331–335. [PMC][10.1080/08897077.2014.943386] [25127003] [PubMed: 25127003]
- Hu M-C, Muthén B, Schaffran C, Griesler PC, & Kandel DB (2008). Developmental trajectories of criteria of nicotine dependence in adolescence. *Drug and Alcohol Dependence*, 98, 94–104. [CrossRef][10.1016/j.drugalcdep.2008.04.017] [PubMed: 18602225]
- Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, & Patrick ME (2018). Monitoring the Future national survey results on drug use, 1975–2017: Overview, key findings on adolescent drug use Ann Arbor: Institute for Social Research, The University of Michigan.
- Jordan CJ, & Andersen SL (2017). Sensitive periods of substance abuse: early risk for the transition to dependence. *Developmental Cognitive Neuroscience*, 25, 29–44. [CrossRef][10.1016/j.dcn.2016.10.004] [PubMed: 27840157]
- Keyes KM, Wall M, Cerdá M, Schulenberg J, O'malley PM, Galea S, ... Hasin DS (2016). How does state marijuana policy affect US youth? Medical marijuana laws, marijuana use and perceived harmfulness: 1991–2014. *Addiction*, 111, 2187–2195. [CrossRef][10.1111/add.13523] [PubMed: 27393902]
- Kilmer B, & Pacula RL (2017). Building the data infrastructure to evaluate cannabis legalization. *Addiction*, 112, 1140–1141. [PMC][10.1111/add.13824] [28477353] [PubMed: 28477353]
- Krauss MJ, Sowles SJ, Sehi A, Spitznagel EL, Berg CJ, Bierut LJ, & Cavazos-Rehg PA (2017). Marijuana advertising exposure among current marijuana users in the US. *Drug and Alcohol Dependence*, 174, 192–200. [CrossRef][10.1016/j.drugalcdep.2017.01.017] [PubMed: 28365173]
- Lanza ST, Vasilenko SA, Dziak JJ, & Butera NM (2015). Trends among U.S. high school seniors in recent marijuana use and associations with other substances: 1976–2013. *Journal of Adolescent Health*, 57, 198–204. [CrossRef][10.1016/j.jadohealth.2015.04.006] [PubMed: 26206440]
- Lee DC, Crosier BS, Borodovsky JT, Sargent JD, & Budney AJ (2016). Online survey characterizing vaporizer use among cannabis users. *Drug and Alcohol Dependence*, 159, 227–233. [CrossRef][10.1016/j.drugalcdep.2015.12.020] [PubMed: 26774946]
- Levy S, & Weitzman ER (2016). Building a learning marijuana surveillance system. *JAMA Pediatrics*, 170, 193–194. [PMC][10.1001/jamapediatrics.2015.3489] [26784457] [PubMed: 26784457]
- Lipperman-Kreda S, Gruenewald PJ, Grube JW, & Bersamin M (2017). Adolescents, alcohol, and marijuana: Context characteristics and problems associated with simultaneous use. *Drug and Alcohol Dependence*, 179, 55–60. [CrossRef][10.1016/j.drugalcdep.2017.06.023] [PubMed: 28755540]
- Loflin M, & Earleywine M (2014). A new method of cannabis ingestion: the dangers of dabs?. *Addictive Behaviors*, 39, 1430–1433. [CrossRef][10.1016/j.addbeh.2014.05.013] [PubMed: 24930049]
- Lynne-Landsman SD, Livingston MD, & Wagenaar AC (2013). Effects of state medical marijuana laws on adolescent marijuana use. *American Journal of Public Health*, 103, 1500–1506. [CrossRef][10.2105/AJPH.2012.301117] [PubMed: 23763418]
- Mackey TK, Miner A, & Cuomo RE (2015). Exploring the e-cigarette e-commerce marketplace: identifying Internet e-cigarette marketing characteristics and regulatory gaps. *Drug and Alcohol Dependence*, 156, 97–103. [CrossRef][10.1016/j.drugalcdep.2015.08.032] [PubMed: 26431794]
- Macleod J, Oakes R, Copello A, Crome I, Egger M, Hickman M, ... Davey Smith G (2004). Psychological and social sequelae of cannabis and other illicit drug use by young people: a systematic review of longitudinal, general population studies. *Lancet*, 363, 1579–1588. [CrossRef][10.1016/S0140-6736(04)16200-4] [PubMed: 15145631]
- Maloney J, & George-Cosh D (2017, 10 29). Big brewer makes a play for marijuana beverages. *The Wall Street Journal*. Retrieved from <http://www.wsj.com/articles/big-brewer-makes-a-play-for-marijuana-beverages-1509300002>
- Malouff JM, Rooke SE, & Copeland J (2014). Experiences of marijuana-vaporizer users. *Substance Abuse*, 35, 127–128. [PMC][10.1080/08897077.2013.823902] [24821347] [PubMed: 24821347]
- Mason WA, Fleming CB, Ringle JL, Hanson K, Gross TJ, & Haggerty KP (2016). Prevalence of marijuana and other substance use before and after Washington State's change from legal medical marijuana to legal medical and nonmedical marijuana: Cohort comparisons in a sample of

adolescents. *Substance Abuse*, 37, 330–335. [CrossRef][10.1080/08897077.2015.1071723] [PubMed: 26252354]

