Cannabis Control Commission
COMMONWEALTH OF MASSACHUSETTS

A Baseline Review and Assessment of Cannabis Use and Youth: Literature Review and Preliminary Data in Massachusetts.

September 2019

Massachusetts Cannabis Control Commission:

Steven J. Hoffman, Chairman
Kay Doyle, Commissioner
Jennifer Flanagan, Commissioner
Britte McBride, Commissioner
Shaleen Title, Commissioner
Shawn Collins, Executive Director

Prepared by the Massachusetts Cannabis Control Commission Research Department:

Samantha M. Doonan, BA, Research Analyst
Jessica R. Hamilton, BA, Research Intern
Julie K. Johnson, PhD, Director of Research

Acknowledgements

Cannabis Control Commission

Chief of Staff
Erika Scibelli

Communications
Cedric Sinclair, Director of Communications
Maryalice Gill, Press Secretary
Kirsten Swenson, Communications Specialist

External

University of Massachusetts Amherst
Jennifer Whitehill, PhD
Seth Baker, MPH

Boston Children's Hospital
Sion K. Harris, PhD

Boston Medical Center
Alissa Cruz, MPH

Suggested bibliographic reference format:

Doonan SM., Hamilton, JR., Johnson, JK (2019, September). A Baseline Review and Assessment of Cannabis Use and Youth: *Literature Review and Preliminary Data in Massachusetts*. Boston, MA: *Massachusetts Cannabis Control Commission.*

Purpose

This report has been prepared in response to the enabling legislation, Chapter 55 section 17a (iii) to assess one item on the Cannabis Control Commissions' research agenda. This legislation section states: "*The commission shall develop a research agenda in order to understand the social and economic trends of marijuana in the commonwealth, to inform future decisions that would aid in the closure of the illicit marketplace and to inform the commission on the public health impacts of marijuana*."

One of the research agenda priority items includes:

> (1) patterns of use, methods of consumption, sources of purchase and general perceptions of marijuana among minors;

Chapter 55 additionally asserts the Commission shall incorporate available data, annually report on the results of its research, and make recommendations for further research or policy changes.

Table of Contents

I. Executive Summary

Non-medical cannabis use remains illegal for youth younger than 21 years old across the United States (U.S.), yet cannabis is the second most commonly used substance among this cohort. In 2017, 38% of Massachusetts high schoolers and 6% of middle schoolers reported having ever ("lifetime") used cannabis, while 24% of high schoolers and 2% of middle schoolers reported past 30-day ("current") cannabis use.[1] Meanwhile, youth perceptions about the risks from cannabis use are decreasing nationally.[2–6] Cannabis use patterns, perceptions, and related behaviors are critical to track for prevention and harm reduction as the adult-use cannabis market emerges.

The Massachusetts Cannabis Control Commission (CNB) conducted a scoping review of the issue and baseline data is herein presented. This report aims to assess youth cannabis use patterns and perceptions in the Commonwealth and nationally prior to adult-use cannabis implementation ("baseline"). To achieve this aim, we first present Massachusetts Youth Risk Behavior Survey (YRBS) data from 2007-2017. An overview of preliminary literature around the effects of varying cannabis legalization on youth cannabis use follows. Next, we present literature reviews on youth patterns of use, methods of consumption, sources of purchase, and general perceptions (*i.e. risk of harm, ease of access, parent disapproval, peer disapproval, and personal disapproval of peer use*). We further highlight a public health framework for cannabis legalization as it pertains to youth. Lastly, the report ends with a discussion of research and policy considerations.

Time and resource restraints did not permit an assessment of Massachusetts data around incidents of cannabis-related school suspensions and expulsions for this report, nor did it permit a cohort-specific assessment of at-risk youth (*e.g. those in treatment or screen positive for substance use disorder*). Future data sources are outlined, and procurements are in progress.

Main Findings

Massachusetts Youth Risk Behavior Survey

- In 2017, 38% of Massachusetts high schoolers reported having ever tried cannabis ("lifetime") use;
- Youth cannabis use rates decreased from 2011 to 2017, but have not decreased as quickly as alcohol use rates;
- Cannabis use is more common among 11th and 12th graders;
- Males and females are similarly likely to report lifetime and past-month ("current") cannabis use. Males are more likely to report heavy cannabis use;
- Cannabis use rates are similar among Black, Hispanic, and White cohorts, and are markedly lower among Asian cohorts;
- Achieving higher grades in school, having adult support, and being heterosexual were associated with lowered odds of cannabis use (“protective factors”); and
- Multiple factors may be "risk factors" for cannabis use. These behaviors/experiences fall under: (1) Disability; (2) Risky driving behaviors; (3) Weapon carrying/exposure, violence and bullying; (4) Hopelessness and suicidality behaviors; and (5) Sexual orientation and sexual behaviors.

National Trends in Youth Perceptions

- Researchers predict it will take at least a generation to see full effects of cannabis legalization on cannabis use patterns, thus, effects on youth use will likely be lagged;
- Changes to youths' perceptions of cannabis are critical to monitor;
- Nationally, youth perceptions of cannabis' harms are decreasing;
- Most older adolescents report that cannabis is easy to access, with the majority reporting accessing cannabis through friends;
- Most youth believe their parent strongly disapprove of youth cannabis use, but this trend has decreased over time; and
- Youth disapproval of their peers use of cannabis has decreased.

II. Brief History of Cannabis Policies

Cannabis has been used for religious, recreational, and therapeutic purposes for thousands of years, it is no surprise that cannabis is currently the most frequently cultivated, trafficked, and abused illicit substance ("drug") worldwide.[18–22] In the United States (U.S.), cannabis cultivation and use were legal under federal and state policies for most of American history. An increase in cannabis use from 1910-1920, coupled with political hysteria, led twenty-nine states including Massachusetts to pass policies prohibiting the possession or sale of cannabis.[19,23,24]

In 1970, the Federal Controlled Substance Act (CSA) replaced the Marihuana Tax Act of 1937 and placed cannabis ("marijuana") as a Schedule 1 drug, the most restrictive ranking. Despite increasing stringency of federal cannabis policies over time, the recreational use of cannabis increased. In 1971, President Richard Nixon declared a war on drugs aiming to combat substance abuse on the supply and demand sides. However, a disproportionate number of War on Drug policies focused on criminal justice enforcement and punishment for drug offenses—creating systematic changes in the criminal justice system.

Currently in the CSA and under the U.S. Drug Enforcement Agency (DEA) jurisdiction, cannabis remains classified as a Schedule 1 drug, contending that it has: (1) a high potential for abuse, (2) no current accepted medical use in the U.S., and (3) a lack of accepted safety for use under medical supervision.[25,26]

Moving Toward Legalization

Movement toward cannabis legalization has occurred on a state-by-state basis. The first wave of cannabis legalization was decriminalization, which replaced criminal sanctions for possession and small-scale distribution of cannabis with civil fines.[27] Since 1972, 26 states and the District of Columbia (D.C.) have enacted policies decriminalizing small amounts of cannabis.

Medicinal marijuana policies followed, allowing access and use of cannabis for certain medical purposes. Since 1996, 33 states, D.C., Guam, and Puerto Rico have enacted varying policies permitting comprehensive medicinal cannabis programs.

Adult-use legalization policies allow cannabis use by adults in certain settings and may allow retail stores. Since 2012, eleven states and D.C. have enacted varying policies permitting small amounts of cannabis for non-medical adult-use for those 21 years-old or older ("21≤").[28]

Massachusetts

Massachusetts has enacted and implemented all three types of cannabis legalization in disparate waves. All waves of Massachusetts cannabis legalization were enacted via ballot initiatives: cannabis decriminalization in 2008 with Question 2, "*The Sensible Marijuana Policy Initiative*," medical cannabis in 2012 with Question 3, "*An Initiative Petition for a Law for the Humanitarian Medical Use of Marijuana*," and non-medical adult-use cannabis legalization in 2016 with Question 4, "*Massachusetts Legalization, Regulation and Taxation of Marijuana Initiative.*"

III. Data Sources and Limitations

Chapter 55 of the Acts of 2017 section 17(a)(vii) states the Cannabis Control Commission research agenda shall include "*patterns of use, methods of consumption, sources of purchase and general perceptions of marijuana among minors, among college and university students and among adults;"* and *"a compilation of data on the number of incidents of discipline in schools, including suspensions or expulsions, resulting from marijuana use or possession of marijuana or marijuana products."*

Use Patterns

Youth patterns of use were assessed through data analysis of the Massachusetts Youth Risk Behavior Survey (YRBS) survey. The YRBS samples randomly selected classrooms within randomly selected public schools in the Commonwealth every other year. As with any data source, YRBS is subject to limitations. YRBS data is self-reported and not validated by external measurements.[29] Therefore, students may inaccurately report, and/or give socially desirable answers. Only those who attend school and are present on the day of survey administration are included in the sample. This is a limitation as youth who are frequently absent or do not attend school may be more likely to engage in risky behaviors (*e.g. cannabis use*).[29] To complement analyses, a literature review was also conducted.

Consumption Methods, Sources, and Perceptions

A series of literature reviews were conducted around youth methods of consumption, sources of purchase, and perceptions. These included: (1) perceived risk of harm from cannabis use, (2) perceived access to cannabis, (3) perceived parent disapproval of cannabis use for youth, (4) perceived peer disapproval, and (5) youth personal disapproval of cannabis use. All reviews attempt to assess time trends, the impact of medical cannabis legalization, and the impact of adult-use legalization on perceptions.

School Discipline

Due to resource constraints, incidents of suspensions and expulsions for cannabis-related offenses could not be assessed in time for this report. Future reports will include analysis concerning the frequency of cannabis-related discipline, over time and by demographic sub-group.

The Department of Elementary and Secondary Education (DESE) collects data on school discipline, including suspensions and expulsions for all students in public education. Two cannabis-specific variables are captured in the reason for discipline: "marijuana possession" and

"marijuana use." Deidentified student data, including race, ethnicity, gender, special education status, economic disadvantage, limited English proficiency, and high needs status, along with reason for discipline and length of discipline are available publicly at http://www.doe.mass.edu/infoservices/research/ and will be assessed in future reports.

Substance-Use Screening

Chapter 52 of the Acts of 2016, An Act Relative to Substance Use, Treatment, Education and Prevention (known as the STEP Act), requires all public schools in the Commonwealth to implement a verbal screening tool (*e.g. Screening, Brief Intervention, and Referral to Treatment [SBIRT]*) to screen students for substance use disorders, including those related to cannabis.[1] Implementation was required by the 2017-18 school year and de-identified screening results must be submitted to the Department of Public Health annually. Due to time and resource restraints, substance use screening data for youth could not be obtained for purposes of this report. However, in future reports assessing youth and cannabis, attempts will be made to include screening data results for all available years stratified by age/grade, and by any cannabis use. Feasibility of obtaining historical data from the SBIRT program's use of the screening tool around school nurse trainings and school-specific implementation, and in inpatient and outpatient provider settings will also be investigated.

[1] https://malegislature.gov/Laws/SessionLaws/Acts/2016/Chapter52

IV. Important Considerations

1) Policy impacts on youth will likely be lagged

The impact of adult-use cannabis legalization on youth use will likely be delayed and may be lagged. Evidence from the alcohol literature suggests effects could be delayed ten-years or longer.[7] Although comparisons are imperfect, researchers note delayed effects for alcohol levels to reach pre-prohibition levels after prohibition ended and the lag between pre-rolled cigarette manufacturing and their subsequent health impact.[8–10] Caulkins et al. 2016 predict it will take at least a generation to see full effects of cannabis legalization on use patterns.[10]

Researchers have also identified a number of factors that could change over time and may delay effects. These include, implementation delays,[11] policy change/evolution,[12] price changes,[8,12] potency changes/limits,[8] changes to types of products,[8] and social norm changes.[8,11]

In light of projected lagged effects, research suggests there are several indicators to monitor which may precede increased youth use. Researchers have emphasized monitoring changes in perceived risks and social acceptability of cannabis, [See *Section VII. Literature Reviews*], frequency of use by current users, use by those in the juvenile justice system, those in treatment for mental health[13] or substance use disorder conditions, and changes to rates of cannabis use disorders.[14]

2) All youth may not be affected equally

Policy changes may not affect all youth the same way. Research should assess diversity among youth to understand how policy may impact cohorts differentially (*e.g. age, gender, race/ethnicity, sexual minority status, disability status, and more*).

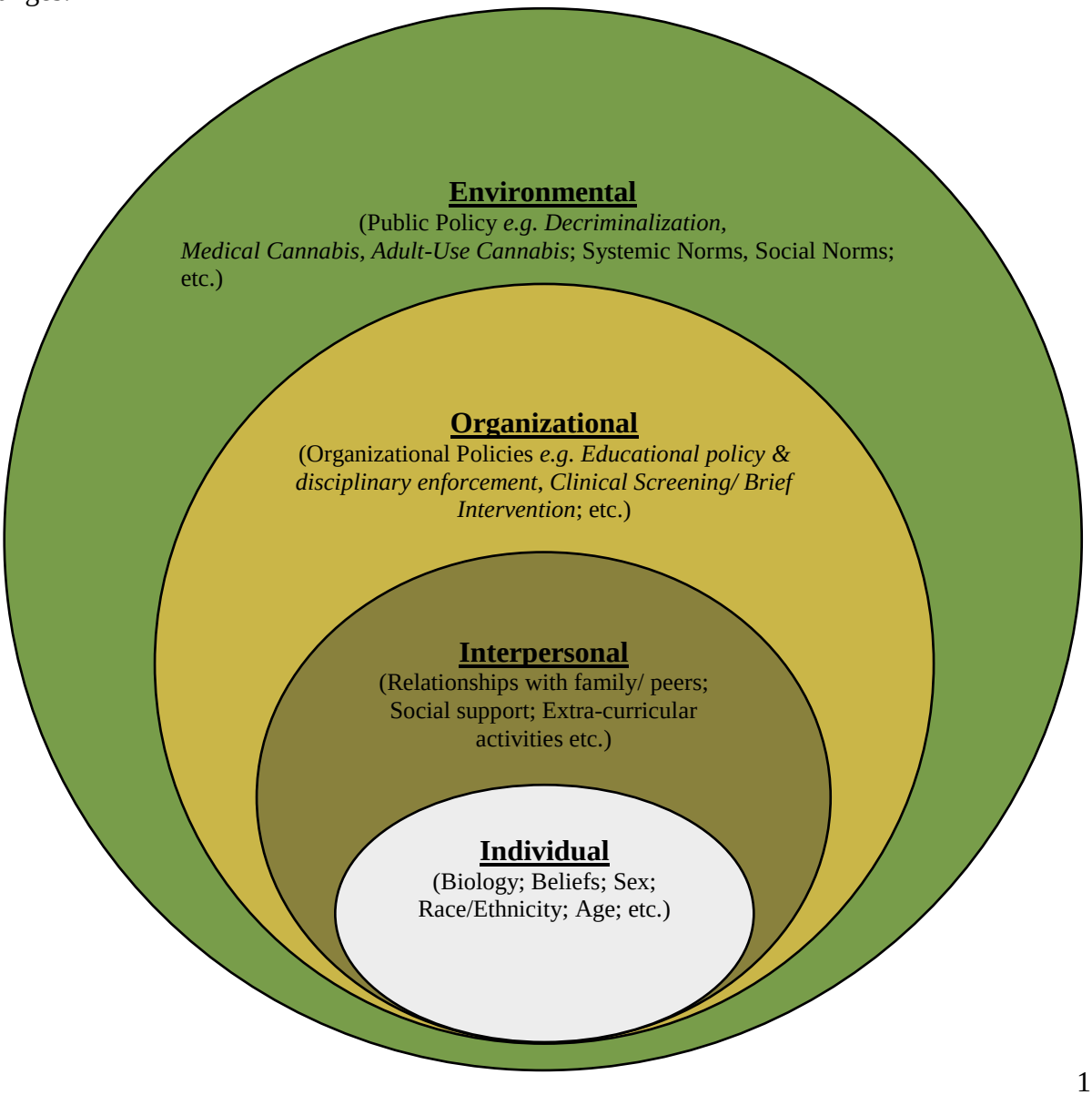
The Youth Risk Behavior Surveillance Survey used in this report to assess varying cannabis use trends in Massachusetts has limitations. The YRBS does not capture all youth in the state and may systemically exclude youth cohorts most at-risk, such as those who are chronically absent, dropped out of school, or are incarcerated.[15] Therefore, the data presented likely excludes youth at higher-risk than the general youth population. Data is also self-reported and inaccuracies could not be assessed. However, it is likely that these sources of bias remain constant over time permitting a more accurate comparison of trends across time rather than prevalence estimates.

Due to resource and time restraints, a full analysis of all potentially relevant variables could not be conducted. Additionally, data from youth who are seeking treatment for substance use disorders could not be obtained. In future reports, we will aim to access and include this data.

3) Youth cannabis use should be assessed in context of environment

Youth development occurs within multiple environmental systems, and adolescent behavior is shaped by these environments (*e.g. family, neighborhood, community, culture, society*).[16] Additionally, environmental contexts may affect youth differently based on individual characteristics. Youth are exposed to a range of views of cannabis at multiple environmental levels, including messages that aim to normalize cannabis use among adults, and conversely, messaging that portrays cannabis to be as harmful as substances such as heroin.[17] The effects of these messages are not fully understood.

Leveraging data that permits the assessment of social and environmental contexts surrounding youth may help explain cannabis use and related trends. Future reports will aim to access and include better contextual and social norm data. Consideration of specific policy environments ("policy heterogeneity") where youth live is also critical to understanding any impacts of policy changes.[12]



V. Baseline Data

Youth Risk Behavior Surveillance Survey

Overview

This study used the Massachusetts Youth Risk Behavior Surveillance Survey (YRBS) data. The YRBS data was procured by the Cannabis Control Commission's Research Department for purposes of this report.

The complete YRBS study sample consists of eight cohorts, each representing the year respondents in that cohort were surveyed as high school students, grades 9-12 in Massachusetts, years 2007-2017 [N=17,691].

YRBS data is based on a two-stage cluster sample design to ascertain a representative sample of high school students in the state jurisdiction. The sampling frame includes all 9-12th grade students attending high school. The primary sampling units (PSUs) are all public schools within Massachusetts. In the first stage, a random sample of public high schools are selected for participation in the survey. Most schools are selected with probability proportional to enrollment size. In the second stage, a random sample of a required course or period classrooms are selected within each selected school. All students in selected classrooms are invited to participate in the survey. All years of data are weighted, meaning Massachusetts had a scientifically selected sample, appropriate documentation, and a 60 percent response rate in each year of data collection.

In the findings below, reference charts of student alcohol and tobacco use are provided whenever possible for context.

All Grades (9-12th) Cannabis Use

Ever Use ("Lifetime")

In 2017, 38.1% of Massachusetts high schoolers report lifetime cannabis use. In comparison, 56.4% of high schoolers report lifetime alcohol use. The percentage of high schoolers reporting lifetime cannabis use increased from 2007 to 2011, followed by a downward trend from 2011 to 2017. The percent of youth reporting lifetime alcohol use has trended downward from 2007—decreasing at a greater rate in comparison to lifetime cannabis use. [See *Chart V.A.1, Chart V.A.2* below]

Chart V.A.1. MA High Schoolers Lifetime Cannabis Use, YRBS 2007-2017

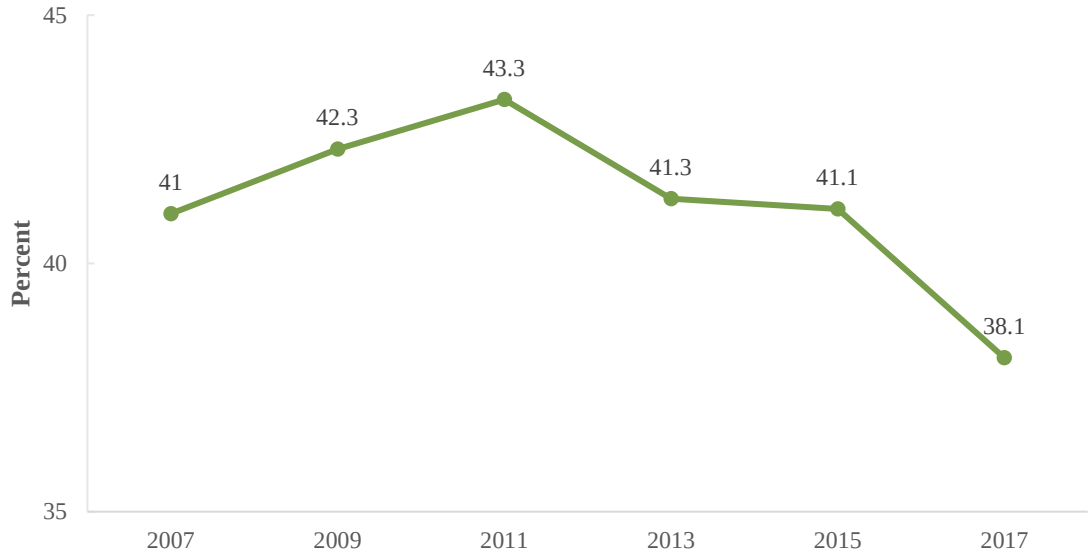
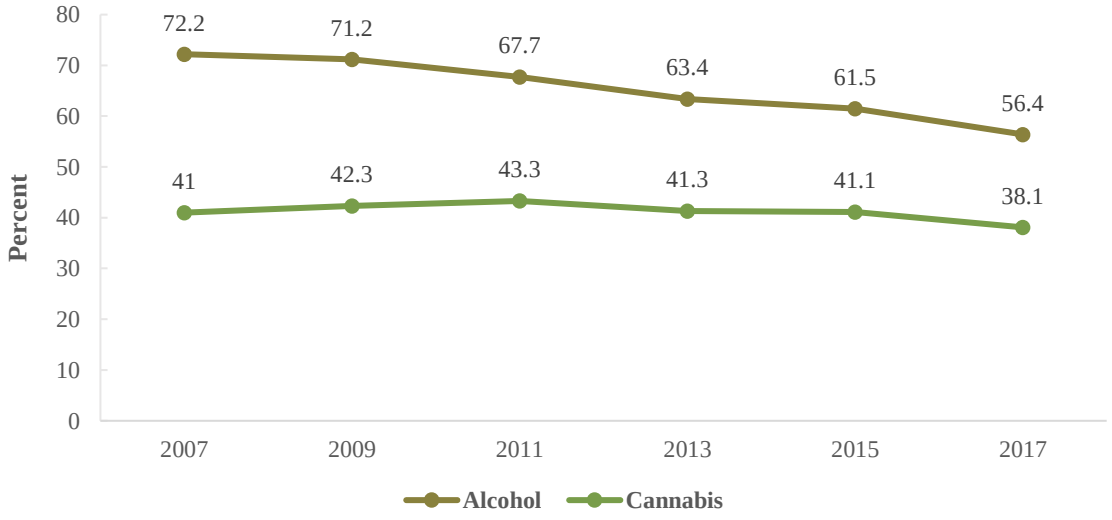


Chart V.A.2. MA High Schoolers Lifetime Cannabis and Alcohol Lifetime Use, YRBS 2007-2017



Current Use (Past 30-Day)

In 2017, 24.2% of Massachusetts high schoolers report past 30-day ("current") cannabis use. The percent of current cannabis users increased from 2007 to 2011, before decreasing from 2011 to 2017. In comparison, 31.5% of high schoolers report current alcohol use and 6.1% report current tobacco use (*not including vaping*). Both past 30-day alcohol and tobacco use rates have decreased since 2007 at greater rates than cannabis use rates. [See *Chart V.A.3, Chart V.A.4* below]

Chart V.A.3. MA High Schoolers Current Cannabis Use, YRBS 2007-2017

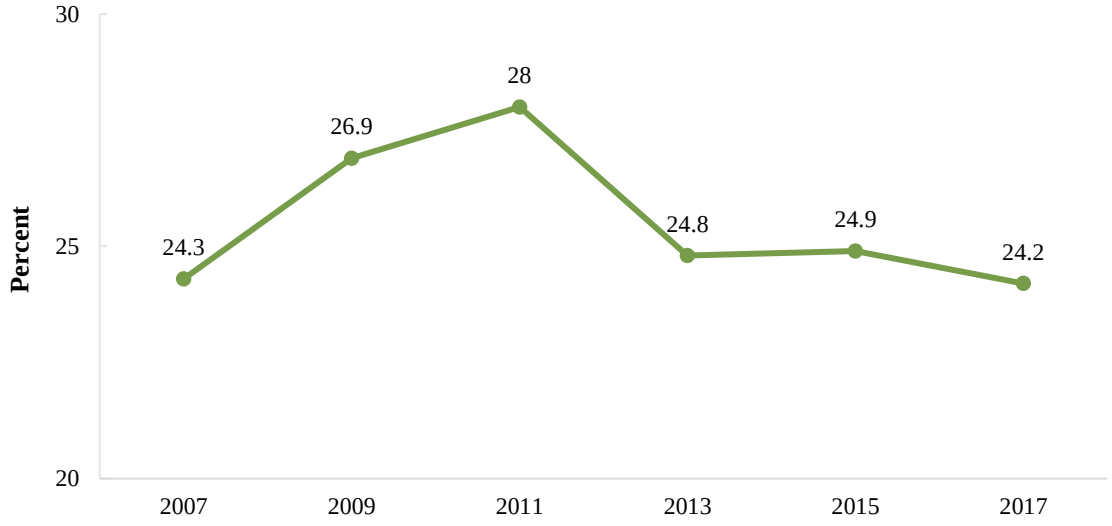
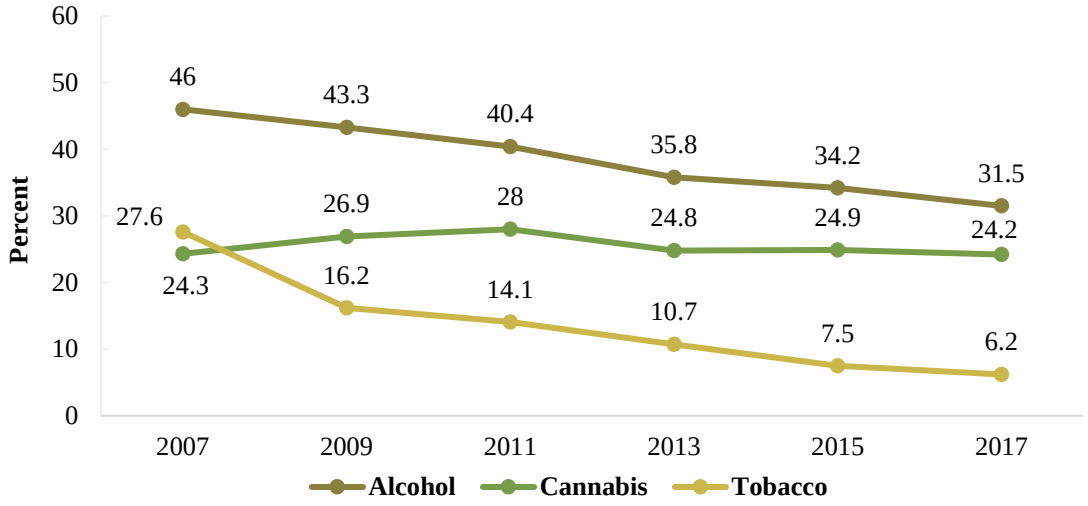


Chart V.A.4. MA High Schoolers Current Cannabis, Alcohol, Tobacco Use,* YRBS 2007-2017



*Vaping is excluded from tobacco category.

Heavy Use (Past 30-Day)

In 2017, 5.6% of Massachusetts high schoolers report that they had used cannabis 20 or more times ("heavy use") in the past 30-days. In comparison, 15.9% of high schoolers report heavy alcohol use ("binge drinking") in the past 30-days. Between 2007 and 2011, heavy cannabis use trended upward, followed by a downward trend from 2011 to 2017. Binge drinking in the past 30-days has consistently declined. [See *Chart V.A.5, Chart V.A.6* below]

Chart V.A.5. MA High Schoolers Heavy Cannabis Use, YRBS 2007-2017

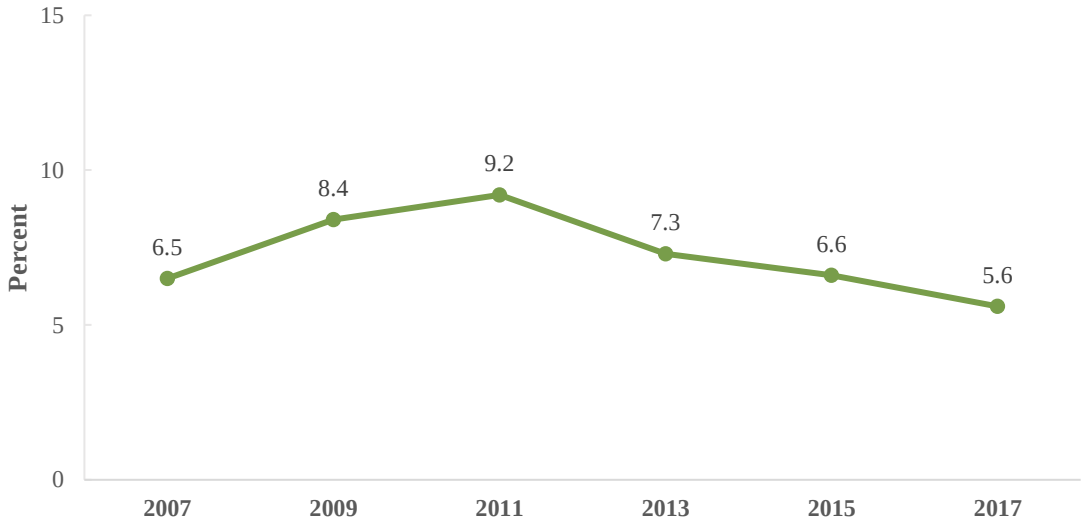
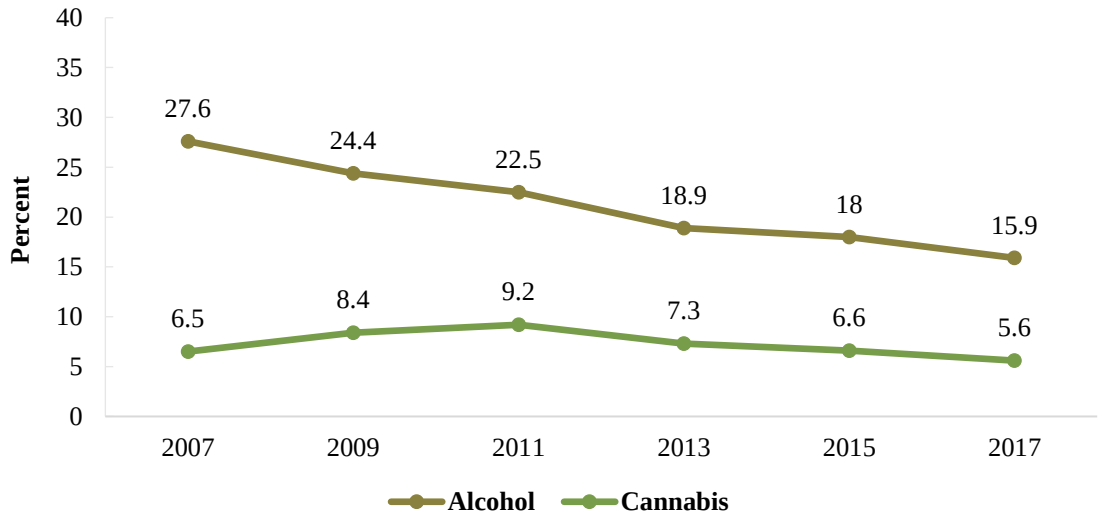


Chart V.A.6. MA High Schoolers Heavy Cannabis and Alcohol Use, YRBS 2007-2017



Cannabis Use by Grade

Ever Use ("Lifetime")

Fewer students in grades 9 and 10 report lifetime cannabis compared to students in 11 and 12. This trend is consistent across time and is similarly seen in youth who report lifetime alcohol use. The percent of Massachusetts ninth and eleventh graders who report lifetime cannabis use has trended downward from 2011-2017; other grades did not show clear trends. Lifetime alcohol use trended downward from 2007 to 2017 for all grades. [See *Chart V.B.1, Chart V.B.2* below]

Chart V.B.1. MA High Schoolers Lifetime Cannabis Use by Grade, YRBS 2007-2017

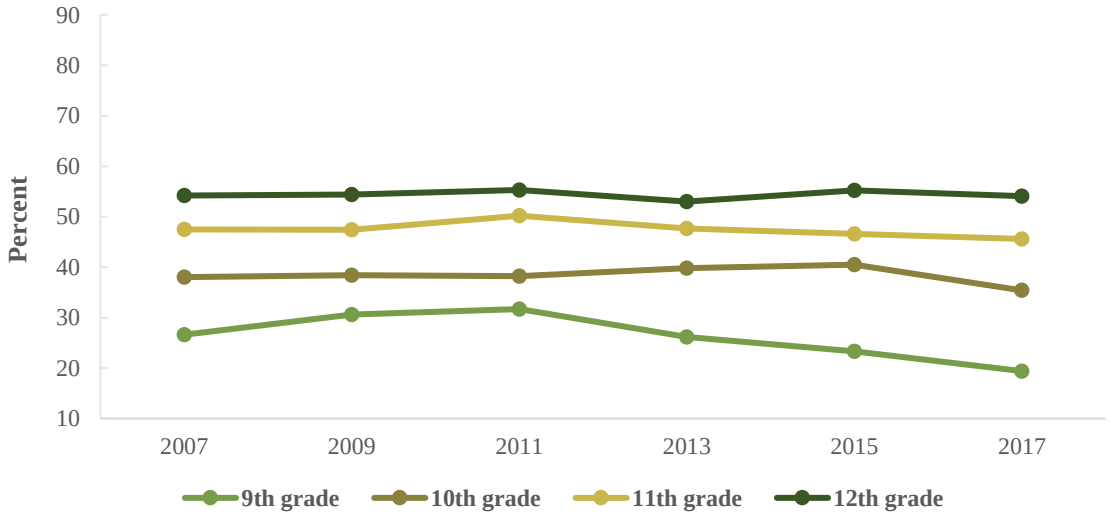
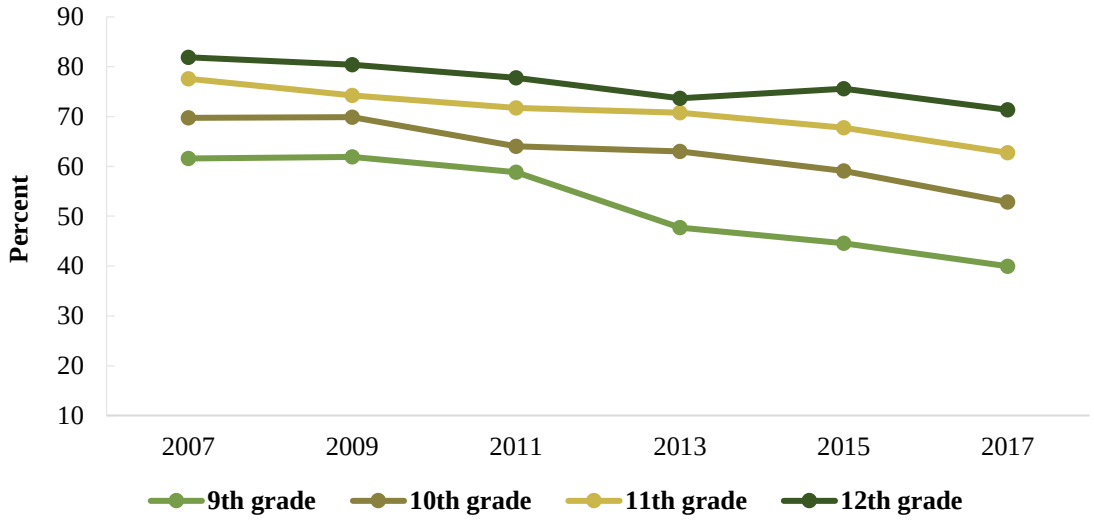


Chart V.B.2. MA High Schoolers Lifetime Alcohol Use by Grade, YRBS 2007-2017



Current Use (Past 30-Day)

A smaller percentage of students in grades 9 and 10 report current cannabis use compared to students in grades 11 and 12. This trend is consistent across time and is similarly seen in current alcohol use rates. The percentage of Massachusetts ninth graders reporting current cannabis use decreased from 2011-2017; other grades do not show clear trends. Current alcohol and tobacco use (*excluding vaping*) trended downward from 2009 to 2017 for all grades. [See *Chart V.B.3, Chart V.B.4, Chart V.B.5* below]

Chart V.B.3. MA High Schoolers Current Cannabis Use by Grade, YRBS 2007-2017

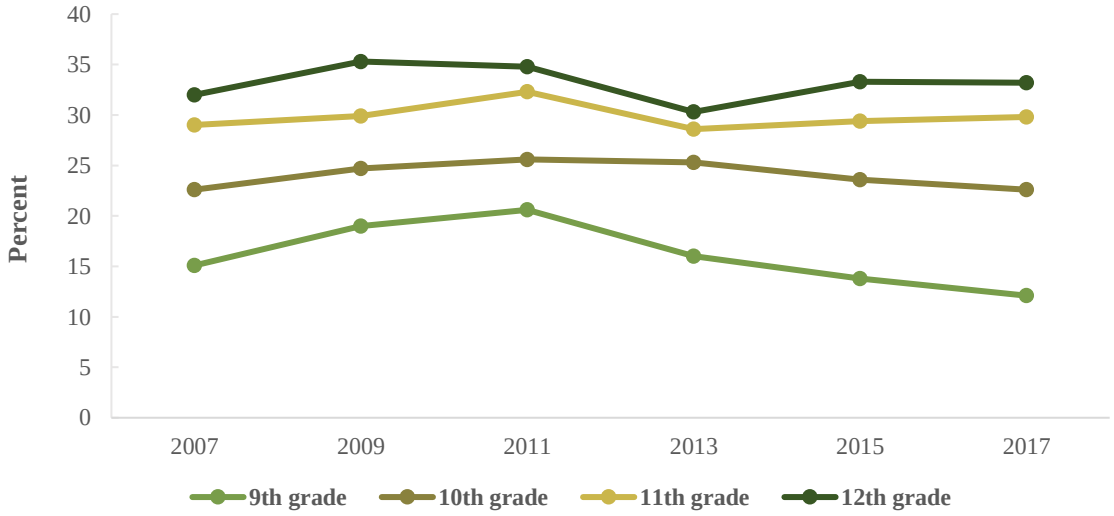


Chart V.B.4. MA High Schoolers Current Alcohol Use by Grade, YRBS 2007-2017

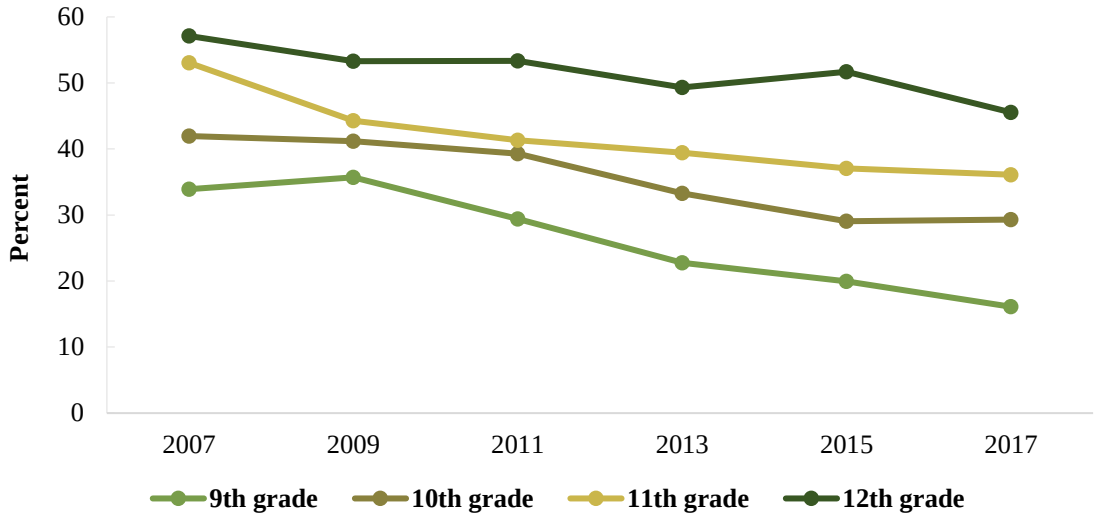
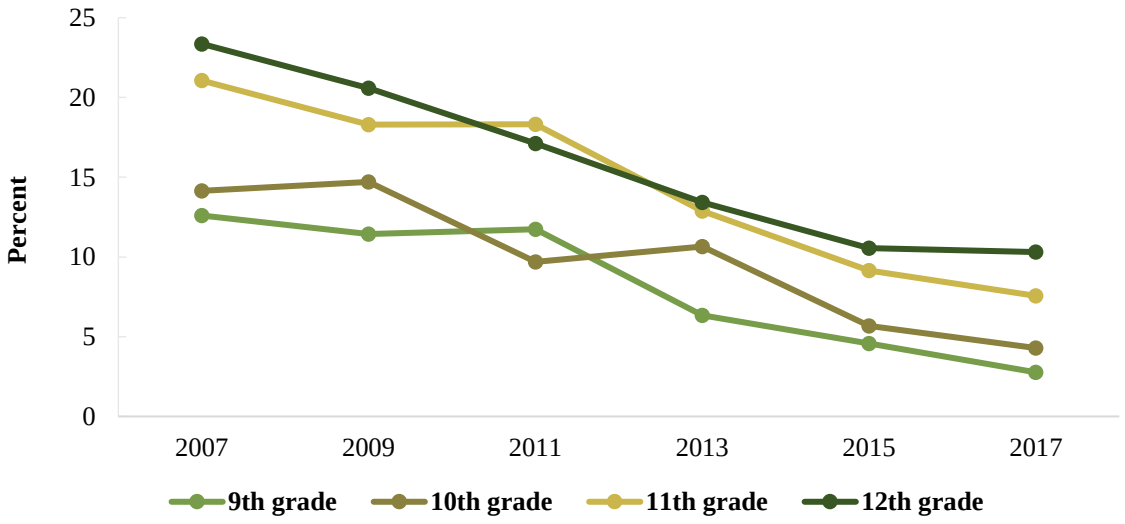


Chart V.B.5. MA High Schoolers Current Tobacco Use* by Grade, YRBS 2007-2017



*Vaping is excluded from tobacco category.

Heavy Use (Past 30-Day)

Similar to lifetime and current use, fewer students in grades 9 and 10 report heavy cannabis use compared to students in grades 11 and 12. The percentage of Massachusetts ninth and tenth graders who report heavy cannabis use decreased from 2013-2017; other grades do not show clear trends. Binge drinking trended downward from 2007 to 2017 for all grades. [See *Chart V.B.6, Chart V.B.7* below]

Chart V.B.6. MA High Schoolers Heavy Cannabis Use by Grade, YRBS 2007-2017

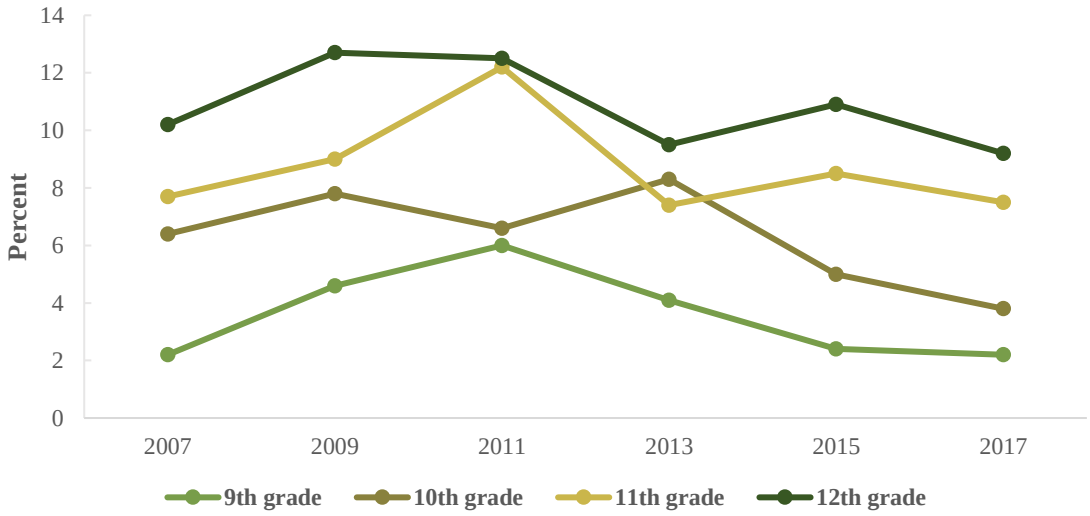
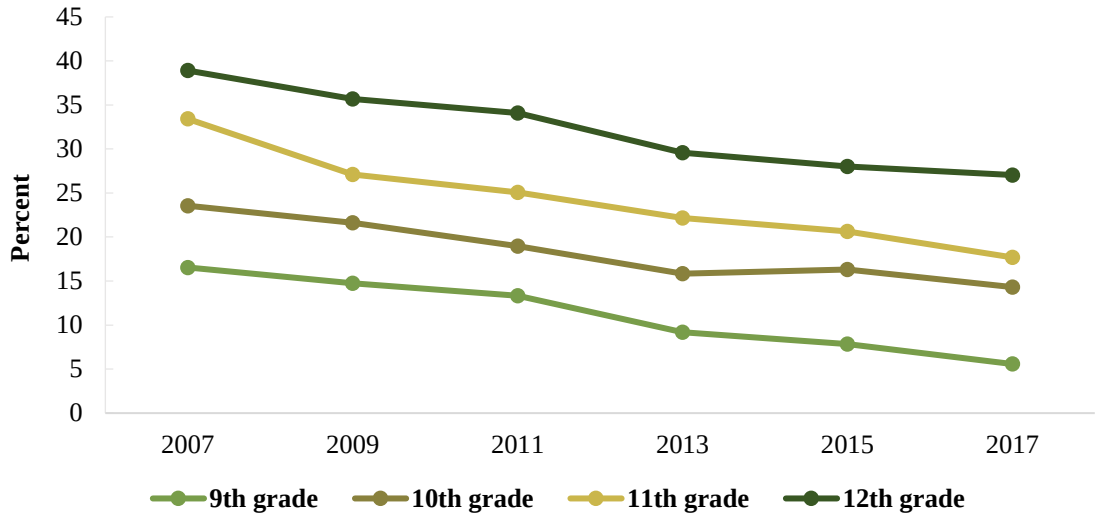


Chart V.B.7. MA High Schoolers Binge Drinking by Grade, YRBS 2007-2017



Cannabis Use by Gender

Ever Use ("Lifetime")

More males (44.1%) compared to females (39.4%) report lifetime cannabis between 2007 and 2017; However, this gap is decreasing. From 2011 to 2017, lifetime cannabis use among males trended downward, while lifetime cannabis use among females trended upward. In 2017, the gender gap in lifetime cannabis closed, with females (38.4%) reporting slightly higher lifetime use compared to males (37.5%). [See *Chart V.C.1, Chart V.C.2* below]

For alcohol, females report higher lifetime use rates between 2007 and 2017. Both male and female lifetime alcohol use decreased from 2007 to 2017, with rates decreasing faster in males than females from 2013 to 2017. [See *Chart V.C.3, Chart V.C.4* below]

Chart V.C.1. MA High Schoolers Lifetime Cannabis Use by Gender, YRBS 2007-2017

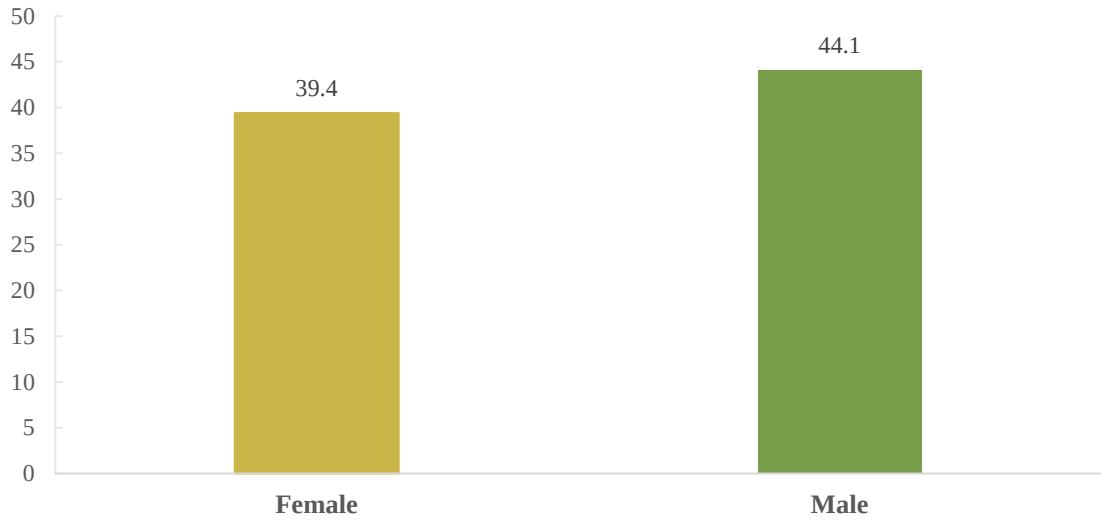


Chart V.C.2. MA High Schoolers Lifetime Cannabis Use by Gender Over Time, YRBS 2007-2017

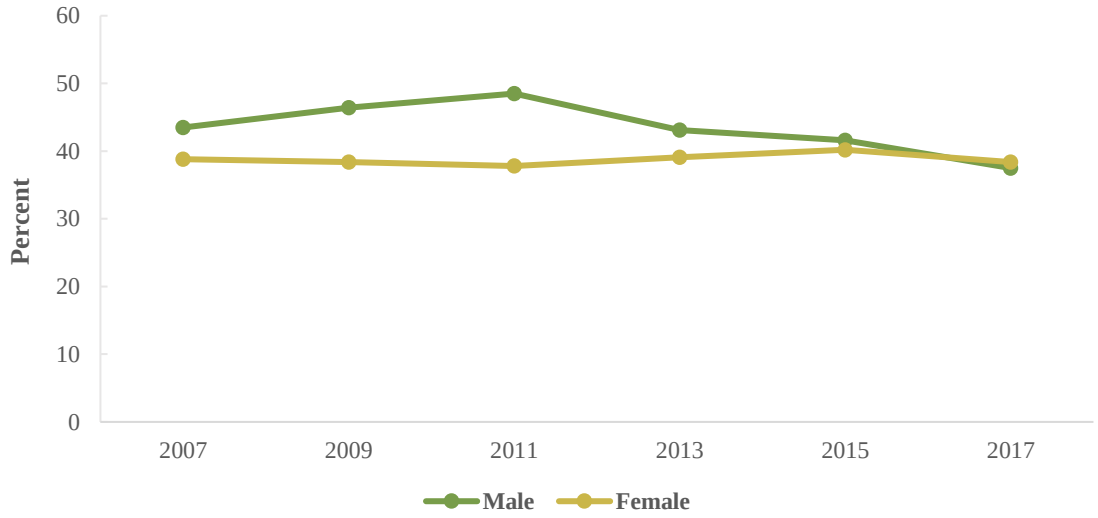


Chart V.C.3. MA High Schoolers Lifetime Cannabis and Alcohol by Gender, YRBS 2007-2017