McQuoid J, Thrul J, & Ling P (2018). A geographically explicit ecological momentary assessment (GEMA) mixed method for understanding substance use. *Social Science & Medicine*, 202, 89–98. [CrossRef][10.1016/j.socscimed.2018.02.014] [PubMed: 29518701]

Meier MH (2017). Associations between butane hash oil use and cannabis-related problems. *Drug and Alcohol Dependence*, 179, 25–31. [CrossRef][10.1016/j.drugalcdep.2017.06.015] [PubMed: 28750253]

Miech RA, Johnston LD, O'malley PM, Bachman JG, & Schulenberg JE (2016). *Monitoring the Future National Survey Results on Drug Use, 1975–2015; Volume I, Secondary school students*. Ann Arbor: Institute for Social Research, The University of Michigan.

Morean ME, Kong G, Camenga DR, Cavallo DA, & Krishnan-Sarin S (2015). High school students' use of electronic cigarettes to vaporize cannabis. *Pediatrics*, 136, 611–616. [CrossRef][10.1542/peds.2015-1727d] [PubMed: 26347431]

Moss HB, Chen CM, & Yi H-y. (2014). Early adolescent patterns of alcohol, cigarettes, and marijuana polysubstance use and young adult substance use outcomes in a nationally representative sample. *Drug and Alcohol Dependence*, 136, 51–62. [CrossRef][10.1016/j.drugalcdep.2013.12.011] [PubMed: 24434016]

National Academies of Sciences, Engineering, and Medicine. (2017). *The health effects of cannabis and cannabinoids: Current state of evidence and recommendations for research*. Washington, DC: The National Academies Press.

Pacek LR, Mauro PM, & Martins SS (2015). Perceived risk of regular cannabis use in the United States from 2002 to 2012: differences by sex, age, and race/ethnicity. *Drug and Alcohol Dependence*, 149, 232–244. [CrossRef][10.1016/j.drugalcdep.2015.02.009] [PubMed: 25735467]

Pacula RL, Powell D, Heaton P, & Sevigny EL (2015). Assessing the effects of medical marijuana laws on marijuana use: the devil is in the details. *Journal of Policy Analysis and Management*, 34, 7–31. [PMC][25558490] [PubMed: 25558490]

Pacula RL, & Sevigny EL (2014). Marijuana liberalization policies: why we can't learn much from policy still in motion. *Journal of Policy Analysis and Management*, 33, 212–221. [CrossRef][10.1002/pam.21726] [PubMed: 24358530]

Palmer R, Young S, Hopfer C, Corley R, Stallings M, Crowley T, & Hewitt J (2009). Developmental epidemiology of drug use and abuse in adolescence and young adulthood: Evidence of generalized risk. *Drug and Alcohol Dependence*, 102, 78–87. [CrossRef][10.1016/j.drugalcdep.2009.01.012] [PubMed: 19250776]

Pape H, Rossow I, & Storvoll EE (2009). Under double influence: assessment of simultaneous alcohol and cannabis use in general youth populations. *Drug and Alcohol Dependence*, 101, 69–73. [CrossRef][10.1016/j.drugalcdep.2008.11.002] [PubMed: 19095380]

Patrick ME, Kloska DD, Terry-McElrath YM, Lee CM, O'malley PM, & Johnston LD (2017). Patterns of simultaneous and concurrent alcohol and marijuana use among adolescents. *The American Journal of Drug and Alcohol Abuse*, 1–11. [CrossRef][10.1080/00952990.2017.1402335][TQ4]

Patrick ME, Veliz PT, & Terry-McElrath YM (2017). High-intensity and simultaneous alcohol and marijuana use among high school seniors in the United States. *Substance Abuse*, 38, 498–503. [CrossRef][10.1080/08897077.2017.1356421] [PubMed: 28726580]

Patton GC, Coffey C, Carlin JB, Sawyer SM, & Lynskey M (2005). Reverse gateways? Frequent cannabis use as a predictor of tobacco initiation and nicotine dependence. *Addiction*, 100, 1518–1525. [CrossRef][10.1111/j.1360-0443.2005.01220.x] [PubMed: 16185213]