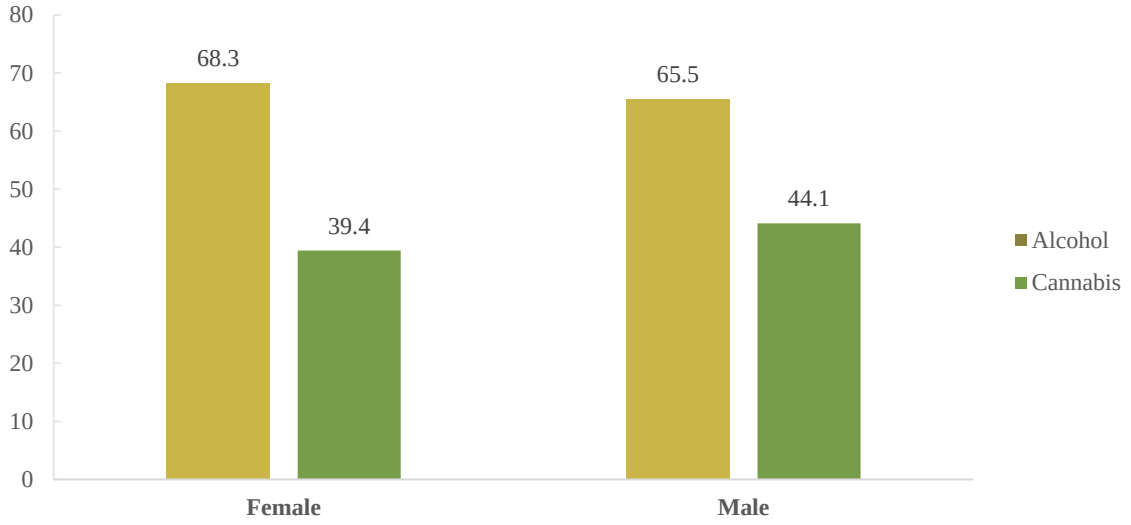
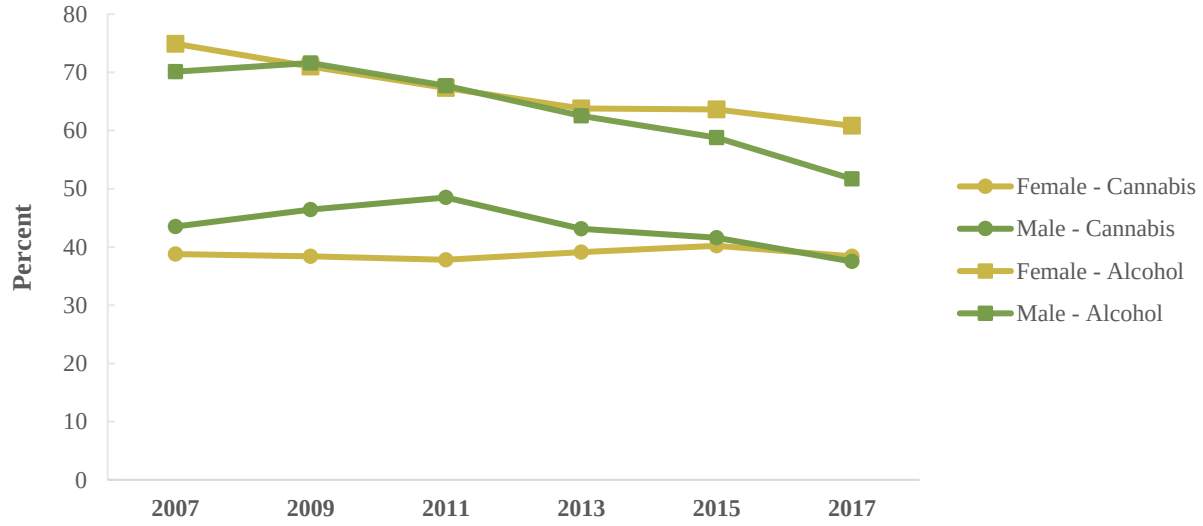


Chart V.C.4. MA High Schoolers Lifetime Cannabis and Alcohol by Gender Over Time, YRBS 2007-2017



Current Use (Past 30-Day)

More males (28.5%) than females (22.6%) report past 30-day ("current") cannabis use between 2007 and 2017; However, this gap is decreasing. From 2011 to 2017, current cannabis use among males decreased, while current cannabis use among females increased from 2013-2017. In 2017, males (24.9%) had a slightly higher current use rate than females (23.2%). [See *Chart V.C.5, Chart V.C.6*]

For alcohol, a slightly higher percentage of females report current use compared to males. More males than females were current tobacco (*excluding vaping*) users. Both male and female current alcohol use and non-vaped tobacco use trended downward between 2011 and 2017. [See *Chart V.C.7, Chart V.C.8* below]

Chart V.C.5. MA High Schoolers Current Cannabis Use by Gender, YRBS 2007-2017

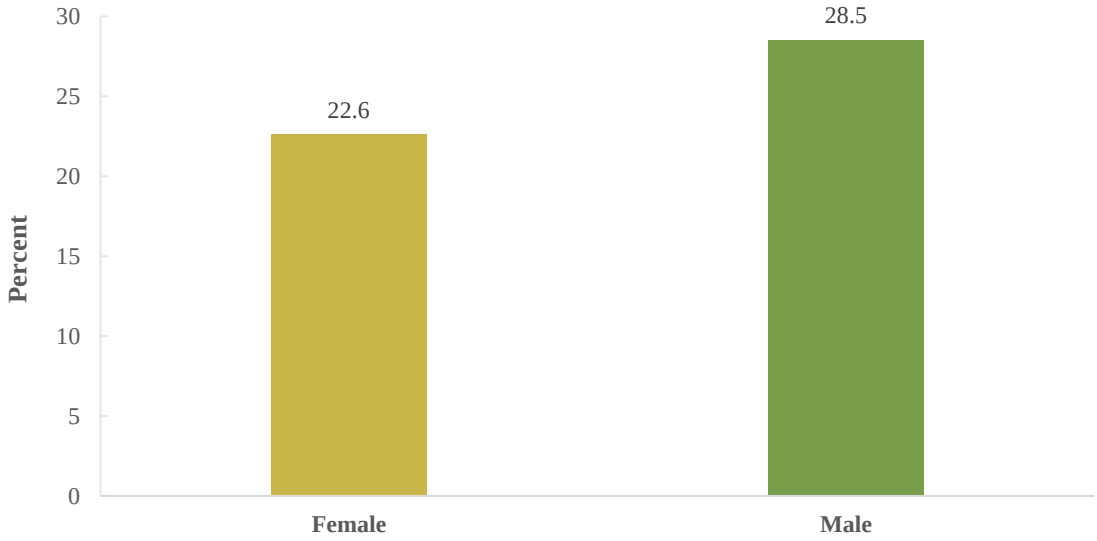


Chart V.C.6. MA High Schoolers Current Cannabis Use by Gender Over Time, YRBS 2007-2017

Chart V.C.7. MA High Schoolers Current Cannabis, Alcohol, and Tobacco Use* by Gender, YRBS 2007-2017

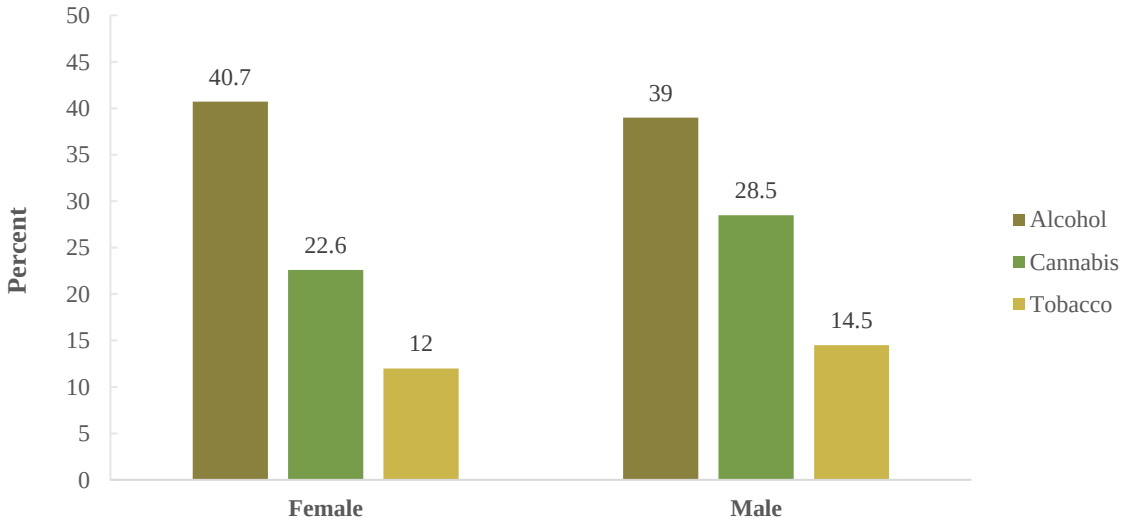
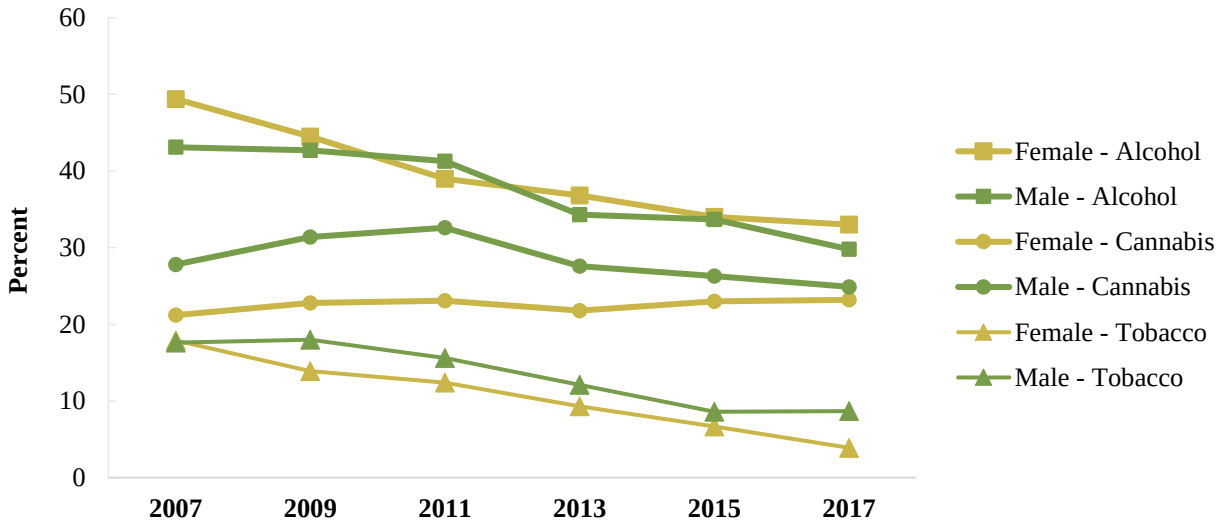


Chart V.C.8. MA High Schoolers Current Cannabis, Alcohol, and Tobacco Use* by Gender Over Time, YRBS 2007-2017



Heavy Use (Past 30-Day)

More males (10.2%) than females (4.5%) report that they have used cannabis 20 or more times in the past 30-days ("heavy user") between 2007-2017. Both genders show slight downward trends from 2011 to 2017. [See *Chart V.C.9, Chart V.C.10* below]

For alcohol, a higher percent of males report binge drinking compared to females. Both male and female binge drinking rates decreased from 2007 to 2017. [See *Chart V.C.11, Chart V.C.12* below]

Chart V.C.9. MA High Schoolers Heavy Cannabis Use by Gender, YRBS 2007-2017

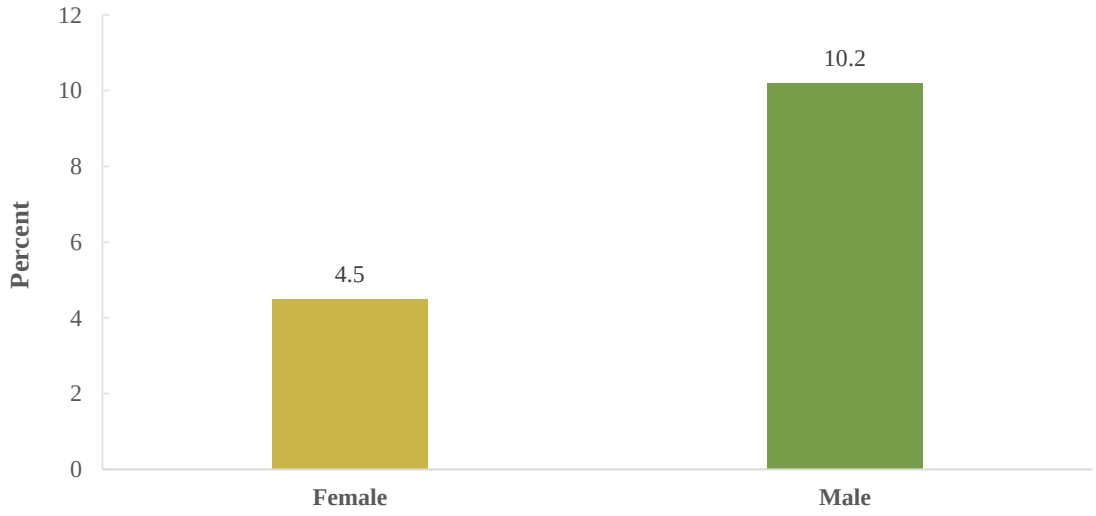


Chart V.C.10. MA High Schoolers Heavy Cannabis Use by Gender Over Time, YRBS 2007-2017

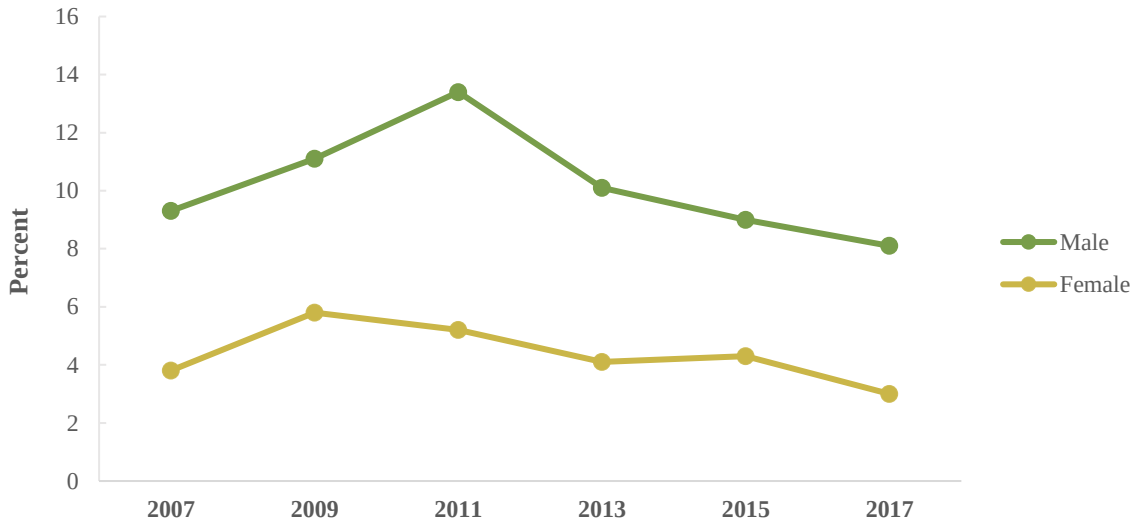
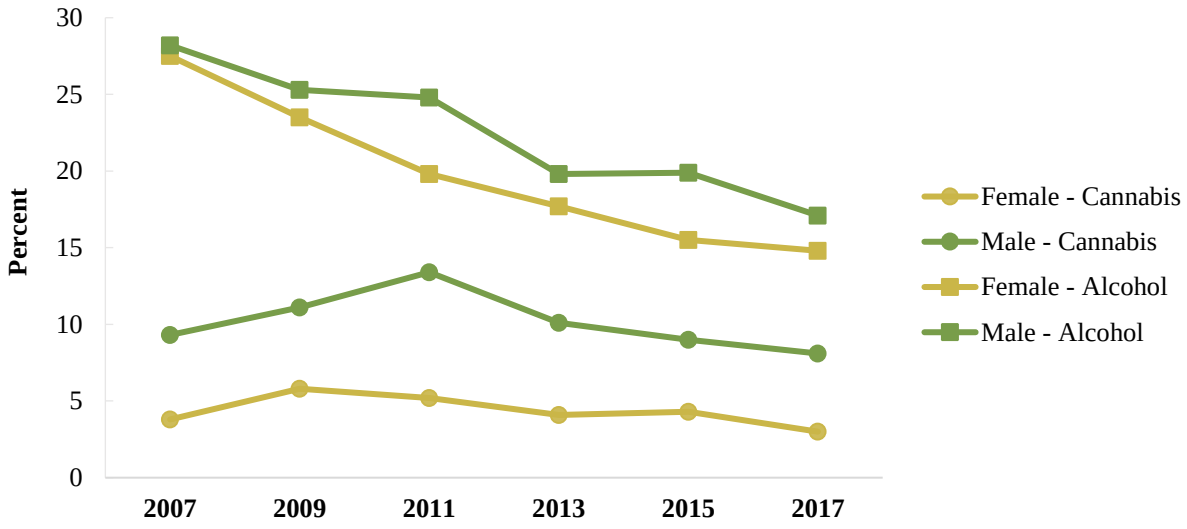


Chart V.C.11. MA High Schoolers Heavy Cannabis and Alcohol Use by Gender, YRBS 2007-2017

Chart V.C.12. MA High Schoolers Heavy Cannabis and Alcohol Use by Gender Over Time, YRBS 2007-2017



Cannabis Use by Race/Ethnicity

Only results for White, Black, Hispanic, and Asian students are included in this section, as sample sizes for American Indian/Alaskan Natives and Native Hawaiian/Pacific Islanders were low. [See *Appendix Table II.3. MA High Schoolers Cannabis Use by Demographics, YRBS 2007-2017* for full tables including these two groups]

Ever Use ("Lifetime")

Hispanics (43.2%), followed by Whites (41.9%) and Blacks (40.4%), report the largest percentages of having ever tried cannabis ("lifetime use") between 2007-2017. Asians (20.1%) report less lifetime cannabis use between 2007-2017. All racial/ethnic groups report less lifetime use between 2015 and 2017, However, Whites had the smallest decline. In 2017, 41.6% of Hispanics, 39.5% of Whites, 33.1% of Blacks, and 16.1% of Asians report lifetime cannabis use. [See *Chart V.D.1, Chart V.D.2* below]

For alcohol, Hispanics and Whites report the highest percentage of lifetime use, followed by Blacks and Asians between 2007-2017. All racial/ethnic groups report less lifetime alcohol use between 2015 and 2017, with Whites having the smallest decline. [See *Chart V.D.3, Chart V.D.4* below]

Chart V.D.1. MA High Schoolers Lifetime Cannabis Use by Race/Ethnicity, YRBS 2007-2017

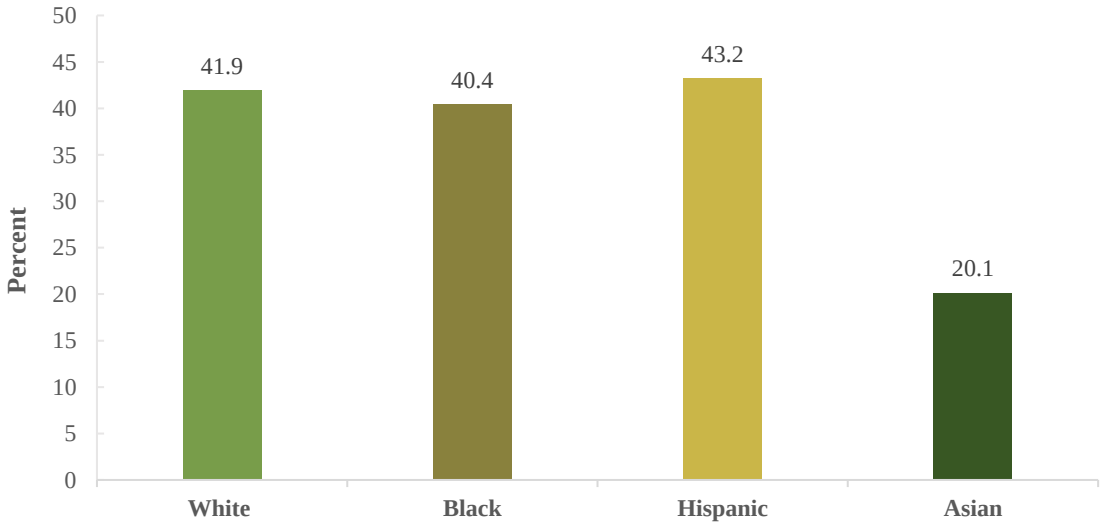


Chart V.D.2. MA High Schoolers Lifetime Cannabis Use by Race/Ethnicity Over Time, YRBS 2007-2017

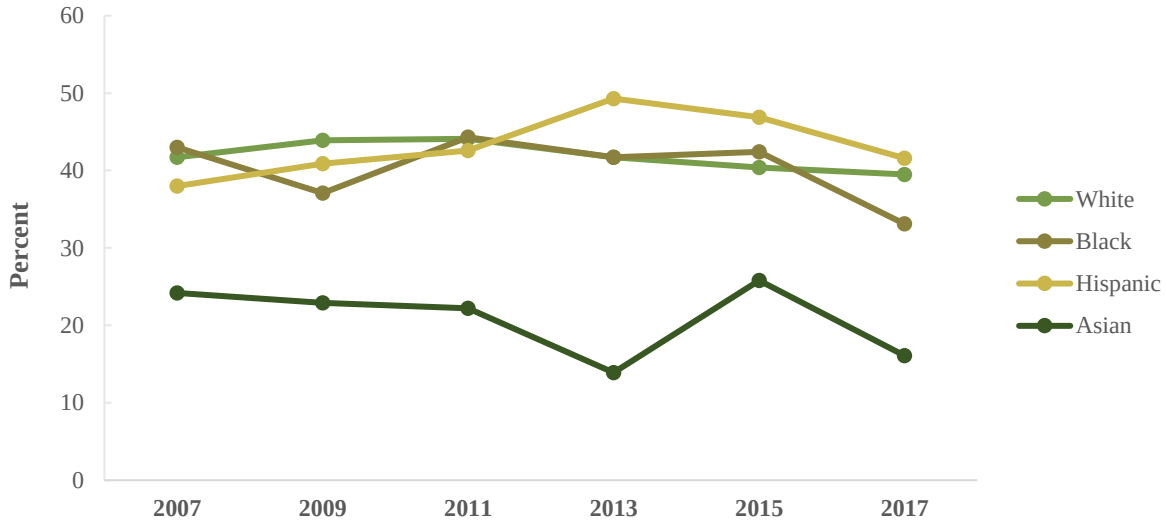


Chart V.D.3. MA High Schoolers Lifetime Cannabis and Alcohol by Race/Ethnicity, YRBS 2007-2017

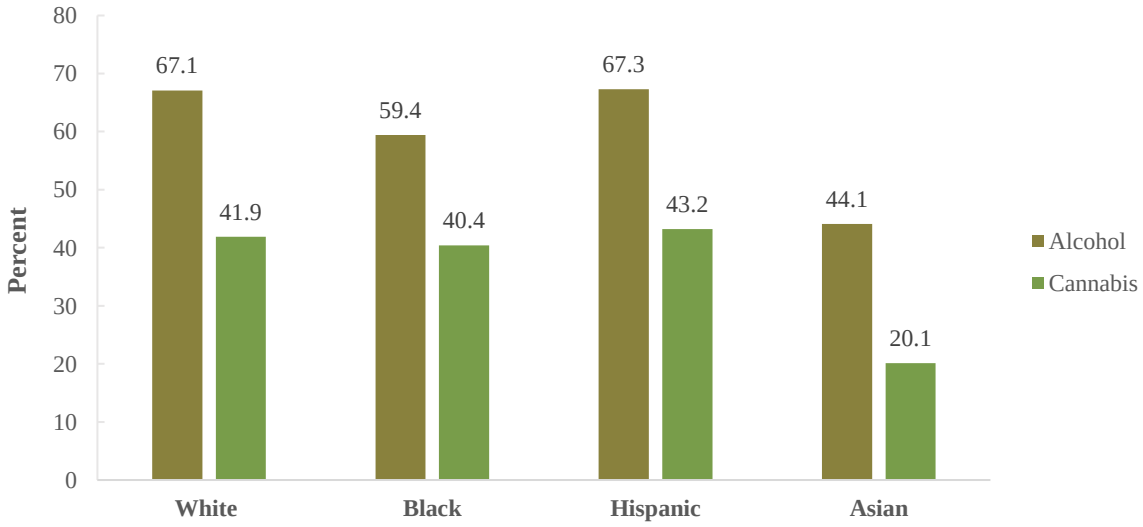
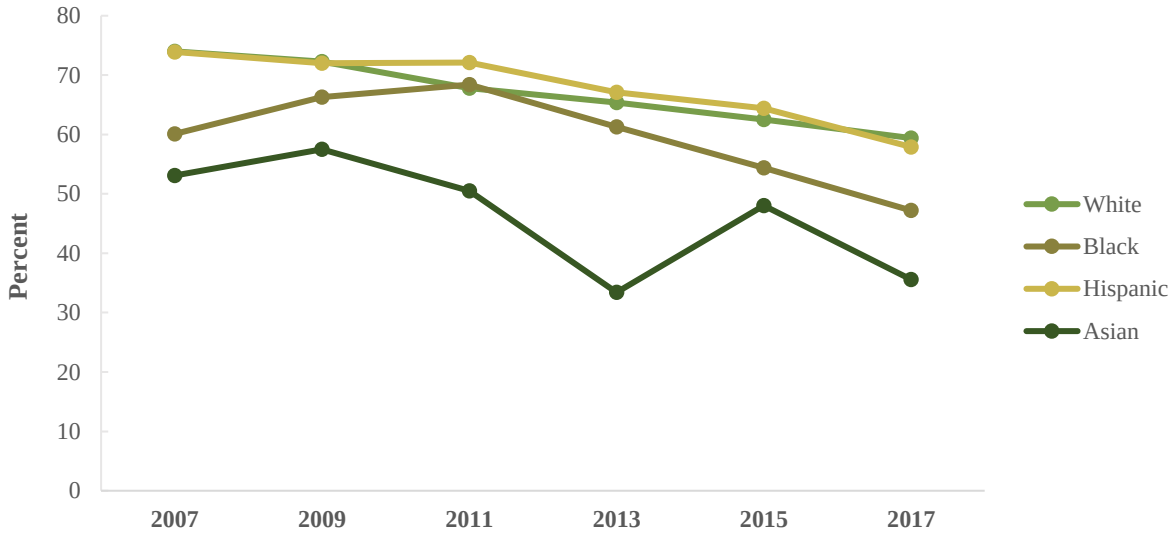