Peters EN, Budney AJ, & Carroll KM (2012). Clinical correlates of co-occurring cannabis and tobacco use: a systematic review. *Addiction*, 107, 1404–1417. [CrossRef][10.1111/j.1360-0443.2012.03843.x] [PubMed: 22340422]

Peters EN, Schauer GL, Rosenberry ZR, & Pickworth WB (2016). Does marijuana "blunt" smoking contribute to nicotine exposure?: Preliminary product testing of nicotine content in wrappers of cigars commonly used for blunt smoking. *Drug and Alcohol Dependence*, doi:10.1016/j.drugalcdep.2016.09.007[TQ5]

- Peters EN, Schwartz RP, Wang S, O'grady KE, & Blanco C (2014). Psychiatric, psychosocial, and physical health correlates of co-occurring cannabis use disorders and nicotine dependence. *Drug and Alcohol Dependence*, 134, 228–234. [CrossRef][10.1016/j.drugalcdep.2013.10.003] [PubMed: 24183498]
- Pew Research Center. (2018). About six-in-ten Americans support marijuana legalization. Retrieved from <http://www.pewresearch.org/fact-tank/2018/01/05/americans-support-marijuana-legalization/>
- ProCon.org. (2018). 29 Legal Medical Marijuana States and DC: Laws, Fees, and Possession Limits. Retrieved from <https://medicalmarijuana.procon.org/view.resource.php?resourceID=000881>
- Rabin RA, & George TP (2015). A review of co-morbid tobacco and cannabis use disorders: possible mechanisms to explain high rates of co-use. *American Journal on Addictions*, 24, 105–116. [CrossRef][10.1111/ajad.12186] [PubMed: 25662704]
- Ramo DE, Liu H, & Prochaska JJ (2012). Tobacco and marijuana use among adolescents and young adults: a systematic review of their co-use. *Clinical Psychology Review*, 32, 105–121. [CrossRef][10.1016/j.cpr.2011.12.002] [PubMed: 22245559]
- Ream GL, Benoit E, Johnson BD, & Dunlap E (2008). Smoking tobacco along with marijuana increases symptoms of cannabis dependence. *Drug and Alcohol Dependence*, 95, 199–208. [CrossRef][10.1016/j.drugalcdep.2008.01.011] [PubMed: 18339491]
- Richter KP, & Levy S (2014). Big marijuana-lessons from big tobacco. *The New England Journal of Medicine*, 371, 399–401. [PMC][10.1056/NEJMp1406074] [24918955] [PubMed: 24918955]
- Roffman R (2016). Legalization of cannabis in Washington State: How is it going?. *Addiction*, 111, 1139–1140. [CrossRef][10.1111/add.13247] [PubMed: 26781325]
- Rolls S, & Murkin G (2016). How to regulate cannabis: A practical guide, (2nd ed.). Transform Drug Policy Foundation. <http://www.tdpf.org.uk/resources/publications/how-regulate-cannabis-practical-guide>. [TQ6]
- Rubinstein ML, Rait MA, & Prochaska JJ (2014). Frequent marijuana use is associated with greater nicotine addiction in adolescent smokers. *Drug and Alcohol Dependence*, 141, 159–162. [CrossRef][10.1016/j.drugalcdep.2014.05.015] [PubMed: 24928480]
- Russell C, Rueda S, Room R, Tyndall M, & Fischer B (2018). Routes of administration for cannabis use—basic prevalence and related health outcomes: A scoping review and synthesis. *International Journal of Drug Policy*, 52, 87–96. [CrossRef][10.1016/j.drugpo.2017.11.008] [PubMed: 29277082]
- Schauer GL, & Peters EN (2018). Correlates and trends in youth co-use of marijuana and tobacco in the United States, 2005–2014. *Drug and Alcohol Dependence*, [TQ7]
- Schauer GL, Berg CJ, Kegler MC, Donovan DM, & Windle M (2015). Assessing the overlap between tobacco and marijuana: Trends in patterns of co-use of tobacco and marijuana in adults from 2003–2012. *Addictive Behaviors*, 49, 26–32. [CrossRef][10.1016/j.addbeh.2015.05.012] [PubMed: 26036666]
- Schauer GL, King BA, Bunnell RE, Promoff G, & McAfee TA (2016). Toking, vaping, and eating for health or fun: marijuana use patterns in adults, US, 2014. *American Journal of Preventive Medicine*, 50, 1–8. [CrossRef][10.1016/j.amepre.2015.05.027] [PubMed: 26277652]
- Schauer GL, Rosenberry ZR, & Peters EN (2017). Marijuana and tobacco co-administration in blunts, spliffs, and mulled cigarettes: A systematic literature review. *Addictive Behaviors*, 64, 200–211. [CrossRef][10.1016/j.addbeh.2016.09.001] [PubMed: 27654966]
- Schuster RM, Mermelstein RJ, & Hedeker D (2016). Ecological momentary assessment of working memory under conditions of simultaneous marijuana and tobacco use. *Addiction (Abingdon, England)*, 111, 1466–1476. 10.1111/add.13342 [CrossRef][10.1111/add.13342]
- Shi Y, Lenzi M, & An R (2015). Cannabis liberalization and adolescent cannabis use: a cross-national study in 38 countries. *PLoS One*, 10, e0143562. [CrossRef][10.1371/journal.pone.0143562] [PubMed: 26605550]
- Steinberg L (2008). A social neuroscience perspective on adolescent risk-taking. *Developmental Review*, 28, 78–106. [CrossRef][10.1016/j.dr.2007.08.002] [PubMed: 18509515]
- Stolzenberg L, D'alessio SJ, & Dariano D (2016). The effect of medical cannabis laws on juvenile cannabis use. *International Journal of Drug Policy*, 27, 82–88. [CrossRef][10.1016/j.drugpo.2015.05.018] [PubMed: 26123892]