Chart V.D.4. MA High Schoolers Lifetime Alcohol by Race/Ethnicity Over Time, YRBS 2007-2017



Current Use (Past 30-Day)

Whites (26.5%), followed by Hispanics (24.9%) and Blacks (24.3%), report the largest percentages of past 30-day cannabis use ("current use") between 2007-2017. Asians (10.7%) report less current cannabis use between 2007-2017. Between 2015 and 2017, current cannabis use rates remained relatively stable for Blacks, Hispanics, and Whites. Asian rates decreased between 2015 and 2017. In 2017, 26.7% of Hispanics, 25.5% of Whites, 21.6% of Blacks, and 9% of Asians report current cannabis use. [See *Chart V.D.5, Chart V.D.6* below]

For alcohol, Whites, followed by Hispanics, report the highest percentage of current use between 2007-2017. All racial/ethnic groups report slight decreases in current alcohol use between 2015 and 2017, except for Asians, who had an increase in current use between 2015 and 2017. [See *Chart V.D.7, Chart V.D.8* below]

For tobacco, Whites, followed by Hispanics, report the highest percentage of current use between 2007-2017. All racial/ethnic groups report decreases in current tobacco (*excluding vaping*) use between 2015 and 2017, except for Asians who had an increase in current use between 2015 and 2017. [See *Chart V.D.9* below]

Chart V.D.5. MA High Schoolers Current Cannabis Use by Race/Ethnicity, YRBS 2007-2017

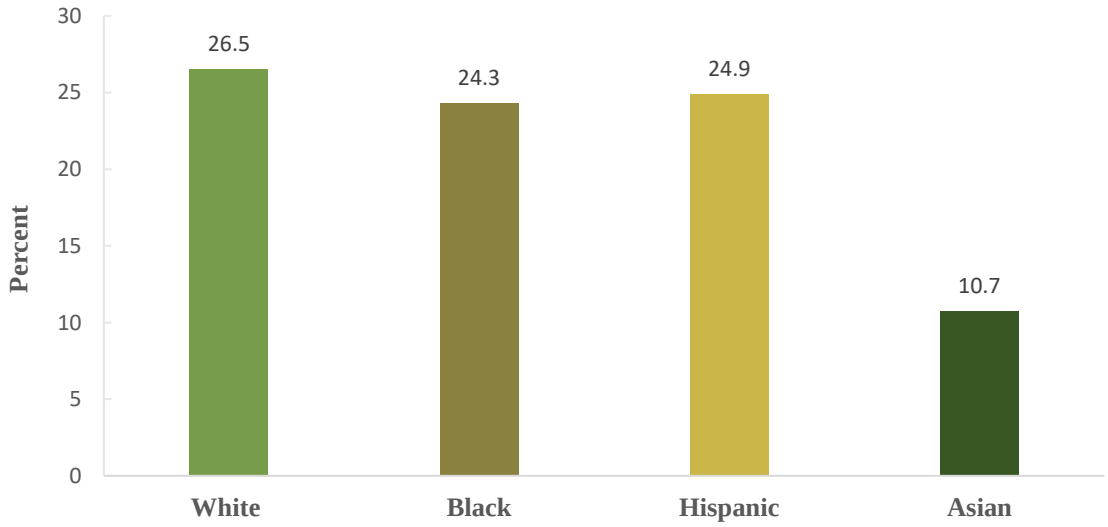


Chart V.D.6. MA High Schoolers Current Cannabis Use by Race/Ethnicity Over Time, YRBS 2007-2017

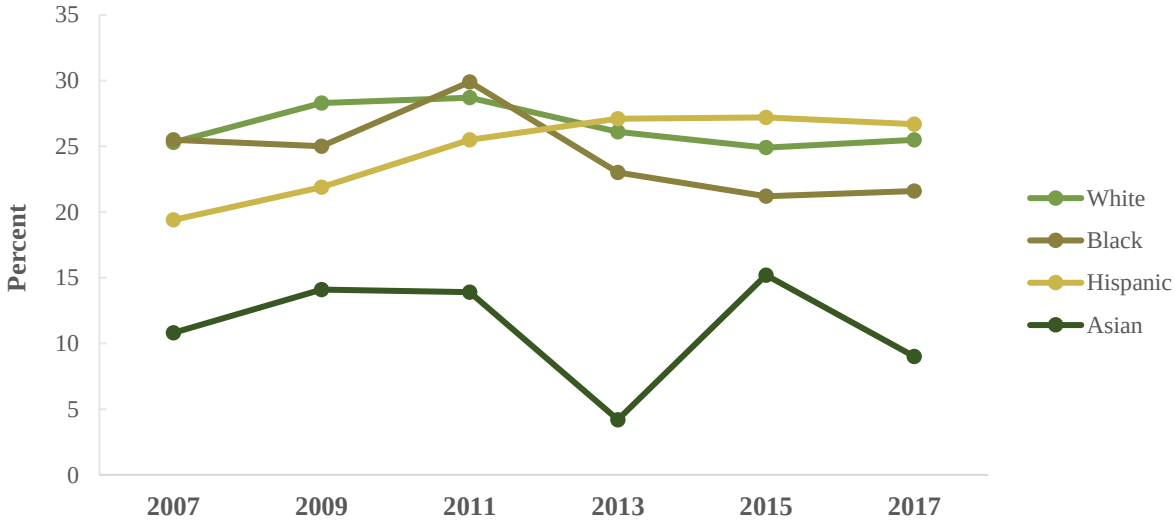
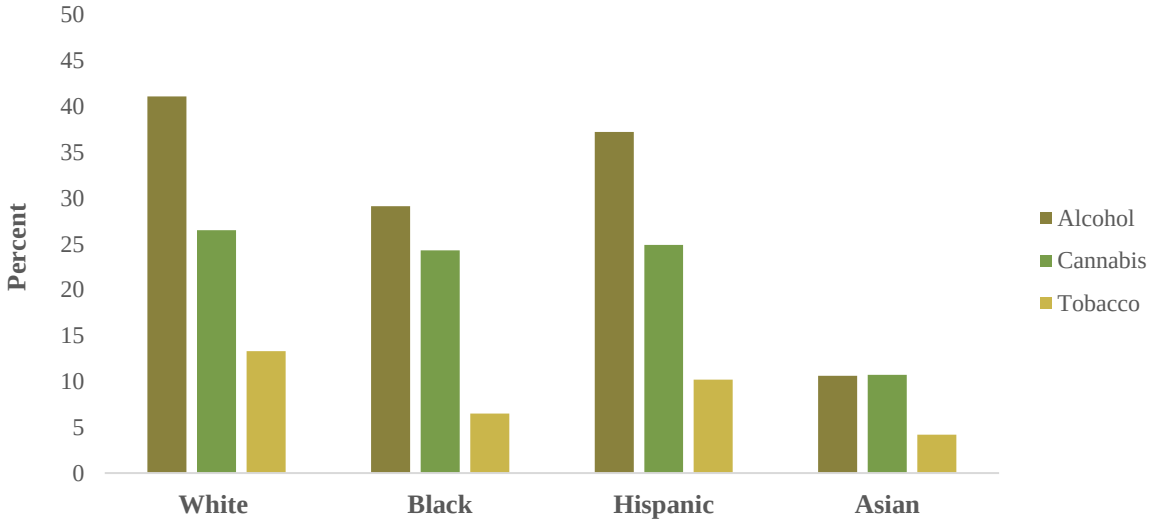


Chart V.D.7. MA High Schoolers Current Cannabis, Alcohol, and Tobacco* Use by Race/Ethnicity, YRBS 2007-2017



***Note:** Vaping was not included in this tobacco use measure

Chart V.D.8. MA High Schoolers Current Alcohol Use by Race/Ethnicity Over Time YRBS 2007-2017

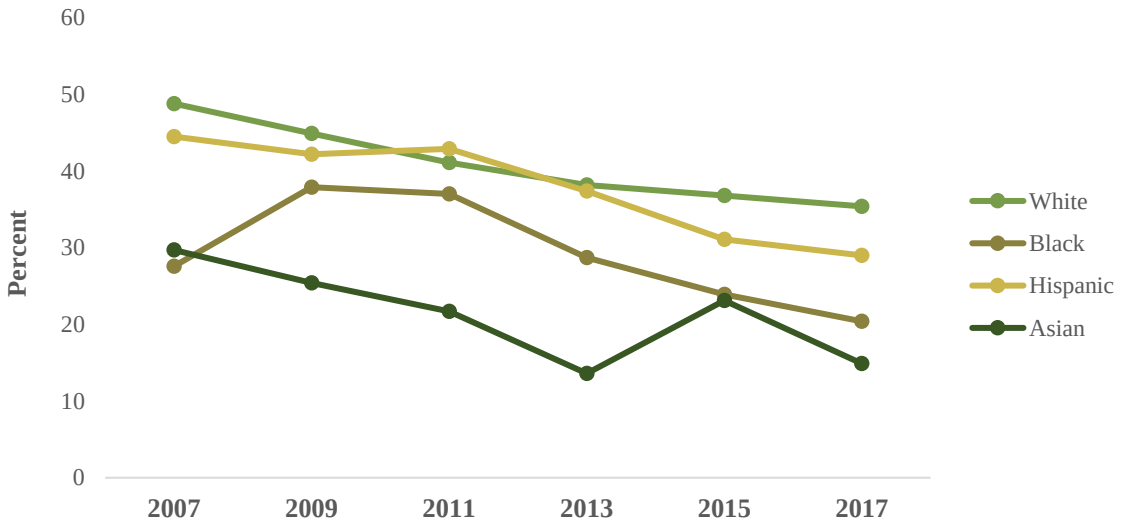
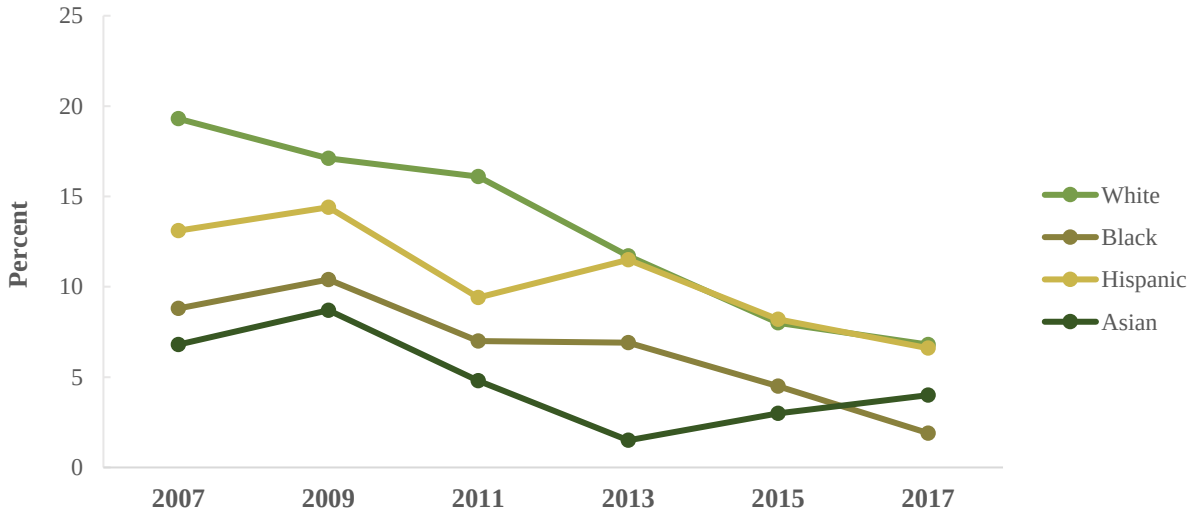


Chart V.D.9. MA High Schoolers Current Tobacco Use* by Race/Ethnicity Over Time YRBS 2007-2017



***Note:** Vaping was not included in this tobacco use measure

Heavy Use (Past 30-Day)

Blacks (8.1%), followed by Whites (7.4%) and Hispanics (7%), report the largest percentages of twenty or more times of cannabis use ("heavy use") in the past 30-days between 2007-2017. Asians (3%) report less heavy cannabis use between 2007-2017. However, an increase in heavy use among Blacks in 2011, which returned to levels consistent with other groups in the following time point, may overstate cohort differences. Between 2015 and 2017, heavy cannabis use rates remained relatively stable for Black and White cohorts and decreased for Asian and Hispanic cohorts. In 2017, 6.2% Hispanics, 6.1% Blacks, 5.8% whites followed by 1.4% of Asians report heavy cannabis use. [See *Chart V.D.10, Chart V.D.11* below]

For alcohol, Whites, followed by Hispanics, report the highest percentage of binge drinking between 2007-2017. Hispanics and Asians had decreased binge drinking rates between 2015 and 2017. Whites and Blacks experienced the smallest declines. [See *Chart V.D.12, Chart V.D.13* below]

Chart V.D.10. MA High Schoolers Heavy Cannabis Use by Race/Ethnicity, YRBS 2007-2017

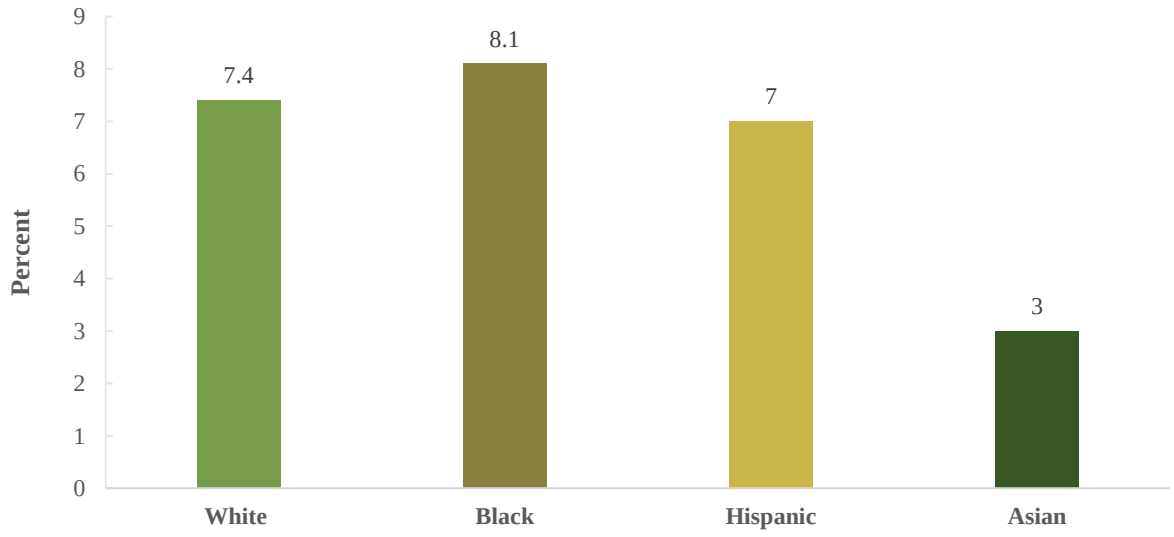


Chart V.D.11. MA High Schoolers Heavy Cannabis Use by Race/Ethnicity Over Time, YRBS 2007-2017

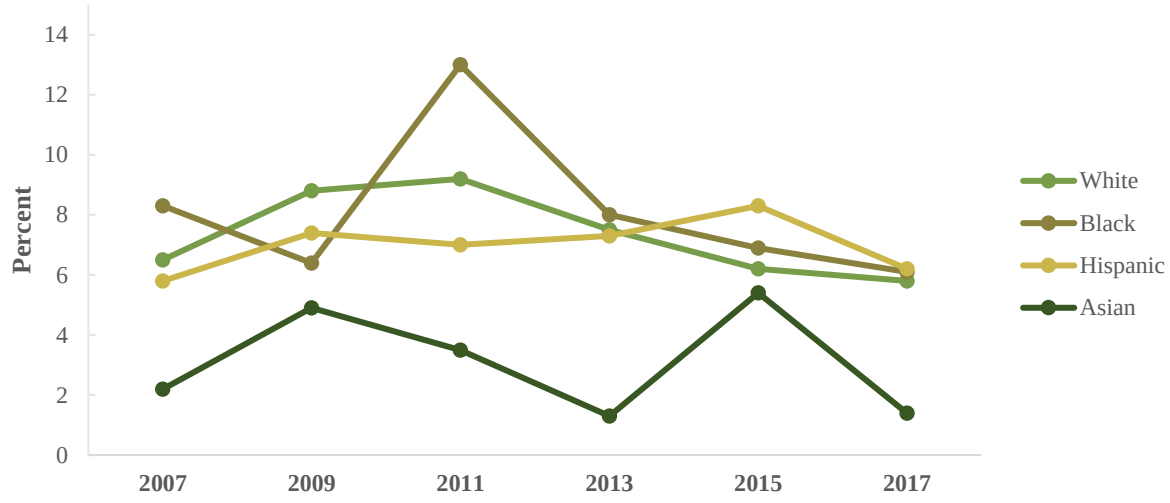


Chart V.D.12. MA High Schoolers Heavy Cannabis and Alcohol Use by Race/Ethnicity, YRBS 2007- 2017

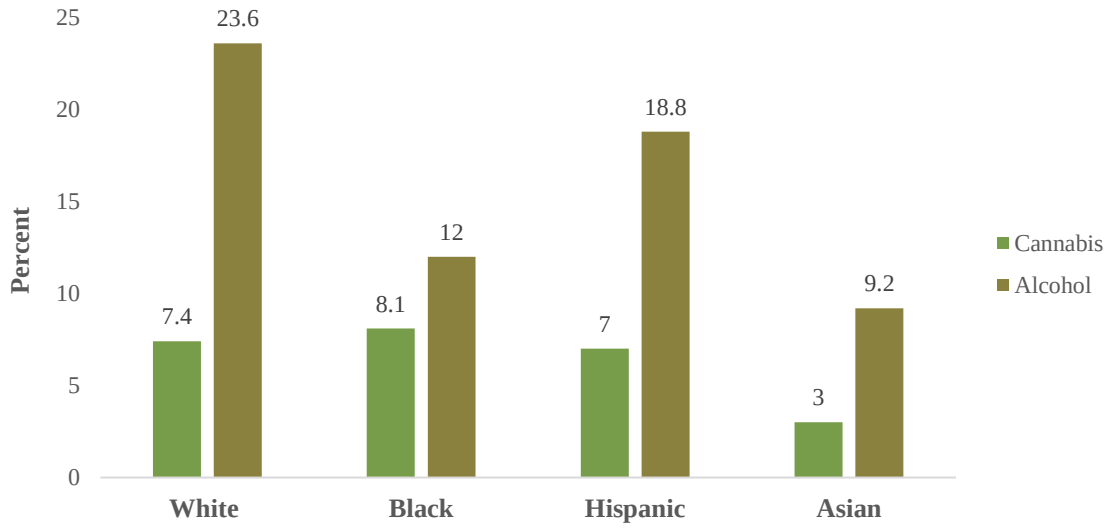
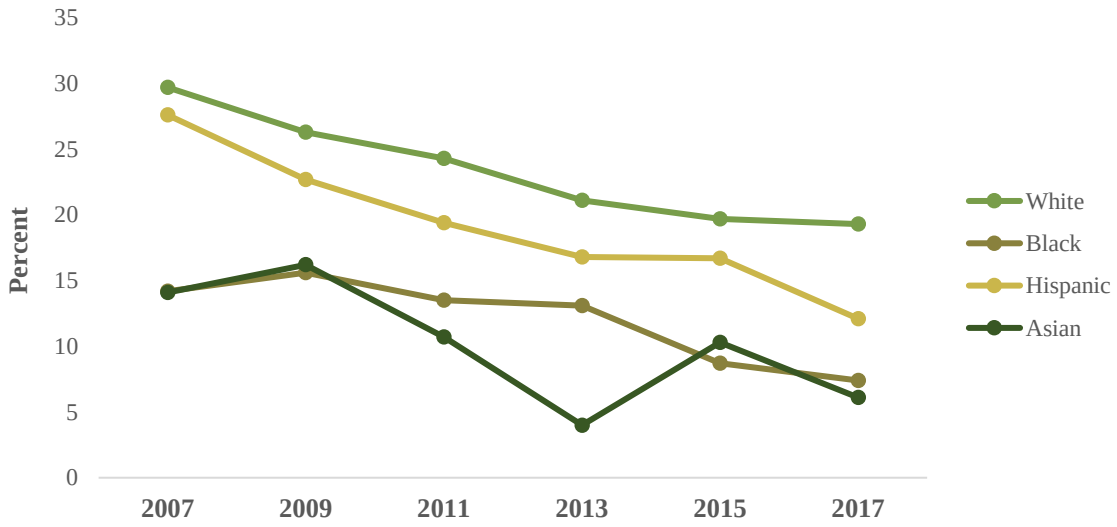


Chart V.D.13. MA High Schoolers Binge Drinking by Race/Ethnicity Over Time, YRBS 2007-2017



All Substance Use ("Lifetime")

Alcohol (65.5%) was the most common tried/used substance by Massachusetts high schoolers, followed by cannabis (41.2%) between 2007-2017. While the rates of youth reporting alcohol use have declined between 2007 and 2017, the rates of youth reporting cannabis use have remained relatively stable. In contrast, other illicit substance use remains low among high schoolers. [See *Chart V.E.1, Chart V.E.2* below]

Chart V.E.1. MA High Schoolers Lifetime All Substance Use, YRBS 2007-2017

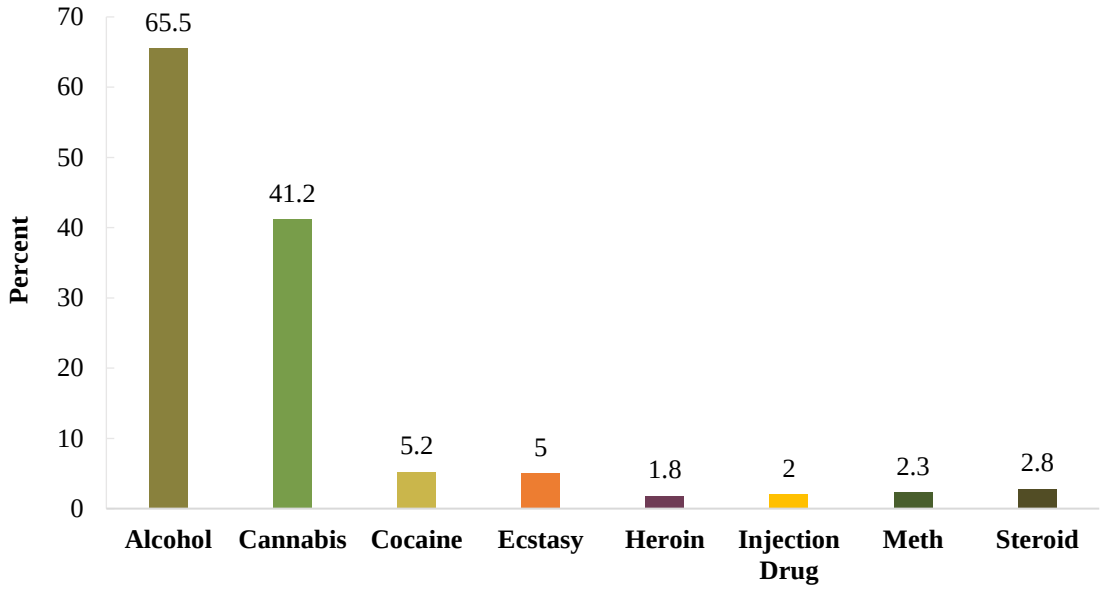
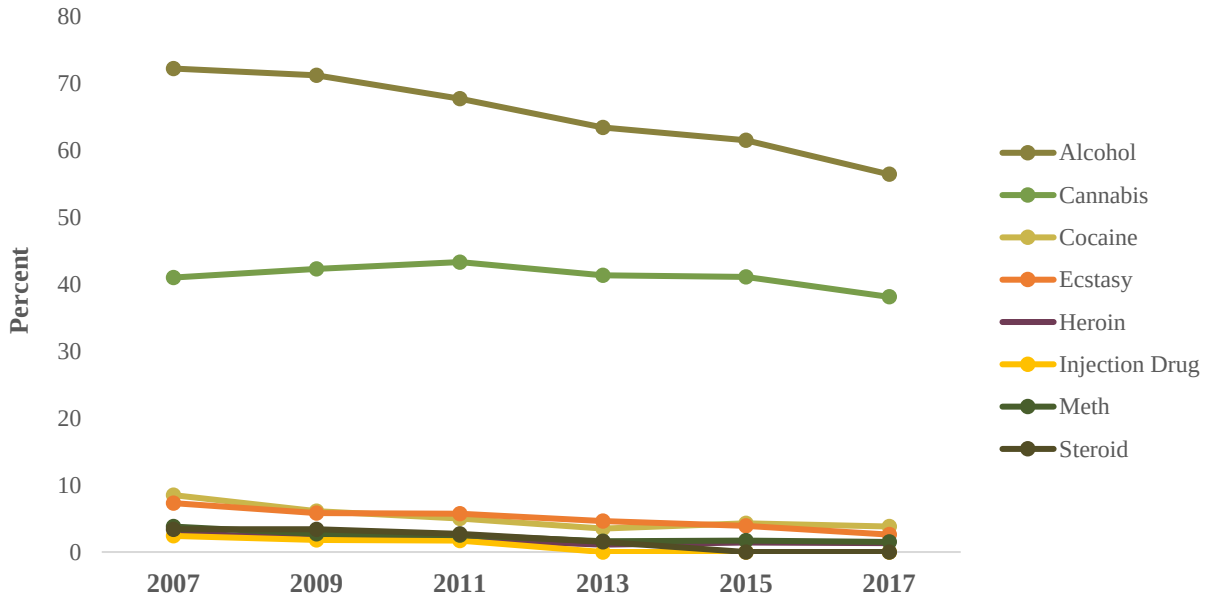


Chart V.E.2. MA High Schoolers Lifetime All Substance Use Over Time, YRBS 2007-2017



Logistic Regression Analyses

Five series of logistical regression models were run to assess effects of varying cannabis policy and/or risky behaviors on substance use outcomes using state-level YRBS data from 2007-2017. All analyses are adjusted for: (1) Year of data collection (2007-2017); (2) Sex [1- Female; 2- Male; Missing], and (3) Race/Ethnicity [1- American Indian/Alaska Native; 2- Asian, 3- Black or African American, 4- Native Hawaiian/Other Pacific Islander, 5- White, 6- Hispanic/Latino, 7- Multiple-Hispanic, 8- Multiple-Non-Hispanic]. Sensitivity analyses models, as noted, are also adjusted for enactment of cannabis legalization in Massachusetts (*e.g. decriminalization, medical cannabis, or adult-use cannabis*).

Since all dependent "outcome" variables are binary ("yes/no"), tables present the odds ratios and confidence intervals for all models. Odds ratios (OR) are a measure of association between an exposure and outcome and are not simple probabilities. Rather, odds ratios represent the likelihood that an outcome will occur divided by the likelihood that the outcome will not occur, thus, results warrant careful interpretation.[30]

It is important to note that the associations (or correlations) represented by the ORs between two variables means that these behaviors have a statistical relationship to each other. Results cannot assume that one behavior causes the other without additional evidence (*e.g. if drinking coffee and cannabis use are associated, this does not necessarily mean coffee drinking causes cannabis use, or cannabis use causes coffee drinking).* There may be a third variable that causes both behaviors. Importantly, lack of evidence does not indicate lack of association. The cannabis research field is in its early stages and there are major gaps in knowledge.

Cannabis Policy and Youth Substance Use Behaviors

Results from YRBS data spanning from 2007-2017 indicate that the enactment of cannabis policies, including decriminalization, medical cannabis, and adult-use, are not statistically associated with greater odds of reporting lifetime and past 30-day substance use behaviors. Conversely, policy enactment analyses suggest these policies are associated with lowered odds among many lifetime and current substance use behaviors. [See *Chart V.F.1* below] Results should not be interpreted as cannabis policies negatively impacting youth substance use behaviors, but rather, there may be multiple phenomenon simultaneously occurring that are not adjusted for in the data, which warrant further exploration. Further, all results should be taken into the context of secular trends occurring at the national and state level, which report a decrease in substance use among youth.[31]

Table V.F.1. Youth Substance Use and Cannabis Policy Enactment

Cannabis	Decriminalization		Medical Cannabis Policy		Adult-Use Cannabis Policy	
	Adjusted[+] OR	(95% CI)	Adjusted[+] OR	(95% CI)	Adjusted[+] OR	(95% CI)
Cannabis Variables						
Lifetime cannabis use	1.00	(0.85-1.19)	0.92	(0.82-1.04)	0.85	(0.73-0.98)
Past 30-day cannabis use	1.08	(0.89-1.31)	0.92	(0.83-1.02)	0.92	(0.80-1.05)
Past 30-day heavy cannabis use	1.14	(0.88-1.46)	0.79*	(0.66-0.95)	0.71**	(0.56-0.89)
Past 30-day cannabis use at school	1.06	(0.85-1.31)	0.81*	(0.69-0.96)	0.89	(.69-1.15)
Tobacco Variables						
Lifetime cigarette use	0.55***	(0.46-0.65)	0.47***	(0.42-0.54)	0.39***	(0.34-0.45)
Past 30-day cigarette use	0.63***	(0.52-0.76)	0.52***	(0.46-0.59)	0.44***	(0.37-0.52)
Past 30-day vape use	(NA) [a]	(NA) [a]	(NA) [a]	(NA) [a]	0.81*	(0.67-0.98)
Past 30-day cigar use	0.63***	(0.52-0.76)	0.52***	(0.46-0.59)	0.44***	(0.37-0.52)
Past 30-day chewing tobacco use	0.89	(0.66-1.20)	0.70***	(0.57-0.84)	0.74***	(0.61-0.88)
Past 30-day any tobacco use (cigarette, cigar, chewing)	0.57***	(.46-.70)	0.47***	(0.40-0.55)	0.43***	(0.34-0.54)
Alcohol Variables						
Lifetime alcohol use	0.68***	(0.59-0.78)	0.64***	(0.58-0.70)	0.62***	(0.54-0.71)
Past 30-day alcohol use	0.68***	(0.58-0.80)	0.66***	(0.60-0.73)	0.68***	(0.58-0.81)
Past 30-day binge drink	0.64***	(0.53-0.76)	0.64***	(0.57-0.72)	0.65***	(0.55-0.78)
Past 30-day alcohol use at school	0.68**	(0.52-0.91)	0.73**	(0.61-0.89)	0.70*	(0.53-0.93)
Past 30-day ride with driver who had been drinking	0.73***	(0.63-0.85)	0.61***	(0.55-0.67)	0.58***	(0.51-0.66)
Lifetime Substance Use Variables						
Synthetic cannabis use	(NA) [a]	(NA) [a]	(NA) [a]	(NA) [a]	0.61***	(0.48-0.78)
Cocaine use	0.49***	(0.39-0.62)	0.57***	(0.47-0.68)	0.67**	(0.52-0.88)
Heroin use	0.52***	(0.37-0.72)	0.53***	(0.41-0.68)	0.64	(0.39-1.05)
Meth use	0.49***	(0.36-0.67)	0.53***	(0.40-0.69)	0.59*	(0.38-0.93)
Ecstasy use	0.58***	(0.46-0.72)	0.56***	(0.46-0.68)	0.46***	(0.33-0.64)
Steroid use	0.70**	(0.54-0.90)	0.46***	(0.31-0.69)	(NA) [a]	(NA) [a]
Injection drug use	0.67*	(0.47-0.97)	(NA) [a]	(NA) [a]	(NA) [a]	(NA) [a]

[+]Adjusted for: (1) Year of data collection [2007-2017]; (2) Sex [1- Female; 2- Male; Missing], and (3) Race/Ethnicity [1- Am Indian/Alaska Native; 2- Asian, 3- Black or African American, 4- Native Hawaiian/Other PI, 5- White, 6- Hispanic/Latino, 7- Multiple-Hispanic, 8- Multiple-Non-Hispanic]

*p<0.5; **p<.01; ***p<.001 [a]NA refers to measures that were not included in survey instrument during one or more policy intervention (*e.g. measure only included in post decriminalization survey years, 2013-2017*)

Risk and Protective Factors

The second series of logistical regression models assessed associations between risk and protective factors as identified in the literature and cannabis use outcomes. These analyses do not represent an exhaustive list of potential risk and protective factors that may be associated with cannabis use behaviors. [See *Appendix III: Associated Risk Factors Justification* for a brief rationale for each variable assessed] The aim of these analyses was to identify risk and protective factors associated with youth cannabis use behaviors, and if cannabis policy enactment (*i.e. decriminalization, medical cannabis, and adult-use*) had moderating effects on cannabis use outcomes.

Results show the varying behaviors and/or experiences that were associated either positively (greater odds suggesting a "risk" factor) or negatively (lower odds suggesting a "protective" factor) with cannabis use outcomes in Massachusetts youth, 2007-2017. The three cannabis use outcomes assessed included: lifetime cannabis use, past 30-day cannabis use, and past 30-day heavy cannabis use. Heavy cannabis use is categorized as youth reporting using cannabis 20≤ times in the past 30 days. [See *Chart V.G.1 below*]

Protective Factors: Results suggest that select factors assessed may be "protective" against all cannabis use behaviors assessed, including: (1) obtaining better grades (A's and B's vs. C's and D's), (2) having any adult (family or other adult support), and (3) identifying as heterosexual. Three additional factors showed protective against select cannabis use behaviors. Sport involvement in the past year and physical activity in the past week were both protective against past 30-day heavy cannabis use. Playing video games was protective for both lifetime cannabis use and past 30-day heavy cannabis use behaviors. Protective factors are indicated by odds ratios (OR) less than 1, followed by any significance level, indicated by 1-3 asterisks (*e.g.* OR *0.58****).*

Risk Factors: Conversely, results suggest that multiple factors assessed may be "risk" factors for cannabis use. Broadly, these behaviors/experiences fall under: (1) Disability; (2) Risky driving behaviors; (3) Weapon carrying/exposure, violence, and bullying; (4) Hopelessness and suicidality behaviors; and (5) Sexual orientation and sexual behaviors. Risk factors are indicated by OR greater than 1, followed by any significance level, indicated by 1-3 asterisks (*e.g.* OR *3.91****).

Table V.G.1. Risk and Protective Factors: Youth Cannabis Use

	Any Use		Past 30-Day Use		Past 30-Day Heavy Use (≥20 times)[a]	
	Adjusted[+] OR	(95%CI)	Adjusted[+] OR	(95%CI)	Adjusted[+] OR	(95%CI)
Risk/Protective Factors and Cannabis Use						
Disability						
Learning Disability	1.34***	(1.13- 1.58)	1.33***	(1.14- 1.56)	1.58**	(1.20- 2.07)
Physical Disability	1.14*	(1.02- 1.28)	1.12	(0.96- 1.31)	1.26	(0.96- 1.65)
Driving Behaviors						
Ride with driver who had been drinking (past 30-day)	3.91***	(3.58- 4.27)	4.13***	(3.79- 4.49)	4.62***	(4.04- 5.29)
Drive after drinking alcohol (past 30-day)	2.15***	(1.95- 2.39)	2.33***	(2.05- 2.64)	3.07***	(2.59- 3.65)
Text or email while driving (past 30-day)	3.67***	(3.22- 4.18)	2.74***	(2.33- 3.22)	2.28***	(1.80- 2.90)
Talk on cell phone while driving (past 30-day)	3.25***	(2.74- 3.86)	2.67***	(2.23- 3.20)	2.11***	(1.63- 2.74)
Weapon carrying/exposure, violence, and bullying						
Carry weapon (past 30-day)	3.59***	(3.22- 4.01)	3.54***	(3.15- 3.97)	4.33***	(3.73- 5.02)
Carry weapon on school property (past 30-day)	4.61***	(3.61- 5.89)	4.66***	(3.82- 5.69)	5.72***	(4.75- 6.89)
Carry gun (past 30-day)	4.48***	(3.44- 5.84)	4.55***	(3.42- 6.05)	6.69***	(4.99- 8.98)
Threatened or injured with weapon on school property (past 12- month)	3.30***	(2.76- 3.95)	3.29***	(2.68- 4.04)	4.07***	(3.35- 4.94)
Physical fight (past 12- month)	3.92***	(3.55- 4.33)	3.82***	(3.50- 4.18)	4.82***	(4.35- 5.35)
Bullied on school property (past 12- month)	1.52***	(1.37- 1.69)	1.49***	(1.32- 1.69)	1.51***	(1.28- 1.79)
Sexual and Dating Violence						
Physically forced to have sex (lifetime)	2.64***	(1.93- 3.63)	2.43***	(1.83- 3.21)	3.29***	(2.05- 5.27)
Physically forced to have sex or physical dating violence (lifetime)	2.83***	(2.57- 3.12)	2.28***	(2.24- 2.74)	2.84***	(2.43-3.21)
Support, Hopelessness, and Suicide Behaviors						
Hopelessness (past 12- month)	2.22***	(2.01- 2.46)	2.03***	(1.82- 2.25)	2.42***	(2.11- 2.79)
Consider suicide (past 12- month)	2.35***	(2.06- 2.68)	2.32***	(2.05- 2.62)	2.43***	(2.09- 2.82)
Plan suicide (past 12- month)	2.08***	(1.86- 2.33)	2.0***	(1.77- 2.26)	2.13***	(1.77- 2.55)
Attempt suicide (past 12- month)	2.72***	(2.29- 3.23)	2.61***	(2.22- 3.07)	3.15***	(2.61- 3.81)
Treated for suicide attempt (past 12- month)	3.18***	(2.34- 4.33)	3.05***	(2.32- 4.02)	4.34***	(3.24- 5.81)

Purposely hurt yourself (past 12-month)	2.34***	(2.10- 2.59)	2.24***	(2.02- 2.49)	2.48***	(2.05- 3.01)
Sexual Orientation and Behaviors						
Sexual intercourse (lifetime)	7.20***	(6.52- 7.95)	5.94***	(5.33- 6.62)	8.10***	(6.55- 10.02)
Age first sexual intercourse encounter	1.28***	(1.25- 1.30)	1.22***	(1.20- 1.25)	1.19***	(1.15- 1.23)
Sex partners (past 90-days)	2.44***	(2.31- 2.57)	2.03***	(1.93- 2.13)	1.85***	(1.76- 1.95)
Alcohol or drug use before sexual intercourse last time	12.26***	(10.22- 14.70)	8.76***	(7.56- 10.15)	9.46***	(8.13- 11.01)
Condom use last sexual encounter	3.20***	(2.85- 3.58)	2.63***	(2.37- 2.92)	2.05***	(1.76- 2.40)
Ever been or gotten someone pregnant (lifetime)	4.46***	(3.64- 5.47)	3.20***	(2.70- 3.79)	4.64***	(3.89- 5.53)
Ever been tested for any Sexually Transmitted Disease(s) (STDs) (lifetime)	2.74***	(2.50- 3.0)	2.24***	(2.00- 2.50)	2.65***	(2.25- 3.13)
Sexuality- Heterosexual ("straight")	0.48***	(0.42- 0.55)	0.50***	(0.44- 0.58)	0.42***	(0.34- 0.51)
Sexuality- Gay, Lesbian, or Bisexual	2.08***	(1.81- 2.39)	1.99***	(1.72- 2.30)	2.39***	(1.96- 2.91)
Other Risk/Protective Factors						
Any adult support (family or other)	0.58***	(0.50- 0.67)	0.56***	(0.50- 0.63)	0.43***	(0.37- 0.50)
Physically active (past week)	0.95	(0.86- 1.06)	0.97	(0.87- 1.08)	0.68***	(0.57- 0.81)
Sports team involvement (past 12-month)	0.94	(0.86- 1.03)	0.89*	(0.81- 0.98)	0.60***	(0.52- 0.69)
Play video games on average school day	0.89**	(0.82- 0.97)	0.95	(0.86- 1.04)	0.86*	(0.77- 0.98)
Watch TV on average school day	0.95	(0.88- 1.03)	0.93	(0.85- 1.03)	0.86	(0.71- 1.05)
Grades are A's and B's	0.34***	(0.34- 0.38)	0.34***	(0.30- 0.38)	0.25***	(0.21- 0.29)

[+]Adjusted for: (1) Year of data collection [2007-2017]; (2) Sex [1- Female; 2- Male; Missing], and (3) Race/Ethnicity [1- Am Indian/Alaska Native; 2- Asian, 3- Black or African American, 4- Native Hawaiian/Other PI, 5- White, 6- Hispanic/Latino, 7- Multiple-Hispanic, 8- Multiple-Non-Hispanic]

*p<0.05; **p<.01; ***p<.001

[a]NA refers to measures that were not included in survey instrument during one or more policy intervention (*e.g. measure only included in post decriminalization survey years, 2013-2017*)

Risk and Protective Factors and Cannabis Use Behaviors—*Do Cannabis Policies Moderate the Effect of Cannabis Use?*

The third series of logistical regression models served as sensitivity analyses to assess if any cannabis policy (*i.e. decriminalization, medical cannabis, and adult-use cannabis*) moderated the effect size of the varying risk/protective behaviors on cannabis use behaviors. [See *Appendix IV: Sensitivity Analyses: Table IV.1., Table IV.2., Table IV.3.*]

The only variable that resulted in discernable change when models additionally adjusted for cannabis policy enactment (*i.e. decriminalization, medical cannabis, and adult-use cannabis*) was *driving after alcohol use*. For all three cannabis use dependent variables (*i.e. lifetime cannabis use, past 30-day cannabis use, and past 30-day heavy cannabis use*), decriminalization enactment moderated the effect size of youth reporting driving after drinking alcohol and cannabis use. Similarly, enactment of medical cannabis and adult-use cannabis had similar moderation effects in youth reporting driving after drinking alcohol and heavy cannabis use in the past 30-days. In these models, the odds ratios (OR) associated with *cannabis use* adjusting for *driving after alcohol use* is greater than the OR associated with cannabis use when the model adjusts for both *driving after alcohol use* and *decriminalization enactment*.

VI. Cannabis Legalization and Youth Use Overview

Cannabis legalization and youth research should include at least three considerations. First, behavior changes may lag policy change.[7–10] Therefore, it is too early to assess the full impacts of legalization on youth cannabis use and associated behaviors. Second, certain groups of youth (*e.g. working youth, youth at risk of a substance use disorder, etc.*) may be uniquely impacted. Therefore, impact assessments should consider the diversity of youth (*e.g. gender, race/ethnicity, sexuality minority status, disability status, etc.*). Third, youth cannabis use occurs in a context. Therefore, research could employ a social ecological or similar model to assess all potential factors affecting an individual. This includes monitoring perception and social norm changes in society, community, familial, and within individuals, alongside cannabis use patterns and rates. [See *Section II. Important Considerations*] This section provides a brief overview on research assessing the impact of cannabis policy on youth cannabis use.

There are mixed findings as to whether cannabis decriminalization is associated with increased youth cannabis use.[32] Research has not found that medical cannabis legalization increases youth cannabis use.[2,33–39] Early findings are mixed as to whether adult-use legalization increases youth use.[34,40–42] However, meaningful changes to use are likely to be lagged.

Decriminalization

While most decriminalization research occurred in the 1980 and 90s, three recent studies were identified.[32,43–45] In a review, Melchior et al. 2019 identified 13 studies which examined the impact of decriminalization on youth. Out of the five high quality studies, four found no impact to youth use and one found use increased.[44] In a multi-country study, Shi et al. 2015 did not find a significant effect of decriminalization of youth use.[45] In contrast, Miech et al. 2015 examined a 2010 California change in policy, which removed criminal penalties for small amounts of cannabis and found that 12th graders in California were increasingly likely to report current cannabis use compared to changes among peers in other states.[32]

Medical Cannabis Legalization

Research has not found significant increases in youth cannabis use following medical cannabis legalization.[2,33–39,44] While cannabis use rates are higher among youth who live in states with medical cannabis, most researchers found higher rates preceded medical cannabis legalization and were not a result of policy change.[2,33–39]

Adult-use Cannabis Legalization

Research assessing the impact of adult-use cannabis policy is in its infancy and long-term effects are unknown. Cerda et al. 2017 found that Washington youth (8th and 10th graders) rates of cannabis use increased following adult-use legalization but Colorado youth rates did not change,

suggesting there may be state-to-state differences.[34,40] Others have also found no increase in Colorado youth rates.[41,42] One metanalysis found adult-use legalization was associated with a small increase in youth cannabis use.[44] A Washington study of heavy youth users found that their patterns also remained steady after legalization, although participants reported more problematic use symptoms after legalization.[46] A longitudinal study from Oregon found that never-using youth did not increase use, but those with a history of cannabis use increased their use following legalization.[47] Early findings suggest legalization will not affect all youth equally.

Certain youth groups may be negatively affected by cannabis legalization policies compared to their peers. For example, Graves et al. 2019 found that working youth had increased rates of cannabis use following legalization, unlike their non-working peers.[48] Authors suggest rising rates of cannabis use and changing social norms among adult coworkers may create pressure and/or increase access to cannabis.[48] These youth also may have more disposable income than non-working peers.[48] Importantly, these findings are associations and cannot be assumed as causal.

Youth at risk for problem cannabis use ("cannabis use disorders [CUDs]") may be disproportionality affected by legalization.[46] A small study of Colorado substance use treatment providers found that providers observed that more of their clients viewed cannabis use as socially acceptable in recent years.[49] These providers also reported seeing greater access to and use of highly potent cannabis in their youth clients.[49] Providers emphasized the increased potential for substance use disorders when using potent products.[49] Higher potency products and method of consumption both contribute to the likelihood of developing a cannabis use disorder, and may be impacted by cannabis legalization. Youth use trends in the general population, specific cohorts, and those in treatment for substance use disorders should be monitored.

Challenges and Limitations

There are major challenges to conducting this research. Research on states that legalize cannabis are not true experiments, state differences effect whether or not a state legalizes cannabis.[34] Statistical methods can help control for these differences but state comparisons are imperfect to detect what might have happened within a state if it had not legalized. Other challenges surround the differences in policies, regulation, and implementation ("heterogeneity") between legalized states. This heterogeneity may result in different outcomes between states. For example, Borodovsky et al. 2018 found that youth in states with a higher density of cannabis dispensaries were more likely to have consumed an edible or vaporized cannabis.[50] Additionally, youth edible use was only associated with legalized states that permit home grow.[50] Importantly, behavior changes resulting from legalization may be lagged.[34] To potentially isolate these lagged effects,

researchers examine perceptions, which may precede behavior change; however, using perceptions to predict behavior is also imperfect.

VII. Literature Reviews

Perceptions of Harm

AIM: This section synthesizes literature around trends in youth perception of the harm ("risk") from cannabis use.

A lower perception of a substances' riskiness is associated with a greater likelihood of using the substance.[51] Therefore, changes to risk perception of cannabis are critical to monitor, particularly for youth. It is also important to know whether cannabis policies have an impact on risk perceptions. This section presents past-decade findings for youth cannabis risk perceptions nationally, and assesses whether medical and adult-use cannabis policies impact risk perception.

Methods

The search focused on youth perceptions of the harms ("risks") of cannabis use in the past ten years in the U.S. It also examined whether medical and adult-use cannabis policies impacted perceptions. Only studies that directly collected or reported on youth (*i.e. <18 years-old*) were included. Studies published in 2009 through May 2019 were identified using GoogleScholar, the reference sections of identified articles and author libraries with search terms including the following: "youth," "adolescent," "perception," "perceived," "risk," "harm," "cannabis," "marijuana," "use," "medical," and "legalization."

From these methods twenty-three studies were identified.[2,3,54–63,4,64–66,5,6,40,41,46,52,53] Studies analyzed varying surveys, including: Monitoring the Future (MTF),[2–4,40,61,65,66] National Survey of Drug Use and Health (NSDUH),[4–6,52–54,62,67] Healthy Kids Colorado (HKC),[41,64] Washington Healthy Youth Survey (WHKS),[55] Community Youth Development Study (*longitudinal*),[56] National Longitudinal Study of Youth (NLSY),[57] a commercial panel sample,[63] and smaller non-representative samples.[46,58–60] The majority of studies were cross sectional designs, meaning they looked at a snapshot in time.

National Time Trends

Youth perceptions of cannabis' risks have declined over the past decade. This trend is consistent across two important national surveillance surveys: Monitoring the Future (MTF) and the

National Survey of Drug Use and Health (NSDUH).[4,34] Five studies examined youth perceptions of cannabis risk over time, and all found that risk perceptions decreased over time.[2–6]

MTF findings suggest that cannabis risk perceptions among youth have declined since 1991.[2] MTF asks, "*How much do you think people risk harming themselves (physically or in other ways) if they smoke marijuana regularly?*"[4] In 2018, the lowest percent of 8th, 10th, and 12th graders reported regular cannabis use as a great risk to harm.[68] Among 8th graders, 52.9% reported that people who smoke marijuana regularly were at great risk, 38.1% of 10th graders, and 26.7% of 12th graders also reported great risk.[68] Chen et al. 2018 found dose response evidence between perceiving harm and frequency of use (*i.e. as perceived harm decreases, frequency of use increases*).[66] Younger youth consistently perceived cannabis as more risky than older youth.[62,68,69]

The NSDUH survey similarly found perceived risks of cannabis use have decreased among youth.[5,6] This survey asks, "*How much do people risk harming themselves physically and in other ways when they smoke marijuana once or twice a week*?"[4] In 2017, 37.7% of 12-17 year-olds reported that it was a great risk to smoke once or twice a week.[69] Schmidt et al. 2016 found that there has been a notable decrease in perceived riskiness from 2009 on.[6] A number of researchers examined whether state-level medical cannabis legalization contributed to decreasing risk perceptions among youth.

Impact of Medical Marijuana Policies

Despite concerns that medical cannabis policies "send youth the wrong message,"[6] most studies have not found associations between medical policies and decreased perceptions of risk among youth. Five studies examined whether medical cannabis policies were associated with a decrease in youth perceptions of cannabis' risks.[2,6,52–54] Four national studies did not find evidence that medical cannabis policies were associated with decreases in risk perception,[2,6,52,53] but one study found medical cannabis commercialization in Colorado was associated with a decrease.[54]

Research with MTF has not found that medical cannabis policies decrease youth cannabis risk perception. Keyes et al. 2016 found that medical cannabis policies had no effect on youth risk perceptions overall or by grade.[2] In fact, 8th graders perceived risk of cannabis use increased following medical legalization.[2]

Similarly, most studies using NSDUH data have found that medical cannabis policies are not associated with decreased youth perception of risk. In a replication study, Harper et al. 2012

found no effect of medical cannabis policies on perceptions.[52] Schmidt et al. 2016 and Wen et al. 2019 also found no effect of medical cannabis policies on youth risk perception in NSDUH.[6,67] In contrast, Schuermeyer et al. 2014 examined Colorado NSDUH data before and after medical cannabis commercialization (2009) rather than an enactment or implementation date and found youth perceived risks of cannabis decreased following this period.[54] Causality could not be assessed.