- Subbaraman MS (2016). Substitution and complementarity of alcohol and cannabis: A review of the literature. *Substance Use and Misuse*, 51, 1399–1414. [CrossRef] [10.3109/10826084.2016.1170145] [PubMed: 27249324]
- Subbaraman MS, & Kerr WC (2015). Simultaneous versus concurrent use of alcohol and cannabis in the National Alcohol Survey. *Alcoholism: Clinical and Experimental Research*, 39, 872–879. [CrossRef][10.1111/acer.12698]
- Terry-McElrath YM, O'malley PM, & Johnston LD (2013). Simultaneous alcohol and marijuana use among US high school seniors from 1976 to 2011: Trends, reasons, and situations. *Drug and Alcohol Dependence*, 133, 71–79. [CrossRef][10.1016/j.drugalcdep.2013.05.031] [PubMed: 23806871]
- Timberlake DS (2009). Are smokers receptive to using smokeless tobacco as a substitute?. *Preventive Medicine*, 49, 229–232. [CrossRef][10.1016/j.ypmed.2009.07.012] [PubMed: 19631684]
- United Nations Office on Drugs and Crime (UNODC). (2014). *World Drug Report 2014*. Vienna: United Nations Office on Drugs and Crime.
- Vandrey R, Raber JC, Raber ME, Douglass B, Miller C, & Bonn-Miller MO (2015). Cannabinoid dose and label accuracy in edible medical cannabis products. *Jama*, 313, 2491–2493. [CrossRef] [10.1001/jama.2015.6613] [PubMed: 26103034]
- Volkow ND, Swanson JM, Evins AE, DeLisi LE, Meier MH, Gonzalez R, ... Baler R (2016). Effects of cannabis use on human behavior, including cognition, motivation, and psychosis: A review. *JAMA Psychiatry*, 73, 292–297. [CrossRef][10.1001/jamapsychiatry.2015.3278] [PubMed: 26842658]
- Wackowski OA, & Delnevo CD (2015). Young adults' risk perceptions of various tobacco products relative to cigarettes: Results from the National Young Adult. *Health Education & Behavior*, 43, 328–336. [CrossRef][10.1177/1090198115599988] [PubMed: 26304709]
- Wall MM, Poh E, Cerdá M, Keyes KM, Galea S, & Hasin DS (2011). Adolescent marijuana use from 2002 to 2008: Higher in states with medical marijuana laws, cause still unclear. *Annals of Epidemiology*, 21, 714–716. [CrossRef][10.1016/j.annepidem.2011.06.001] [PubMed: 21820632]
- Weinberger AH, Platt J, & Goodwin RD (2016). Is cannabis use associated with an increased risk of onset and persistence of alcohol use disorders? A three-year prospective study among adults in the United States. *Drug and Alcohol Dependence*, 161, 363–367. [CrossRef][10.1016/j.drugalcdep.2016.01.014] [PubMed: 26875671]
- Wen H, Hockenberry JM, & Cummings JR (2015). The effect of medical marijuana laws on adolescent and adult use of marijuana, alcohol, and other substances. *Journal of Health Economics*, 42, 64–80. [CrossRef][10.1016/j.jhealeco.2015.03.007] [PubMed: 25863001]
- Winters KC, & Lee C-YS (2008). Likelihood of developing an alcohol and cannabis use disorder during youth: Association with recent use and age. *Drug and Alcohol Dependence*, 92, 239–247. [CrossRef][10.1016/j.drugalcdep.2007.08.005] [PubMed: 17888588]
- Yurasek AM, Aston ER, & Metrik J (2017). Co-use of alcohol and cannabis: A review. *Current Addiction Reports*, 4, 184–193. [CrossRef][10.1007/s40429-017-0149-8]