There were important limitations to these studies. Briefly, all studies were quasi-experimental, meaning youth were not randomly assigned to a legalized or non-legalized state, therefore, studies could not assess causality. All studies were cross-sectional, meaning they looked at a snapshot in time and did not follow a group across time (longitudinal). Additionally, there may be spillover effects from one legalized state to other non-legal states, which could obscure potential effects of legalization.[6]

Although youth in states with medical cannabis policies have lower perceived risk of cannabis,[53] this may not be attributed to policy change, but rather result from other factors, including lower risk perception before legalization and national trends. However, further research, including state specific analyses incorporating policy heterogeneity should be conducted to more comprehensively assess potential changes.[57] Thus far, data suggests that decreases in youth perceptions of harm are occurring nationally and not as a result of state specific medical cannabis legalization.[2]

Impact of Adult-use Marijuana Policies

Given the recency of adult-use cannabis policies, research has not yet fully assessed their impact on youth risk perception— and current findings are mixed. Six studies examined adult-use legalization.[40,41,46,60,63,64]

Cerdá et al. 2017 found that perceptions of harm significantly decreased following adult-use legalization in Washington among youth in 8th and 10th grades, but perceptions did not decrease among Washington 12th graders or Colorado youth in comparison to peers in non-legalized states.[40] Assessing retail store implementation, rather than year of legalization enactment, Harpin et al. 2018 found no change in risk perception.[64] Conversely Brooks-Russell et al. 2019 found a decrease in perceived harm among Colorado youth.[41,64] A small study of students enrolled in a prevention program found youth who entered the program after legalization enactment had lower perceived risks of cannabis than those who enrolled prior to legalization enactment.[60] In another

study, Blevins et al. 2018 found no change in perception of risk or use rates among youth cannabis users in Seattle who were surveyed before and adult-use legalization.[46]

Asking different questions on perceived harmfulness of regular cannabis use and effects on mental health, an online commercial panel surveyed a sample of U.S. youth aged 16-19 years-old (n=4,097).[63] Cannabis users were asked whether they worried about damaging their health in the future.[63] No differences in harm perceptions between non-legalized states, legalized states without markets, and legalized states with retail markets were found in this survey.[63] Additional research with longer follow-up periods is needed to assess the full and potentially lagged impact(s) of adult-use legalization on youth perceptions of harm.

Impact of Riskiness on Use

Lower perceptions of cannabis' risks have been associated with increased likelihood of use; However, recent decreases in perceived risk of cannabis have not been associated with equivalent increases in youth use.[55] This has caused some researchers to question whether the association between lower risk perception of cannabis and use remains true. Five studies were identified that examined impact of riskiness on use, or analyzed mechanisms around why use rates are not similarly rising.[4,55,56,65,70] Research suggests risk perception is still an important risk factor for use,[4,55,56,65,70] but decreased cigarette smoking (another risk factor) may explain why youth cannabis use has not changed at a similar pace as risk perception.[4,55]

Between 1991 and 2016, the proportion of 12th graders who thought cannabis posed no risk increased by 11% while cannabis use increased by approximately 1% (MTF).[4] Decreased risk perception without equivalent rises in youth use had similarly been found in NSDUH.[71] Braymiller et al. 2018 categorized MTF respondents by use patterns and perceptions, and found that youth who do not used cannabis reported greater approval of peers' cannabis use from 2010 to 2016.[61] This indicates perception changes are occurring among both youth who use cannabis and those who do not.

MTF analyses indicate that perceiving cannabis use as risky remains a protective factor against use.[65,70] From 1991 to 2016, Terry-McElrath et al. 2017 found that the association between great risk perception and cannabis use strengthened for Hispanics and weakened for Blacks, while remaining stable for Whites and between genders.[70] In this sample, perception of moderate risk increased in strength as a protective factor over time.[70] Similarly, in a longitudinal non-national study (*Community Youth Development Study*), Guttmannova et al. 2019 documented an

association between lower perceived harm of cannabis and the increased likelihood of use for 8th, 10th, and 12th graders, but not 9th graders.[56]

Two studies found the potentially weakening association between riskiness and use could be partially explained by decreased alcohol and cigarette use, which are risk factors for cannabis use.[3,55] Miech et al. 2017 found that decreased cigarette use largely accounted for the lack of increase in cannabis use rates found amount youth (MTF, 1991-2016).[3] Similarly, in a Washington state sample of 10th graders, Fleming et al. 2016 found the association between perceived riskiness of cannabis and use remained but decreases in cigarette use explained the lack of increased cannabis use that would be expected.[55] In a qualitative study assessing the risks of cigarettes and cannabis, youth reported greater harm for cigarettes than cannabis.[59] In sum, the research suggests youth perception of risk contributes to their likelihood of using cannabis, but other associated risk/protective factors (*e.g. cigarette smoking*) matter. Youth prevention efforts should leverage multiple protective factors to maximize impact.[58]

Ease of Access

AIM: This section synthesizes literature around how easily youth believe they could access cannabis.

Perceived access to cannabis is associated with youth use of the substance.[72] Therefore, changes to perceived access are important to monitor. It is also important to know whether changes in cannabis policies impact access perceptions. This section presents findings from U.S. samples within the past ten years that examine youth perceptions of cannabis access, and whether medical and adult-use cannabis policies impact perceived access.

Methods

The search focused on youth perceived ease of access to cannabis within the past decade. It also examined whether medical and adult-use cannabis policies impacted access perceptions. Only studies that directly collected or reported on youth (*i.e. <18 years-old*) were included. Studies published from 2009 through May 2019 were identified using GoogleScholar, in reference sections of identified articles, and within author libraries using the following search terms: "ease of access" "how easy would it be," "marijuana," "cannabis," "youth," "adolescent," "access," "availability," "obtain," "legalization."

Fourteen studies were identified.[5,41,74–77,55,62–64,66,67,72,73] Studies used national surveys including: National Survey of Drug Use and Health (NSDUH),[5,62,67,73,74,77] Monitoring the Future (MTF),[66,73] and a commercial panel survey.[63] Others used state samples including: Healthy Kids Colorado (HKC),[41,64] Washington Healthy Youth Survey (WHYS),[55] and Prevention Needs Assessment Community Student Survey (*Montana*).[75] Additionally, one study used a handheld monitoring device to conduct a momentary assessment of cannabis use factors.[72]

National Time Trends

While most U.S. youth report easy or fairly easy access to cannabis, easy access appears to be declining among youth in the U.S.[5,73,76] Five studies examined youth self-reported access to cannabis overtime.[5,67,68,73,77]

MTF asked: *"How difficult do you think it would be for you to get each of the following types of drugs (e.g. Marijuana), if you wanted some?*"[4] In 2018, 35% of 8th graders, 65% of 10th graders, and 80% of 12th graders reported that cannabis was "fairly easy" or "very easy" to obtain.[68] This

represents a decrease among 8th and 10th graders but is consistent for 12th graders with rates ranging between 80-90% since 1975.[68,77] Younger youth consistently report less access to cannabis than older youth.[68]

NSDUH data also suggests that youth are reporting less access to cannabis nationally; however there was a slight increase in access between 2016 and 2017.[73] This survey asked: "*How difficult or easy would it be for you to get some marijuana, if you wanted some?*"[74] In 2017, 46.1% of 12-17 year-olds reported it would be "fairly easy" or "easy" to obtain cannabis if desired. This is a small increase from 2016.[62] Conversely, from 2002 to 2015, 27% fewer 12-17 year-olds reported it would be "very easy" for them to obtain cannabis.[73] This decrease was pronounced among 12-14 year-olds (*42% reduction*), and consistent between gender, race/ethnicity, and income levels.[73] In contrast, youth reporting tobacco use and involvement with the juvenile delinquency system did not have reductions in "very easy" access.[73] Similarly, Azofeifa et al. 2016 and Wen et al. 2019 found a decrease in youth perceived availability from 2002-2014 and 2004-2012 respectively.[5,67]

Impact of Medical Marijuana Policies

While youth living in states with medical cannabis policies report easier access to cannabis, legalization did not appear to increase access.[67,77]

Wen et al. 2019 examined whether there were differences in states that implemented medical cannabis policies compared to those that did not (NSDUH 2004-2012).[67] Researchers found there were no changes in perceived availability between youth in states with and without medical cannabis.[67] In a different time frame (2004-2013), Martins et al. 2016 also found that medical cannabis policies were not associated with a change in perceived availability of cannabis among youth.[77]

In a Montana sample (2010), Friese and Grube 2013 found higher numbers of medical cannabis cards and a greater percentage of votes in favor of medical legalization in a student's county were separately associated with perceived easier access.[75] Authors concluded that increased access may be related to community norms around cannabis use.[75] However, they note limitations around using county-level data, a low response rate among students, and that findings may not be generalizable.[75] Further research should include policy heterogeneity to better assess any impact on access.

Impact of Adult-use Marijuana Policies

Research has not yet fully assessed the impact of adult-use cannabis legalization on youth perceived ease of access. Four studies examined adult-use legalization.[41,55,63,64]

There are mixed findings regarding whether adult-use legalization increases access among youth shortly following enactment or implementation. One Colorado statewide sample found perceived ease of access to cannabis increased following implementation of adult-use retail sales.[64] Specifically, students reporting cannabis was "sort of easy" and "very easy" to access increased from 46% to 52%.[64] This increase was not associated with the presence of a licensed retail store within two miles of their school.[64] Note this finding is an association— causation cannot be determined.[64] However, also using Healthy Kids Colorado, Brooks-Russell et al. 2019 examined pre- (2013) and post- (2015) retail cannabis sales, and found no difference in perceived ease of access among Colorado high schoolers.[41] In a Washington statewide sample, perceived ease of access decreased from 2010-2014.[55] It is important to note that adult-use legalization was enacted in 2012 and retail stores opened in 2014 so this study does not assess the impact of implementation.[55]

One study compared ease of access in legalized states with a market ("implemented"), legal states without a market yet ("enacted") and non-adult-use but legal medical use states. Wadsworth and Hammond 2018 found that youth living in states with and without adult-use markets established reported similar rates of "easiness" to obtaining cannabis compared to those in non-adult-use states (*commercial sample of 16-19 year-olds*).[63]

Impact of Ease of Access on Use

Perceived access to cannabis is associated with youth use of cannabis.[72] In NSDUH data from 2004-2013, Martins et al. 2016 found that perceived availability of cannabis was associated with past-month use among youth.[77] Similarly, Shrier et al. 2014 found that perceived availability was associated with having any desire to use cannabis.[72] Further, Chen et al. 2018 found evidence of a dose-response relationship between perceived access and frequency of cannabis use.[66] In this MTF sample, the association was strongest for older youth compared to younger youth, and stronger for younger boys than younger girls.[66]

Sources of Purchase

AIM: This section synthesizes literature on youth sources of cannabis and purchasing patterns.

Understanding how youth access cannabis is critical to prevention. Any potential changes to sources of cannabis, whether purchased or received for free, should be monitored. It is also critical to examine whether sources and access change as a result of cannabis legalization and commercialization. This section includes U.S. samples within the past ten years.

Methods

The search focused on youth cannabis sources of purchase in the past decade. Only studies that directly collected or reported on youth cannabis sources were included, theoretical frameworks and studies that only assess use rates and/or perceptions were not included in this section. Studies on young adults and adults were excluded. Studies published in 2009 through April 2019 were identified in GoogleScholar, reference sections, and author libraries with search terms including: "youth," "adolescent," "teen," "cannabis," "marijuana," "access," "source," "purchase," and "free."

Six studies were identified.[5,74,78–81] Studies used Monitoring the Future (MTF),[79] National Survey on Drug Use and Health (NSDUH),[74] Healthy Kids Washington (HKW),[78] court diversion program survey,[80] and a survey of Colorado youth in outpatient substance use treatment.[81] One study used focus groups to examine edible cannabis use.[82] All studies were cross-sectional and could not examine changes over time or establish causality.

Purchasing and Non-Purchasing Trends

In NSDUH, (2012) 59.1% of youth cannabis users reported obtaining cannabis for free ("non-purchasers") and 39.1% reported purchasing cannabis for their last consumption.[74] Females and younger youth (12-13 years-old) were more likely to report obtaining cannabis for free.[74] Azofeifa et al. 2016 found an increase in both purchased and a decrease in freely obtained cannabis from 2002 to 2014.[5] The lack of recent national data to assess purchasing trends represents a limitation to these findings.

Some research suggests that those who purchase cannabis rather than obtain it freely are at a greater risk of negative outcomes. King et al. 2016 found that males, youth aged 14-17, and those who used cannabis in the past month had lower odds of obtaining cannabis for free or sharing it.[74] Similarly, cannabis purchasers in a survey of high-risk youth reported greater days of cannabis use and greater risk of substance use disorder.[80] The high-risk sample found no difference between the demographics of cannabis purchasers and non-purchasers.[80] In a study of

high-risk California youth, Osilla et al. 2014 found that those who reported purchasing both cannabis and alcohol were at greater risk of risky outcomes, particularly increased alcohol use.[80]

Most youth reported obtaining cannabis from a friend or person in their peer network.[74,78,80] In NSDUH (2012), the majority of purchased (33%) and free (26.4%) cannabis was obtained from a friend.[74] Nearly seven percent of youth reported purchasing from someone they just met or did not know, and 1.6% purchased from a relative/family member.[74] Blacks and those who reported 6-19 days of cannabis use in the last 20 days had higher odds of reporting last purchase from someone they just met or did not know in this sample.[74] In a sample of Washington state 10th graders after adult-use legalization enactment, the majority of participants reported receiving cannabis from peers, but 18% reported giving someone money to purchase for them, 11% accessed cannabis from their home with or without parent permission, and another 6% reported buying cannabis themselves at a retail store.[78]

Location

In NSDUH (2012), nearly 37% of youth reported their last cannabis purchase occurred in a house, apartment, or dorm, and nearly 36% reported their last purchase was outdoors in a public area.[74] Blacks and heavier users (*used cannabis 6-19 days of the last 30 days*) had higher odds of making an outdoor purchase compared to Whites and less heavy users (*1-2 days in the last 30 days*).[74] More recent data is needed to explore this trend and any impact of legalization.

Medical Cannabis

While few youth reported use of another person's medical cannabis, those who do may be at greater risk for other risky behaviors.[79,81] In a MTF analysis (2012, 2013), Boyd et al. 2015 found that 6.1% of 12th graders reported use of someone else's medical cannabis in the past year.[79] Males and Whites were more likely to report using someone else's medical cannabis.[79] Compared to illicit cannabis users who did not use someone's medical cannabis, users of someone else's medical cannabis were at greater risk for reporting 10 or more cannabis use incidences, daily use, use with intention of getting high, being "hooked," being drunk in the past year, illegal prescription drug, and other illicit substance use.[79] In a small sample of Colorado youth in treatment for substance use disorders, nearly 49% reported ever using cannabis from another person's medical supply.[81] Those who reported use of another's medical cannabis in this sample also reported greater substance use problems.[81]

Perception of Parent Disapproval

AIM: This section synthesizes literature on youth perception of parental disapproval of their use of cannabis.

Youth perception that their parents would disapprove of substance use is a protective factor against youth substance use.[51] Therefore, the extent to which youth perceive their parents as disapproving of cannabis use is important to monitor. It is also important to know whether changes to cannabis policies impact youth perception of parental disapproval and/or actual parental disapproval. This section presents findings from U.S. samples within the past ten years.

Methods

The search focused on perceived parental disapproval of youth cannabis use in the past decade. It did not examine parents' actual disapproval levels. It also examined whether medical and adult-use cannabis policies impacted perceptions. Only studies that directly collected or reported on youth (*i.e. <18 years-old*) were included. Studies published in 2009 through April 2019 were identified in GoogleScholar, reference sections of identified articles, and author libraries with search terms including: "marijuana," "cannabis," "youth," "adolescent," "perceived parental," and "parent."

Eleven studies were identified.[5,6,87,41,56,62,67,83–86] Studies used the National Survey of Drug Use and Health survey (NSDUH),[5,6,62,67,84] Monitoring the Future (MTF),[87] Community Youth Development Study,[56] a survey of American Indian 7th – 12th graders,[83] Healthy Kids Colorado,[41] and Oregon Healthy Teens survey.[85]

National Time Trends

Three studies examined perceptions of parental disapproval of youth cannabis use over time.[5,62,87] Although the majority of youth perceived that their parents strongly disapprove of cannabis use, NSDUH data showed a decrease in youth who perceive that their parents strongly disapprove of cannabis use.[62] This survey asked whether their parents would "neither approve nor disapprove," "somewhat disapprove," or "strongly disapprove" if they used cannabis.[62] In 2017, 86.5% of 12-17 year-olds reported their parents would strongly disapprove of them using cannabis once or twice, and 89% reported that their parents would strongly disapprove of them using cannabis once a month or more.[62] This represents a decrease from 2002-2015. Conversely rates of strong parental disapproval increased for cigarette smoking and alcohol use.[62] An earlier analysis (2004-2014) found a decrease in perceived (strongly or somewhat) parental disapproval for current youth cannabis users, but no change for youth overall.[5]

Younger youth consistently report more parental disapproval than older youth (*e.g. 93.7% of 12-13 year-olds and 76.5% of 16-17 year-olds reported parents would strongly disprove of them trying cannabis once or twice*).[56,88]

In 2017, MTF asked 12th graders whether their parents would disapprove of their cannabis use. This question had not been asked in the survey for the past 39 years, therefore recent trends could not be assessed.[87] Seventeen percent of 12th graders reported that their parents would not disapprove of cannabis use once or twice, and 13% believed their parents would not disprove of regular cannabis use.[87] Compared to the last time this question was asked (mid- to late 1970s), more 12th graders believed that their parents do not disapprove of cannabis use.[87]

Impact of Medical Marijuana Policies

Three studies were identified that assessed whether medical cannabis policies were associated with lower perceptions of parental disapproval of youth cannabis use.[6,67,85,86]

A NSDUH analysis (2004-2013) found that while perceived parental approval of a youth trying cannabis was higher in medicinally legalized states, this finding was not a result of legalization.[6] Rather, Schmidt et al. 2016 found that a national trend toward more permissive perceptions were higher in states that ultimately enacted legalization.[6] Wen et al. 2019 also examined whether there were differences in states that implemented medical cannabis policies compared to those that did not (NSDUH 2004-2012).[67] Researchers found that medical cannabis implementation was associated with a 0.37% increase in youth perceived parental disapproval of cannabis use.[67] Similarly, a small study in Washington state found that parents remained strongly disapproving of youth cannabis following adult-use legalization.[86] In contrast, Paschall et al. 2017 found that parental disapproval decreased in all counties from 2006 to 2015, and levels were lower in counties with more medical cannabis patients and growers using a statewide survey in Oregon.[85]

Impact of Adult-use Marijuana Policies

Research has not yet fully assessed the impact of adult-use cannabis legalization on youth perceived parental disapproval. One study examined adult-use legalization.[41]

Using Healthy Kids Colorado, Brooks-Russell et al. 2019 examined pre- (2013) and post- (2015) retail cannabis sales and found no difference in perceived parental approval of cannabis use among Colorado high schoolers.[41]

Impact of Parent Disapproval on Use

Three studies were identified that examined whether youth perceptions of parental disapproval of cannabis use were associated with less youth use ("protective factor").[56,83] All studies found that youth perceptions of parental disapproval of cannabis use acts as a protective factor against youth cannabis use.[56,83,84]

Wu et al. 2015 examined perceived parental disapproval and cannabis use in NSDUH data (2004-2012) and found parental disapproval was associated with less cannabis use for all racial and ethnic groups except Native Hawaiians/Pacific Islanders.[84] Asian-Americans reported the highest levels of parental disapproval.[84] Guttmannova et al. 2019 found that youth perceptions that their parents did not think it was wrong for them to use cannabis predicted youth cannabis use one year later.[56] In a sample of American Indian youth in 7th through 12th grade, Stanley et al. 2017 similarly found that students who perceived their parents as disapproving of cannabis use was a protective factor against using cannabis.[83]

Perception of Friend Approval

AIM: This section synthesizes literature on youth perceptions of friends' approval of them using cannabis.

Youth perception that their friends' disapprove of substance use is a protective factor for youth substance use.[89] Therefore, the extent to which youth perceive their peers as disapproving or approving of cannabis is important to monitor. It is also important to know whether changes to cannabis policies impact these perceptions. This section presents findings from U.S. national and state-wide samples published in the past ten years.

Methods

The search focused on perceived friend approval of cannabis use in the past decade. It also examined whether medical and adult-use cannabis policies impacted perceptions. This section did not examine perceived or true rates of peer's cannabis use. Only studies that directly collected or reported on youth (*i.e. <18 years-old*) were included. Studies published in 2009 through April 2019 were identified in GoogleScholar, reference sections of identified articles, and author libraries with search terms including: "marijuana," "cannabis," "youth," "adolescent," "perceived peer," "peer," "approval," and "friends' approval."

Six studies were identified.[56,62,84,87,90,91] Studies used National Survey of Drug Use and Health survey (NSDUH),[62,84] Monitoring the Future (MTF),[87] the Community Youth Development Study,[56] the national survey of parents and youth,[91] and a non-representative sample of heavy users.[90]

National Time Trends

Both MTF and the NSDUH measure perceived friend approval.[87,88] MTF asked 12th graders, "*How do you think your close friends feel (or would feel) about you [trying marijuana once or twice; smoking marijuana occasionally; and smoking marijuana regularly*]."[87] In 2017, 44% of 12th graders reported that their friends would disapprove of them experimenting with cannabis, and 65% reported that their friends would disapprove of them regularly smoking cannabis.[87] The percent of youth perceiving friend disapproval of cannabis use has trended downward in the past decade.[87]

NSDUH also assesses perceptions of close friends' views of cannabis. In 2017, 93% of 12-13 year-olds, 79.1% of 14-15 year-olds, and 63.6% of 16-17 year-olds reported that their close friends would strongly or somewhat disapprove of them trying cannabis once or twice.[88] There was a significant decrease among 14-15 year-olds from 2016 to 2017.[88] A slightly higher proportion of youth reported their close friends would disapprove of them using cannabis once a month or more (*94% of 12-13 year-olds, 81.71% of 14-15 year-olds, and 65.5% of 16-17 year-olds*).[88]

Impact of Medical Marijuana Policies

No studies were identified that assessed if medical cannabis policies were associated with changes in perception of friend approval of cannabis use.

Impact of Adult-Use Marijuana Policies

No studies were identified that assessed if adult-use cannabis policies were associated with changes in perception of friend approval of cannabis use.

Impact of Friends' Disapproval on Use

Four studies were identified that examined whether youth perceptions of friends' disapproval of cannabis use were associated with decreased youth use ("protective factor").[56,84,90,91] All found that perceiving friend disapproved of one's use was a protective factor against youth use.[56,84,90,91] However, researchers note this association is likely impacted by many factors including: having a friend that uses the substance will increase likelihood of use and someone who uses or does not use substances may seek friends with similar behaviors.[87]

Wu et al. 2015 examined perceived close friends' disapproval and cannabis use in NSDUH data (2004-2012) and found that close friend disapproval was associated with less cannabis use for all racial and ethnic groups except among Native Hawaiians/Pacific Islanders.[84] Guttmannova et al. 2019 found that 9th graders who perceived their peers as more approving and using more had higher cannabis use rates in 10th grade.[56] Additionally, Hohman et al. 2014 found that youth who held a neutral view of cannabis were more likely to be affected by perceptions of close friends compared to those with strongly held positive or negative views of cannabis.[91] In a sample of heavy users in Seattle, Washington, Walker et al. 2011 found that perceived friend approval was associated with use of cannabis, and mediated through self-efficacy in the ability to refuse cannabis.[90]

Disapproval of Peer Use

AIM: This section synthesizes previous literature on trends in youths' disapproval of same-aged youth ("peer") use of cannabis.

Less work has been done on youth attitudes around cannabis and their subsequent use, compared to tobacco and alcohol, or compared to college-aged students and emerging adults.[92] Approval or less disapproval of peers' cannabis use is associated with cannabis use among youth.[62] It is also important to know whether changes to cannabis policies impact youths' disapproval. This section presents findings from U.S. samples within the past ten years.

Methods

The search focused on youths' disapproval of peer cannabis use in the past decade. It also examined whether medical and adult-use cannabis policies impacted perceptions. Only studies that directly collected or reported on youth (*i.e. <18 years-old*) were included. Studies isolated to small geographic sampling (*e.g. one county or city*) were excluded. Studies published in 2009 through April 2019 were identified in GoogleScholar, reference sections of identified articles, and author libraries with search terms including: "marijuana," "cannabis," "youth," "adolescent," "personal disapproval," "peer," "personal acceptance," "favorable," and "approval."

Six studies were identified.[41,55,56,62,67,84] Studies used the National Survey of Drug Use and Health survey (NSDUH),[62,67,84] Community Youth Development Study,[56] Washington State Healthy Youth Survey,[55] and Healthy Kids Colorado.[41]

National Time Trends

Two studies examined youth disapproval of same-aged peers' use of cannabis over time, results appear specific to age group.[62,73]

NSDUH asks whether youth "neither approve nor disapprove," "somewhat disapprove," or "strongly disapprove" of their peers using cannabis.[62] In 2017, 78.8% of 12-17 year-olds reported that they strongly or somewhat disapproved of peers trying cannabis once or twice, and 79% reported that they strongly or somewhat disapproved of peers using cannabis once a month or more.[88] This represents a decrease from 2016 perceptions of trying and monthly use of cannabis (*80%, 80.2%, respectively*).[88]

Importantly, there are differences between younger and older youth.[73] Older youth consistently report less disapproval of peer substance use compared to younger youth. Nearly 94% of 12-13

year-olds and 65% of 16-17 year-olds reported that they strongly or somewhat disproved of peers trying cannabis once or twice in 2017.[88] Further, the decrease in disapproval of peer use between 2016 to 2017 was only significant among 14-15 year-olds.[88]

Additionally, Salas-Wright et al. 2016 note that separate analysis of "strong disapproval" and "somewhat disapproval" rather than treating them as one category impacts results.[73] In their analysis of 2002 to 2013 NSDUH data, Salas-Wright et al. 2016 found an increase in strong disapproval among younger youth between 2002 and 2013.[73] However, they observed a decrease in strong disapproval among older youth between 2009 and 2013, driven by decreases in disapproval among 17 year-olds, which returned to 2002 levels.[73] Authors conclude that youth trends towards permissiveness have not been similarly affected as adults.[73]

MTF asks about disapproval of use by adults 18 years old and older, but does not ask about peer use disapproval.[87] Therefore, results are not included in this section.

Impact of Medical Marijuana Policies

One study was identified that attempted to determine if medical cannabis policies were associated with a change in youth approval of peer cannabis use.[67]

Wen et al. 2019 examined NSDUH data (2004-2012) and found that there was no change in youth acceptance of peer cannabis use following medical cannabis legalization.[67]

Impact of Adult-use Marijuana Policies

Research has not yet fully assessed the impact of adult-use cannabis legalization on peer disapproval. Two studies examined adult-use legalization.[41,55]

Brooks-Russell et al. 2019 assessed how youth perceived cannabis use by same-aged peers before (2013) and after (2015) adult-use implementation, and found no effect of adult-use legalization in Colorado (Healthy Kids Colorado).[41] In Washington state, Fleming et al. 2016 found that youth reported less or similar perceived peer wrongness following legalization.[55] Similarly to perceived harm, where this measure once tracked cannabis use (which has decreased), it has since diverged.[55] However, authors note that this could be due to the increased medical cannabis market in 2009 and/or adult-use legalization in 2012. Authors additionally note that these recent changes might reflect the effects of rapid expansion of the medical cannabis market after 2009 and the legalization of recreational cannabis in 2012.[55]

Impact of Disapproval of Peer Use

Three studies were identified that examined whether youth disapproval of peer use of cannabis was associated with decreased youth use ("protective factor").[15,55,84] All found that youth disapproval of cannabis use was associated with decreased cannabis use.[15,55,84]

In a longitudinal cohort, youth were asked how wrong they think it is for someone their age to smoke cannabis, Guttmannova et al. 2019 found that more accepting attitudes preceded use one year later at most years measured.[15] Heavy cannabis use was also associated with increased approval and other perception risk factors one year later.[15]

Wu et al. 2015 examined disapproval of cannabis use by same-aged peers and self-reported cannabis use in NSDUH data (2004-2012) and found that disapproval was associated with less cannabis use for all racial and ethnic groups.[84] Fleming et al. also looked this association among Washington state youth, and similarly found an association.[55]

Overview: Methods and Types of Use

Inhalation

Smoking

Smoking cannabis refers to the combustion of cannabis flower and the inhalation of smoke emitted. Among youth users, smoking is the most common method of cannabis consumption.[93] There are an array of devices and methods used to smoke cannabis and each method will affect the amount of smoke inhaled.

In the U.S., joints and blunts typically refer to cannabis rolled in a paper for smoking.[94] Blunts are cannabis rolled in cigar paper made from tobacco leaves.[94] Spliffs contain both cannabis and tobacco. Hand pipes are another common smoking device, which are often made of glass, clay, wood, or stone.[95] Water pipes work similarly to hand pipes, but incorporate water (*e.g. bongs, bubblers*).[95] Hookahs are a relatively uncommon method of cannabis consumption.[95]

Vaporizing

Vaporizers are a more recent device for cannabis consumption. Vaporization is a process that occurs by heating cannabis to a temperature where cannabinoid oils (*e.g. THC and CBD*) are released but the cannabis does not combust.[95] Vaporizers minimize certain health risks associated with combustion, and reduce odors (in comparison to smoking).[95] There are a variety of vaporizers available. Portable vaporizers are comparable to e-cigarettes and are used more commonly than fixed devices. Fixed devices require an outlet power source and are usually more durable and larger. Many portable vaporizers use cannabis concentrates including butane hash oil (BHO) rather than flower.

“Dabbing” is another vaporization process for cannabis consumption. Dabbing is a form of vaporization in which cannabis concentrates are administered to a heated “nail,” creating vapor that the user then traps in a glass globe and inhales. Dabbing is a much more potent method to consume cannabis compared to other vaporizing methods or smoking.

Oral Delivery

Edibles

Edibles refer to any food or beverage that contains cannabis and consumed orally. The effects from drinking or eating cannabis are delayed compared to smoking or vaporizing methods, where cannabis enters the bloodstream immediately. Edibles must be digested and metabolized before they are absorbed into the bloodstream, and therefore take a longer time for users to feel effects. Individual metabolic rates also impact the timing of effects. Since cannabis is fat-soluble, edibles may be infused with ingredients high in fat, such olive oil or butter, which enable the extraction of cannabinoids. Edibles are typically made with concentrates that have high levels of THC;[95] However, edibles may be produced with cannabis flower.

Tinctures

Tinctures are a fast-acting liquid cannabis extract taken orally. Generally tinctures are alcohol-based meaning the cannabis is dissolved in alcohol; However, fat-soluble liquids, such as glycerol or vinegar can be used.[95] Tinctures require time to process through the liver, which reduces dosage control.[95]

Ingestible Oils

Ingestible oils commonly come in tablet or pill form and are swallowed and digested by the user.[95] Options include but are not limited to effervescent tablets and capsules with concentrated oils. Effervescent tablets are a water-based cannabinoid delivery method in which the tablet is dissolved in a non-carbonated beverage prior to ingestion. Capsules are pre-filled with cannabis concentrate to specific doses.

Cannabis Concentrates

Kief

Kief is a cannabis concentrate consisting of the resin glands found on the trichomes of cannabis flower.[96] Trichomes are the fine outgrowths or appendages on the cannabis flower that produce cannabinoids, terpenes, and flavonoids.[96] Kief is also referred to as dry sift or pollen.

Hash

Hash is the oldest and most well-known cannabis concentrate, it is more potent that cannabis flower but less potent than butane hash oil. Hash or hashish may be produced from kief by compressing the resin into bricks. It remains popular among cannabis consumers worldwide.[97]

Butane Hash Oil (BHO)

Butane hash oil is a potent concentrate that may be consumed through vaporization through a process called dabbing.[98] Dabs are concentrated doses of cannabis produced by extracting cannabinoids using solvents like butane. Butane extraction leaves behind a wax that varies in consistency (*e.g. honeycomb, shatter*).[99] Amateur production can be very dangerous and may result in poor quality oil, which may contain excessive amounts of residual solvents or contaminants that could be hazardous to consume.

CO2 Oil

CO2 extracted oil is a relatively new concentrate on the market. It is produced by extractors which use pressure and carbon dioxide to separate plant material. The CO2 extraction process is called supercritical fluid extraction and has been shown to be one of the most effective ways of reducing cannabis to its essential compounds.[98] CO2 oil is commonly vaporized in portable vaporizer pens via disposable cartridges containing a mixture of CO2 oil and polypropylene glycol giving the oil a liquid consistency.

*Note: This does not represent an exhaustive list of cannabis concentrates. More research is needed.

Trends in Youth Methods of Use

AIM: This section synthesizes the literature around trends in methods of use for cannabis consumption among youth.

Understanding youth cannabis use patterns are critical for evidence-based prevention efforts. This section examines methods of cannabis delivery, frequency of cannabis consumed, and types of cannabis product consumed by youth. Identified studies examine smoking/combustion, vaporization, and edible use methods, and included cannabis flower, butane hash oil (BHO), and edibles. Gaps in the literature exists around less common and newer use methods (*e.g. dabbing*).

This section also reviews prevalence rates and changes in youth methods of cannabis consumption over time. Health professionals should be aware that youth may use a spectrum of combustible and alternative cannabis products.[100] Among alternative products (non-smoked flower), both edibles and concentrates are rising in popularity among youth users.[100] This section is limited to trends in youth methods of consumption of cannabis products and only briefly discusses co-use use of nicotine and cannabis.

Methods

The search focused on prevalence of youth cannabis use and changes in methods of consumption over time. Literature reviews were collected from 2013-September 2018. Observational studies were collected from 2014-September 2018. One case-report study was included in this section that reported on an instance of lung injury from inhalation of BHO in an 18-year-old female.[101] Reviews on polysubstance use outside of tobacco and cannabis were excluded from this section [see subsection: *Youth Cannabis Co-use Trends*].

Findings

Most literature identified in this section were observation studies with cross-sectional data collected from survey responses. The included literature reviews focused on methods of delivery and trends in cannabis products and user characteristics.

Five literature reviews were identified.[102–106] A variety of outcomes were assessed, including: trends in cannabis concentrate use; trends in vape-pen use; edibles benefits and risks; associated health risks of BHO inhalation and amateur production; polyuse of different cannabis products; frequency of use; and sociodemographic information.

Thirteen studies were identified.[50,63,111–113,82,93,100,101,107–110] Five studies were cross-sectional and identified prevalence rates of youth cannabis use, sociodemographic correlates of use, poly-use of cannabis products, and associations between legal cannabis policy provisions and youth consumption of cannabis.[50,93,100,107,113] Two studies focused exclusively on youth edible use.[82,108] Three studies focused exclusively on butane hash oil (BHO), insights into use of BHO, amateur production techniques, and user characteristics.[109,112,114] Two studies identified vaporization trends, particularly e-cigarette use to vaporize cannabis among college students,[111] and predictors of use.[110] The final observational study assessed youth perceptions of harm and driving under the influence.[63] One case-report study was identified.[101] Anderson et al. 2019 reported on a previously healthy 18-year-old female that was admitted to the emergency department with shortness of breath for three to four days after BHO inhalation via dabbing.[101]

Among the observational studies, samples varied across the U.S., Canada, and Australia. Samples in this section included: Colorado high school students; Ontario high school students; high school students from Victoria, Australia; Los Angeles Country 10th graders; and U.S. nationally representative samples of youth.[50,93,100,107,113] Cohorts varied and included: recreational users, heavy users, occasional users, regular users, ever-users (*used cannabis once in their lifetime*), abstaining users, and non-cannabis users.[50,93,100] All observational study sample sizes were in the thousands, with the largest sample including (n=181,870).[109]

National Prevalence of Youth Cannabis Use

After alcohol, cannabis is the most commonly used substance among youth. As with many illicit substances, cannabis use is more common among older youth (ages 15-18) than younger youth (ages 12-14).[107] The National Institute of Drug Abuse (NIDA) reported that in 2018, 5.6% of 8th graders, 16.7% of 10th graders, and 22.2% of 12th graders reported cannabis use in the last month.[115] Rates are higher in Massachusetts than the national average [See *Chart V.B.3. MA High Schoolers Current Cannabis Use by Grade, YRBS 2007-2017*].

Results from the 2018 Monitoring the Future (MTF) showed that youth cannabis use peaked in 1996/97 (depending on grade), decreased through 2007/08, increased through 2010-2013, decreased and held steady among 8th graders, decreased among 10th graders then increased in 2017 and 2018, decreased among 12th graders until 2015 then increased until 2017, and decreased in 2018.[68] Unlike tobacco or alcohol use, cannabis use rates among 12th graders is higher than it was ten years ago.[68]

Cannabis flower is consistently found to be the most common cannabis product used by youth with smoking as the primary use method.[50,93,100,102,105,107,116] In a sample of 10th graders, Peters et al. 2018 found that use prevalence was highest for smoked cannabis followed by edibles and then vaporized cannabis; results were consistent among ever-users and past 30-day users; the majority of users (61.7%) reported using multiple delivery methods.[100]

Sociodemographic correlates of cannabis use vary. Several studies reported prevalence of cannabis use via alternative delivery methods is increasing but unequally among sociodemographic groups.[50,68,104] Peter et al. 2018 found that low socioeconomic status was associated with higher prevalence rates of cannabis use in both ever-users and past 30-day users for combustion and edibles but not vaporization.[100] Johnson et al. 2015 found a higher prevalence of cannabis use among Black, Hispanic, American Indian/Alaska Native, and multi-racial youth, and lower prevalence among Asians compared to Whites.[113] In regard to gender, the historic gap where males had higher use rates the females is closing or has closed. [113] Peters et al. 2018 found males had higher prevalence of ever-use for vaporizing cannabis whereas females had higher prevalence of ever-use for edibles and smoking.[100]

Edibles

Edibles are defined as any food product that contains cannabis extract. In recent years edibles have grown in popularity and proven lucrative in the legalized market for adult-use and medicinal cannabis.[104] Edibles are often perceived as a discreet way of attaining cannabis' effects without exposure to the harms from combustion.[104] Where the onset of effects from inhalation occur almost immediately, edible's (ingested cannabis) effects are lagged, therefore dosing is more challenging and risk of over-consumption is increased. Barrus et al. 2016 reported that some consumers are unaware of the delayed onset of effects and may consume larger quantities than intended resulting in adverse effects.[104]

The popularity of edibles is notable in states that have legalized adult-use or medicinal cannabis.[104] Barrus et al. 2016 notes that the use of edibles is likely underestimated when examining purchase data as direct purchases of cannabinoid-infused oil or cannabis used to make homemade edibles are not tracked.[104]

No national estimates of youth edible use were identified. Johnson et al. 2016 used a 2013 survey of Colorado high schoolers (n= 25,197) to assess the prevalence of modes of cannabis consumption among youth. Findings from this study indicate that 15% youth cannabis users usually used an alternative cannabis delivery method(s) rather than smoking, 5% of respondents

reported that their usual mode of consumption was edible ingestion.[93] Friese et al. 2017 analyzed California Healthy Kids Survey data collected in one Northern California school district and found that among lifetime cannabis users, 72% reported consuming edibles and 82% of past 30-day cannabis users reported ever using edibles.[108] Edible users also reported earlier age of cannabis use initiation and more frequent attempts to cease cannabis use.[108] Peters et al. 2018 found that in a sample of Los Angeles high school students, 21.3% reported using an edible at least one time (n=3,177).[100] In a San Francisco focus group study about edible use, respondents (*15 to 17-year-olds*) indicated edibles could be purchased at school from students who produced their own or who were selling edibles obtained from a store.[82]

It is uncommon among youth to use edibles as their primary method of cannabis consumption. Peters et al. 2018 reported that among 10th grade participants who reported ever using cannabis, 61.7% used multiple administration methods.[100] Smoking cannabis flower and consuming edibles were the most common methods of consumption.[100] All studies identified for this section that measured prevalence for methods of use, reported that edible use is considerably higher among heavy cannabis users than moderate users and females reported higher rates of lifetime edible use.[100]

Youth perceptions of edible consumption differ from perceptions of other methods of use and between cohorts. Friese et al. 2017 reported that edible users and non-users differed in their perceptions of risk and non-edible users perceived edible use as very risky.[108] Johnson et al. 2016 also found that Coloradan youth users who perceived cannabis as more harmful were more likely to use edibles, perhaps suggesting that these youth saw smoking as more risky than edible consumption.[93]

Butane Hash Oil (BHO): Dabbing

Butane hash oil is a potent concentrate that can be vaporized through a process called dabbing. Dabs are concentrated doses of cannabis made by extracting the cannabinoids using solvents, such as butane (butane is used in production of BHO rather than during user administration and mostly eliminated from the product before use).[106] The term dabbing refers to the process used to consume BHO. The dabbing process commonly consists of a user placing a hollow titanium cylinder referred to as a "nail" into the open end of a modified water pipe referred to as a "rig," the "nail" is heated by a blowtorch to a high temperature, quickly emitting a small amount of vaporized BHO.[106] Users of BHO typically inhale their entire amount in a single breath, administering very high quantities of THC in one breath rather than an extended period (*e.g. multiple inhalations of a joint*).

Some cannabis users manufacture BHO on their own through a process known as "blasting."[106] Amateur blasting can lead to increased impurities in the product from inadequate purging of butane during production.[106] Fire is another risk associated with amateur production. Amateur blasting techniques may result in volatile butane pooling in confined spaces and ignite when exposed to a spark.[112] Fires, explosions, and severe burns have been linked to home production of BHO.[106]

Stogner et al. 2015 noted a lack of scientific literature around BHO, which can have THC concentrations of 80% or higher.[106] Users of more potent cannabis may experience higher levels of harms. For example there is an association between high potency cannabis and psychosis, although causality is unknown.[109] Dabbing requires a high-temperature blowtorch to heat the nail. Temperatures can range between 900-1075°F. At extremely high temperatures, terpenes (*i.e. aromatic cannabis oils*) degrade into byproducts including carcinogens and lung irritants (*e.g. methacrolein, benzene*).[101] Inhalation of high levels of methacrolein and benzene can lead to acute respiratory failure. For example, cases of severe pneumonitis have been reported after inhalation of BHO, which required users to be hospitalized.[101]

Chan et al. 2017 examined the characteristics of BHO users and found that mental health problems and other illicit substance use were associated with use of BHO (n=5,922).[109] Self-reported mental health problems included anxiety and depression, and users were also more likely to have lower education levels.[109] BHO users reported stronger negative effects and less positive effects when using BHO compared to cannabis flower.[109] However, some users may believe dabbing is safer than smoking cannabis flower as they are inhaling vapor and not smoke from burned cannabis.[101]

There are major gaps in research on youth dabbing behaviors. Existing observational research into dabbing BHO predominantly report on young adults (*ages 18-24*). Scientific literature on youth BHO use identified in this section also primarily reports on BHO vaporization through hand-held vaporizers (*i.e. e-cigarettes*).

Vaping Cannabis

E-cigarettes are pen sized handheld vaporizers that heat liquid or solid preparations via atomizers (*heating coils*) to allow a user to inhale psychoactive aerosols (*e.g. nicotine, THC*).[50] E-cigarette use has reached epidemic proportions. In 2018, the FDA reported that over three million middle and high school students were current e-cigarette users.[117] E-cigarettes were originally intended to vaporize tobacco products, in particular, a liquid mixture known as "e-juice." E-juice is

generally a compound of water, food grade flavoring, a choice of nicotine dosage, and propylene glycol or vegetable glycerin. Recently, more technologically advanced e-cigarettes have emerged enabling users to vape cannabis products, including: ground cannabis flower, BHO, and other cannabis concentrates.[103] Cannabis e-juice (cE-juice) generally consists of BHO and diluted medical grade propylene glycol.[103]

Johnson et al. 2016 found that among Colorado high schoolers reporting past 30-day cannabis use, 6.2% reported vaporizing as their usual mode of consumption.[93] Males, Whites, Asians and 12th graders were more likely to report vaporizing cannabis in this sample.[93] In a different survey (2014) of Connecticut high schoolers current cannabis users, 5.4% reported vaporizing cannabis using an e-cigarette.[110] Young adults appear to use e-cigarettes at higher rates than high schoolers.[111]

One driver of e-cigarette use is the belief that it is safer method of consumption than smoking cigarettes. This perception of low risk of harm seems to have transferred to vaping cannabis as well. Johnson et al. 2016's results suggest that youth may be using vaporizers as a way to reduce the harm associated with smoking cannabis.[93] Additionally, e-cigarette vaporization reduces odor and devices are easily concealed compared to combustion. Cannabis users can discretely vape deodorized cannabis extracts and decrease chance of detection.[103]

Survey responses from the 2017 MTF were the first national estimates of youth cannabis vaping. Results indicated that 10% of 12th graders, 8% of 10th graders, and 3% of 8th graders vaped cannabis in the past year.[118] Richard Miech, the Principal Investigator of the study, states that vaping has progressed well beyond a cigarette alternative.[119]

Inconsistencies and Research Gaps

Overall, identified studies in this section had good external validity and reported consistent prevalence rates of youth cannabis use. Current research in youth methods of use for cannabis consumption is considerably lacking, particularly in youth ages 12-14 and for non-smoking consumption methods.

Inconsistencies were found in reported perceptions of harm among males and females regarding alternative cannabis delivery methods. Important limitations included: sample bias and uncontrolled confounding variables. Additionally, all prevalence rates were calculated from self-reported survey responses. Identified gaps in scientific literature include youth BHO dabbing prevalence and behavior. Research gaps led to sample-level characteristic inconsistencies including different age samples and variation in use patterns.

Overview: Patterns of Use

Co-Use vs. Polysubstance Use

Polysubstance use is defined as the act of using three or more psychoactive substances in a defined period of time; co-use is defined as the use of two substances. Polysubstance dependence is not the same as polysubstance use. A person with polysubstance dependence is an individual diagnosed with a psychological addiction to being in an intoxicated state without a preference for one particular substance (DSM-5).

Complementary and Substitution Effects

Complementary and substitution are terms used to categorize patterns of co- or poly-substance use. When an individual uses a substance in conjunction with another, and/or to enhance the effects of another, they are using them as "complements." Therefore, increased use in one substance will increase use of another. In contrast, if an individual uses one substance in place of another, they are using them as "substitutes." If substances act as substitutes, increased use of one substance will decrease use of another.

Cannabis and Tobacco

Cannabis and tobacco are among the most widely used psychoactive substances by youth and are often used as complements. Among U.S. youth, co-use of cannabis and tobacco is more prevalent than tobacco-only or cannabis-only use.[120]

Cannabis and Alcohol

Alcohol is the most widely used psychoactive substance among youth. Alcohol and cannabis appear to be used as both substitutes and complements among youth, with findings diverging between studies.[121] However, the majority of youth reporting both alcohol and cannabis use in a National Alcohol Survey (2005, 2010), reported having used the two substances simultaneously ("co-use").[122] Co-use is associated with worse outcomes than using either substance alone.[122]

Cannabis and Other Substances

The scientific literature lacks research about the co-use of cannabis and other substances including stimulants, depressants, narcotics, and inhalants. Among youth, rates of using other

substances are decreasing and the misuse of narcotics decreased significantly over the last five years.[68] The relationship is important to assess because daily use of cannabis in youth is associated with increased odds of using “other substances” and development of a substance use disorders as an adult.[123]

Youth Cannabis Co-use Trends

AIM: This section synthesizes and builds upon previous literature reviews to examine trends in youth polysubstance use of cannabis and other psychoactive substances.

In research, the youth ("adolescent") cohort usually includes individuals aged 12-18 years-old. Polysubstance use is defined as the act of using three or more psychoactive substance in a defined period of time. Complementary and substitution are terms used to categorize patterns of substance use. When use of one substance increases use of another substance, they are "complements." When an individual uses a substance to replace or instead of another substance, they are using them as "substitutes."

This section reviews the scientific literature assessing the trends in substitution and complementary substance use of cannabis and other psychoactive substances among youth. This section focuses primarily on youth use of cannabis, tobacco, and alcohol. Use of cannabis and other illicit substances is not well researched in youth populations and represents a gap in the scientific literature.

This section is limited to youth trends in substance use and only briefly discusses trends in young adults ages 18-25 ("emerging adults"). Youth polysubstance use is associated with an increased risk of developing substance use disorders in adulthood. There is also concern about the long-term health effects of polysubstance use on cognitive functioning and working memory; However, this area of research is outside the scope of this report and will not be discussed further.

Methods

The search focused on the trends associated with youth co- or poly-substance use of cannabis and other psychoactive substances. Other psychoactive substances included: tobacco, alcohol, stimulants, depressants, narcotics, and inhalants. Literature reviews were collected from 2011-June 2016. Observational studies were collected from 2015-September 2018. This report's section on youth co-use of cannabis and alcohol follows and extends Subbaraman et al.'s 2016 systematic literature review, which includes 39 studies between 1994-2015.[121] The section on use of cannabis and tobacco extends Ramo et al.'s 2012 review, which included 163 articles published between 1999-2009.[124] Observational studies conducted prior to Colorado and Washington's adult-use cannabis legalization in 2012 were excluded due to the potential effects these policies have on substitution and complementary substance use.

Findings

The majority of scientific literature included in this report were observation studies with cross-sectional survey data. The literature reviews focused on analyzing patterns of co- and poly-substance use and implications of drug policy reform.

Four literature reviews were identified.[121,124–126] One study was a systematic review[124] and three were nonsystematic reviews.[121,125,126] Outcomes assessed included: age of onset, psychosis spectrum, correlates and consequences of co-use, and the associations of changing cannabis legislation and how individuals co-use substances.[121,124–126] One study reviewed the impacts of changing cannabis policies on substitution and complementary alcohol use.[125]

Twelve observational studies were identified.[109,123,134,135,126–133] Five studies focused on co-use of cannabis and tobacco.[126,129–131,135] Three studies focused on co-use of cannabis and alcohol.[132,133,135] Two studies focused on co-use of cannabis and other illicit substances; other illicit substance included: opiates, cocaine, stimulants, hallucinogens, inhalants, and sleep medication.[123,134] Two studies focused on concurrent polysubstance use of cannabis, tobacco, and alcohol.[127,128]

Samples varied and included: recreational cannabis users, medicinal cannabis users, co-users of cannabis and alcohol,[132,133] co-users of cannabis and tobacco,[126,129–131] co-users of cannabis and other illicit substances, and lastly polysubstance (three or more substances) users.[123,134] All samples were taken from the U.S. and/or Canada. Most sample sizes were in the thousands with the largest including (n=176,245) participants.[120] Two sample sizes were under 1,000 participants.[127,133]

Cannabis and Alcohol

More research is also needed on cannabis and alcohol co-use patterns in youth. Alcohol and cannabis co-use is critical to monitor as co-users are at a higher risk for negative outcomes including more substance use, greater risk of substance use disorder, lower rates of high school completion, among other negative outcomes compared to alcohol only use.[122,135]

Co-use of alcohol and cannabis occurs among youth, but risk and protective factors are not yet clear. A NSDUH sample from 2011-2014 found that cannabis and alcohol co-users made up approximately 13% of youth. For comparison 38% reported alcohol only use and 10% reported cannabis only use.[135] Cannabis and alcohol co-use were more likely to be male and African

American.[135] In Monitoring the Future (MTF), (1976-2016), Patrick et al. 2018 found that among youth who used alcohol and/or cannabis in the past-year, 32.8% reported simultaneous alcohol and cannabis use (*11.2% reported binge drinking and cannabis use*).[132] Simultaneous alcohol and cannabis users were associated with a higher likelihood of truancy (*unexcused absence*), evenings out, and use of other illicit substances.[132] Simultaneous users were more likely to be White than either Black or Hispanic in this sample.[132]

Whether alcohol and cannabis are used as substitutes or complements is often debated and the current literature appears mixed. In a systematic review of the literature, Subbaraman 2016 found mixed results as to whether youth should complementary or substitution effects with alcohol and cannabis.[121] Another review found evidence of both substitution and complementary effects associated with cannabis policy changes.[125]

In more recent research, a MTF study found evidence of complementary use.[132] In contrast, O'Hara et al. 2016 found evidence of substitution effects.[125,133] Findings remain inconclusive and additional research is needed.

Cannabis and Tobacco

More research is needed to elucidate the relationship between cannabis and tobacco use in youth. Among 8th, 10th, and 12th graders, lifetime, 30-day ("current"), and daily cigarette use are at historic lows yet cannabis use has not followed the same linear decline.[136] Cannabis and tobacco co-use is of concern because research finds that youth co-users report worse outcomes than either single substance-user (*e.g. more substance use, greater psychological symptoms, and behavior problems*).[124,135]

In NSDUH, use of both cannabis and tobacco (*may or may not be simultaneous*) did not increase among youth from 2005 to 2014, despite an increase in cannabis-only use and a decline in tobacco-only use.[120] However use of cannabis and tobacco was more prevalent than tobacco-only or cannabis-only users, suggesting that many youth users are using both substances.[120] A different sample from 2011-2014 found that cannabis and cigarette users made up approximately 5% of current youth substance users, and were more likely to be male.[135] This sample found no differences between Black, Hispanic, or White cannabis and tobacco concurrent (*not necessarily simultaneous*) user rates.[135] In contrast, a 2012 systematic review found that cannabis and tobacco was greater among Black cohorts.[124] More research is needed around risk and protective factors of tobacco and cannabis co-use.

Current research suggests that tobacco and cannabis use is more common in young adults compared to other age groups.[124] Young adults reported using both tobacco and cannabis for a number of reasons including: cannabis use increased the urge to use tobacco, tobacco use increased the urge to use cannabis, and the act of smoking cigarettes helped cope with cannabis urges.[129] Some co-users (31%) reported tobacco use as a means to prolong and sustain cannabis' effects.[129] The most common reasons for co-use of cannabis and tobacco reported were: synergistic effects, complementary use, using one to reduce the other's use, co-administration (*i.e. blunts or spliffs*) and experimentation.[129] From 2005-2014, co-use was associated with higher prevalence of past-year cannabis dependence.[120]

Wang et al. 2016 found that there was a higher proportion of cannabis and tobacco co-users in states with legal medical cannabis compared to states without medical use cannabis, and found that the odds of co-use were highest among youth compared to other age groups.[131]

Cannabis and Other Substances

Research around cannabis and other substance co-use in youth lacks, especially in comparison to research regarding single substance use. For example, MTF results indicate that the use of inhalants (*e.g. sniffing glue, gases or sprays*) among 8th graders is increasing and are more common among younger youth. Johnston et al., 2018 reported that perceptions of risk from using inhalants have steadily been decreasing among youth, and in from 2016 to 2017 the percent of 8th grade students who had ever used inhalants in their lifetime increased from 7.7 to 8.9%, however this follows a downward trend from 1994.[137] Heroin use and misuse of prescription opioids has been declining among youth but the rate of decline is slowing.[68]

Knowledge regarding cannabis and other substances is still developing. Palamar et al. 2015 examined whether reasons for recent cannabis use are associated with other illicit substances including: crack, hallucinogens other than LSD, and amphetamine/stimulants and found using "to experiment" decreased the likelihood of reporting use of other substances; using cannabis for "insight" increased the likelihood for use of hallucinogens other than LSD and use due to "boredom" increased the odds for reporting use of cocaine and hallucinogens.[134]

Use of cannabis has been associated with other substance use in youth and emerging adults; Tzilos et al., 2014 examined the relationship between cannabis use frequency and the use of six other substance classes including: cocaine, opiates, stimulants, hallucinogens, inhalants, and sleep medications.[123] Tzilos et al. 2014 found that daily cannabis use was associated with an

increase in the expected odds of opiate, cocaine, stimulant, hallucinogen, inhalant, and tobacco use.[123]

Several studies found associations between polysubstance use in youth, the psychosis spectrum, and increased odds of substance use disorders in adulthood.[127,128,138] The likelihood of developing substance use disorders in adulthood increased with earlier age of cannabis initiation.[138] Cannabis use by itself was not associated with increased odds of a psychosis spectrum classification.[128] Polysubstance use of cannabis, tobacco, and alcohol in youth was associated with increased odds of psychosis spectrum classification.[128]

VIII. Research Gaps

After a comprehensive review of the state of science regarding youth cannabis use, the Cannabis Control Commission's Research Department, with consultation and collaboration with varying researchers, highlight the following gaps in our collective knowledge that should be addressed in order to guide the development of evidence-based policy decisions.

Consideration 1: Impacts may be lagged

- Provided the recency of adult-use cannabis policies, research has not yet fully assessed their impact on youth cannabis-related perceptions or use pattern changes, such as changes to product types/methods used and changes to potency of products used.
  [See *Section VI. Cannabis Legalization and Youth Use Overview*]
  - More research with extended follow-up periods is needed to assess potentially lagged impacts of legalization.
- Any changes to use of highly potent products and consumption methods (*e.g. dabbing*) should be monitored.
  [See *Section VII. Literature Reviews* subsection *Trends in Youth Methods of Use*]

Consideration 2: Youth will not all be affected equally

- Research with individual-level data is needed.
- Research on cohorts that may be more affected by cannabis policy changes is needed (*e.g. youth seeing treatment for substance use disorders; youth who work; youth in the juvenile justice syste*m).
  [See *Section VI. Cannabis Legalization and Youth Use Overview*]
- More specific outcomes should be assessed among youth cohorts, including the frequency of use, co- or poly-substance use, changes to potency of products used, and changes to method(s) of consumption.
  [See *Section VII. Literature Reviews subsections Trends in Youth Methods of Use, Youth Cannabis Co-use Trends*]

Consideration 3: Cannabis use occurs in context

- Research that examines localized impact(s) of policy and regulatory environments, including state, municipality, and neighborhood at the individual-level is needed.
  - For example, research should consider the impact of cannabis banned in a youth's municipality and the density of retail stores in their proximity (*i.e. municipality, neighborhood, et*c.).
    [See *Section VI. Cannabis Legalization and Youth Use Overview*]

- Research is needed on cannabis and other substance use behaviors, including any complementary and/or substitution effects.
  [See *Section VII. Literature Reviews subsection Youth Cannabis Co-use Trends*]
- National level research should incorporate and/or adjust for cannabis policy and regulation heterogeneity. This would include understanding the regulatory and implementation period(s) specific to the timeframe of the stud.
  [See *Section VI. Cannabis Legalization and Youth Use Overview*]
- Additional research on best practices for youth cannabis use prevention and interventions efficacy is needed (*e.g. SBIRT*).
  [See *Section IV. Data Sources and Limitations*]

IX. Public Health Framework

There are inherent challenges to legalizing and regulating a formerly illicit substance.[139] Any implementation and regulation of cannabis policy(s) requires careful consideration to potential public health effects with special attention to vulnerable cohorts, such as youth. Legalizing and regulating substances with dependence potential are often in juxtaposition to public health policy approaches since the minority of very heavy users (dependent users) account for the majority of consumption, which generates the greatest tax revenue[140] as evidenced by the tobacco and alcohol industries.[7] However, states can proactively implement evidence-based processes to counter adverse public health outcomes.

The public health prevention model is an inclusive model targeting the overall health of the public at large rather than an individualized or small group prevention model. Nurse and Edmondson-Jones 2007 discuss the importance of a framework in public health delivery.[141] Authors state that a framework assists in providing shape, structure, clarity of purpose, and direction for a combination of constructs to improve the health of a population, which includes a complex combination of skills, methods, relationships, and interactions.[141] Public health frameworks work within varying systems that surround an individual and affect individuals' behaviors, aiming to impact his/her choice(s) to partake in a behavior.[141–144]

Key Standards of Public Health

The 10 key standards of public health[141]

- *Surveillance and assessment of the population's health and well-being;*
- *Promoting and protecting the population's health and well-being;*
- *Developing quality and risk management within an evaluative culture;*
- *Collaborative working for health;*
- *Developing health programs and services and reducing inequalities;*
- *Policy and strategy development and implementation;*
- *Working with and for communities;*
- *Strategic leadership for health;*
- *Research and development; and*
- *Ethically managing self, people, and others.*

*Note: Highlighted in green are the standards of public health incorporated into Massachusetts's cannabis regulations and Public Awareness Campaign, *More About Marijuana*.

For the prevention of disease, the Centers for Disease Control and Prevention (CDC), published a framework outlining critical elements, which includes:

- Strong public health fundamentals;

- High-impact intervention; and
- Sound health policies.

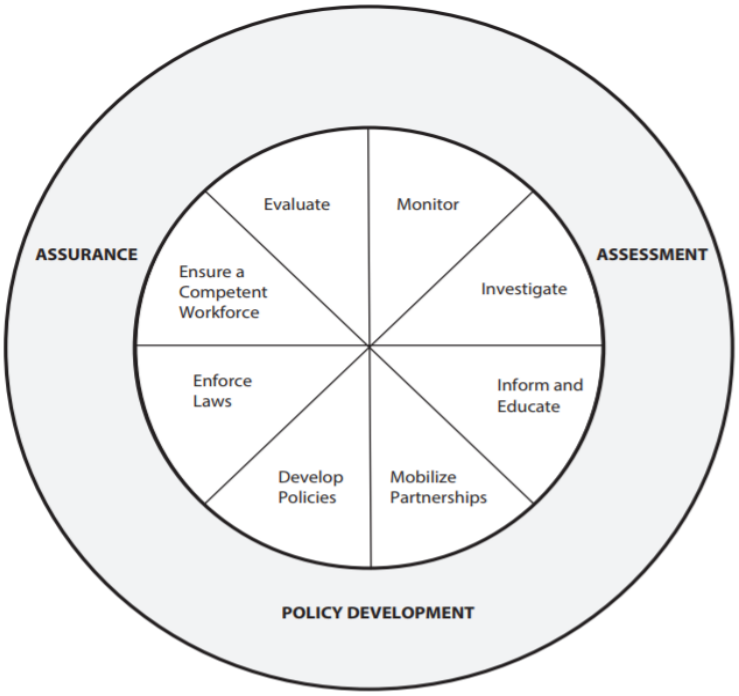
This public health framework is routinely applied to varying public health and public safety issues. In this framework, strong public health fundamentals refer to surveillance, detection, and investigation of the issue, such as problematic youth cannabis use and associated behaviors. For the Commonwealth, this would occur at both the local and state levels. High-impact interventions refer to focused efforts to prevent youth cannabis use within a short timeframe, such as identifying and validating new tools for prevention and expediting the broad use of validated interventions to youth cannabis use.

Sound health policies refers to developing and advancing policies to prevent, detect, and control rates of youth cannabis use, which include: ensuring sound scientific data to support evidence-based policies, working with local state and local public health and public safety departments to both prevent, control, and respond to potential increases in youth cannabis use. These policy efforts are aimed at helping community leaders improve local response and readiness, and educating the public.[145]

Commonwealth of Massachusetts: Regulations and Public Health

In a recent article, Dr. Ghosh and colleagues at the Colorado Department of Public Health present a framework for cannabis legalization built on the core functions of public health, including: (1) Assessing health issues through monitoring and investigation ("Assessment"), (2) Developing policy through education and community partnerships ("Policy Development"), and (3) Providing assurance through enforcement, a competent workforce, and evaluation ("Assurance"). [See *Figure 1. Public Health Framework for Legalized Cannabis: Colorado Department of Public Health and Environment, 2015*]

Figure 1. Public Health Framework for Legalized Cannabis: Colorado Department of Public Health and Environment, 2015.



The following section outlines the processes the Commonwealth of Massachusetts has implemented regarding each domain under the public health framework for legalized cannabis developed by the Colorado Department of Public Health and Environment.

Assessment

In this framework, assessment refers to monitoring, investigating, and providing education around cannabis use and the health effects of use.

1) Research

> In accordance with c.55 section 17 (a) and (b), the Commission is monitoring the following outcomes in the Commonwealth, which are direct or indirect health and public health outcomes: (1) Patterns of use; (2) Methods of consumption; (3) Sources of purchase; (4) General perceptions of marijuana; (5) Incidents of impaired driving; (6) Hospitalization and use of other health care services related to marijuana use; (7)

Financial impacts on the state healthcare system of hospitalizations related to marijuana; (8) Economic and fiscal impacts for state and local governments including the impact of legalization on the production and distribution of marijuana in the illicit market and the costs and benefits to state and local revenue; (9) Ownership and employment trends in the marijuana industry examining participation by racial, ethnic and socioeconomic subgroups, including identification of barriers to participation in the industry; (10) Expansion or contraction of the illicit marketplace and the expansion or contraction of the legal marketplace, including estimates and comparisons of pricing and product availability in both markets; (11) Incidents of discipline in schools, including suspensions or expulsions, resulting from marijuana use or possession of marijuana or marijuana products; and (12) Civil penalties, arrests, prosecutions, incarcerations and sanctions imposed for violations of chapter 94C for possession, distribution or trafficking of marijuana or marijuana products, including the age, race, gender, country of origin, state geographic region and average sanctions of the persons charged. [See *Appendix V. Research Agenda* for full Chapter 55 Research Agenda]

> [See Report: *A Baseline Review and Assessment of Cannabis Use and Public Safety Part 2- 94C Violations and Social Equity: Preliminary Data in Massachusetts* https://mass-cannabis-control.com/wp-content/uploads/2019/04/1.-RR2-94C-Violations-FINAL.pdf]

Additionally, the research agenda includes a report of the state of the science around identifying a quantifiable level of marijuana-induced impairment of motor vehicle operation, which was included in the baseline assessment of impaired driving.

> [See Report: *A Baseline Review and Assessment of Cannabis Use and Public Safety Part 1- Operating under the influence of Cannabis: Literature Review and Preliminary Data in Massachusetts*, Sections: *XIII. State of Science: Detecting Impairment* and *XIV. State of Science: Detecting Cannabis Cannabinoids* https://mass-cannabis-control.com/wp-content/uploads/2019/01/FINAL-RR1-PS1-Cannabis-Impaired-Driving_2019-1-18.pdf]

2) Public Awareness Campaign

The Commission has also created an evidence-based public awareness campaign targeted at a general audience and a campaign specific to parents. These campaigns aim educate the public about cannabis, including a discussion of health effects and its unique harms to youth. See MoreAboutMJ.org for campaign materials. [See *Appendix VI: Public Awareness Campaigns* for additional information about Massachusetts's Public Awareness Campaign, including pre/post survey assessment of youth-related topics and focus group findings from pre-implementation]

Policy Development

1) Public Health in Policy/Regulations

In this framework, policy development refers to the development of policies and regulations to protect the public's health and safety.

As outlined in c.55 section 76, Massachusetts legislators ensured there were both public health and public safety advocates in the cannabis regulatory agency: "*There shall be a Massachusetts cannabis control commission which shall consist of 5 commissioners: 1 of whom shall be appointed by the governor and shall have a background in public health, mental health, substance use or toxicology: 1 of whom shall be appointed by the attorney general and shall have a background in public safety*." Commissioners with a background in public health and public safety have been instrumental in regulating the nascent industry with focus on public health and safety.

Massachusetts policymakers and regulators implemented varying public health policy development strategies as outlined in Appendix VII: Public Health and Prevention in Regulations, as of July 2019. [See *Table VII.1., Table VII.2.*]

Assurance

1) Enforcement

In this framework, assurance refers to the enforcement of public health regulations, such as inspections to ensure products in the legal marketplace are free from contaminants, packaged in a child-resistant packaging, not diverted to minors, and properly labeled.

Massachusetts policymakers and regulators implemented varying public health assurance strategies as outlined in Appendix VII: Public Health and Prevention. [See *Table VII.1.*].

2) Ensure Competent Workforce

Under Cannabis Control Commission regulations, Massachusetts requires all Marijuana Establishment Agents to complete at least 8-hours of annual Responsible Vendor Training, which includes varying mandated topics such as: (1) Effects of cannabis on the human body; (2) Preventing diversion and sales to minors; (3) Seed-to-sale tracking compliance; and (4) Operating in accordance with state policies, regulations, and local rules.

X. Policy Considerations for the Commonwealth

Based on a comprehensive review of the scope of the issue of youth and cannabis use, the Cannabis Control Commission's Research Department, in consultation and collaboration with varying Massachusetts researchers and our internal departments, offer the following considerations to the Commonwealth regarding youth and cannabis use.

Prevention

Education about cannabis use and effects in youth continues to be crucial to mitigate potential adverse effects, including: increased and problematic use, earlier initiation of use, and formulating perceptions of cannabis that are not supported by scientific evidence (*e.g. common misperceptions that cannabis is harmless or that cannabis increases ability to concentrate on behaviors such as driving*), as well as knowledge of Massachusetts policies and provisions (*e.g. legal age to purchase cannabis in a licensed retail store*).

Data assessed in this report suggest that risky behaviors co-occur. It may be more effective if prevention mechanisms, including cannabis prevention, be included within prevention mechanisms and frameworks of other common associated risk behaviors in youth, such as binge drinking, driving after substance use, texting while driving, etc. Similarly, facilitating and strengthening relevant protective factors, such as adult support, should be encouraged.

Consideration 1: Cannabis prevention efforts should be broadly integrated into other evidence-based prevention mechanisms.

[See *V. Baseline Data* subsection, *Cannabis Policy and Youth Substance Use Behaviors: Table V.F.1, Table V.G.1*]

Consideration 2: The Massachusetts Cannabis Control Commission, in collaboration with relevant Massachusetts state agencies, could consider continuing the Public Awareness Campaign, with a continued focus on youth prevention and harm mitigation with revenue raised by cannabis exise taxes.

[See *Section IX: Public Health Framework* and *Appendix VI: Public Awareness Campaigns*]

Data Collection and Monitoring

Monitoring youth cannabis use using reliable, systematic data is essential to assess changes in trends over time. The Commonwealth and its relevant agencies could work collaboratively with researchers to define a priority research agenda and consistent data measures to monitor youth use systematically in Massachusetts. Given the varying data collection mechanisms implemented

across the Commonwealth and its agencies, the state could add measures to these surveillance systems to more accurately assess types, methods, frequency, patterns of cannabis use occurring among youth cohorts as well as changes in social norms.

Consideration 1: The Commonwealth and its relevant agencies could work with the health care system, school health systems, and researchers to monitor the rates of cannabis use disorder and youth presenting to any health care setting (school system *e.g. school nurse*, health care system *e.g. emergency room, primary care office*) with acute cannabis use symptoms or related cannabis use health concerns. As part of this collaboration, foci could extend to securing ongoing surveillance measurements by the Commonwealth, including:

- Adding measures to varying ongoing data collection mechanisms in the Commonwealth;
  [See Consideration 3 below]
- Systemically collecting both cannabis-related incidents at school and CRAFFT scores, delineated by type/category of substance (*i.e. alcohol/other Central Nervous System (CNS) Depressants, CNS Stimulants, Narcotics, Cannabis, Inhalants*);
  [See *Section IV: Data Sources and Limitations*]
- Systematically coding of Internal Classification of Diseases (ICD) ICD-9 and ICD-10 codes in health care settings, especially related to all child exposures; and
- Systematically coding Poison Control Center data especially related to youth cannabis exposures.

Consideration 2: The Cannabis Control Commission could collaborate with the Massachusetts Department of Elementary and Secondary Education (DESE) to assess:

- Youth receiving disciplinary action for cannabis-related incidents at school.
  [See *Section IV. Data Sources and Limitations*]

Consideration 3: The Commonwealth could add measures to the following systematic data collection mechanisms:

- Pregnancy Risk Assessment Monitoring System related to assess:
  - Cannabis exposures and perceived risk/social norms of cannabis use during pregnancy, including:
    - Whether mother was exposed to any cannabis by consuming or second-hand exposure (*i.e. did mother use cannabis 3-months prior to getting pregnant, did mother use any cannabis product while pregnant, frequency of cannabis use while pregnant, partner use of cannabis during pregnancy, proximity of partner's cannabis use to pregnant mother etc.)*; and

        - Perceived social norms of cannabis use during pregnancy (*i.e. how risky is it for mothers to use any cannabis products during pregnancy etc.).*
    - Cannabis exposures and perceived risk/social norms of cannabis use while breastfeeding:
        - Whether mother was exposed to any cannabis by consuming or second-hand exposure (*i.e. did mother use cannabis product while breastfeeding, frequency of cannabis use while breastfeeding, time between last cannabis consumption and breastfeeding, partner use of cannabis during breastfeeding stage, proximity of partner's cannabis use to breastfeeding mother etc.);* and
        - Perceived social norms of cannabis use while breastfeeding (*i.e. how risky is it for mothers to use any cannabis products while breastfeeding etc.).*

          [See *Appendix VI: Public Awareness Campaigns: Table VI.2*]

- Massachusetts Youth Risk Behavior Surveillance System (YRBS) and Massachusetts Health Youth Survey to assess:
    - Method(s) of cannabis consumption in the past 30-days (*e.g. smoke, eat, drink, vaporize, dab, other methods of consumption*);

      [See *Section VII: Literature Reviews* subsection *Trends in Youth Methods of Use*]
    - Preferred method(s) of cannabis consumption (*e.g. smoke, eat, drink, vaporize, dab, other methods of consumption*);

      [See *Section VII: Literature Reviews* subsection *Trends in Youth Methods of Use*]
    - How youth purchased cannabis consumed in the past 30-days (*i.e. friend or relative who legally purchased from a medical marijuana dispensary or retail store dispensary, friend or relative who cultivated marijuana legally at home, purchased from the illicit market, received from friend or relative with unknown source of purchase etc.*).

      [See *Section VII: Literature Reviews* subsection *Sources of Purchase*]
    - Perceived social norms of marijuana use by friends and peers your age (*i.e. how often do people you know [e.g. friends, peers] use marijuana in the past 30-days];*

      [See *Section VII: Literature Reviews* subsections: *Perception of*

[See *Friend Approval; Disapproval of Peer Use*]

- Past 30-day riding with a driver who had recently consumed any cannabis product behaviors (*e.g. smoke, eat, drink, vaporize, dab, other methods of consumption*);

  [See *Table V.G.1. Risk and Protective Factors: Youth Cannabis Use*]

- Perceived social norms of driving after cannabis use (*i.e. how often do people you know [e.g. friends, peers, relatives] drive a motorized vehicle after cannabis consumption etc*.); and

  [See *Table V.G.1. Risk and Protective Factors: Youth Cannabis Use*]

- Perceived risk of harm from driving after cannabis consumption (*i.e. how risky do people perceive driving after cannabis consumption to be etc*.).

  [See *Table V.G.1. Risk and Protective Factors: Youth Cannabis Use*]

XI. References

1. Massachusetts Department of Elementary and Secondary Education (DESE) and Department of Public Health (DPH). *Health and Risk Behaviors of Massachusetts Youth 2017*.; 2013. doi:10.1017/CBO9781107415324.004

2. Keyes KM, Wall M, Cerdá M, et al. How does state marijuana policy affect US youth? Medical marijuana laws, marijuana use and perceived harmfulness: 1991-2014. *Addiction*. 2016;111(12):2187-2195. doi:10.1111/add.13523

3. Miech R, Johnston L, O'Malley PM. Prevalence and Attitudes Regarding Marijuana Use Among Adolescents Over the Past Decade. *Pediatrics*. 2017;140(6):e20170982. doi:10.1542/peds.2017-0982

4. Sarvet AL, Wall MM, Keyes KM, et al. Recent rapid decrease in adolescents' perception that marijuana is harmful, but no concurrent increase in use. *Drug Alcohol Depend*. 2018;186(December 2017):68-74. doi:10.1016/j.drugalcdep.2017.12.041

5. Azofeifa A, Mattson ME, Schauer G, McAfee T, Grant A, Lyerla R. National Estimates of Marijuana Use and Related Indicators — National Survey on Drug Use and Health, United States, 2002–2014. *MMWR Surveill Summ*. 2016;65(11):1-28. doi:10.15585/mmwr.ss6511a1

6. Schmidt LA, Jacobs LM, Spetz J. Young people's more permissive views about marijuana: Local impact of state laws or national trend? *Am J Public Health*. 2016;106(8):1498-1503. doi:10.2105/AJPH.2016.303153

7. Pacula RL, Kilmer B, Wagenaar AC, Chaloupka FJ, Caulkins JP. Developing public health regulations for marijuana: lessons from alcohol and tobacco. *Am J Public Health*. 2014;104(6):1021-1028. doi:10.2105/AJPH.2013.301766

8. Hall W, Lynskey M. Why it is probably too soon to assess the public health effects of legalisation of recreational cannabis use in the USA. *The Lancet Psychiatry*. 2016;3(9):900-906. doi:10.1016/S2215-0366(16)30071-2

9. Hall W. What are the policy lessons of National Alcohol Prohibition in the United States, 1920-1933? *Addiction*. 2010;105(7):1164-1173. doi:10.1111/j.1360-0443.2010.02926.x

10. Caulkins JP, Kilmer B, Kleiman MAR. *Marijuana Legalization: What Everyone Needs to Know*. Second. New York: Oxford University Press; 2016.

11. Ewing SWF, Lovejoy TI, Choo EK. How has legal recreational cannabis affected adolescents in your state? A window of opportunity. *Am J Public Health*. 2017;107(2):246-247. doi:10.2105/AJPH.2016.303585

12. Pacula RL, Sevigny EL. Marijuana Liberalizations Policies: Why We Can't Learn Much from Policy Still in Motion. *J Policy Anal Manag*. 2014;33(1):212-221.

13. Hall W, Weier M. Assessing the Public Health Impacts of Legalizing Recreational Cannabis Use in the USA. *Clin Pharmacol Ther*. 2015;97(6):607-615. doi:10.1002/cpt.110

14. Salas-Wright CP. Marijuana use among young people in an era of policy change: what does recent evidence tell us ? *Am J Drug Alcohol Abuse*. 2017;43(3):231-233.

15. Guttmannova K, Jones AA, Johnson JK, Oesterle S, Johnson RM, Martins SS. Using Existing Data to Advance Knowledge About Adolescent and Emerging Adult Marijuana Use in the Context of Changes in Marijuana Policies. *Prev Sci*. 2019. doi:10.1007/s11121-019-00991-w

16. Ennett ST, Foshee VA, Bauman KE, et al. The Social Ecology of Adolescent Alcohol Misuse. *Child Dev*. 2008;79(6):1777-1791. doi:10.1111/j.1467-8624.2008.01225.x

17. Feinstein EC, Richter L, Foster SE. Addressing the Critical Health Problem of Adolescent Substance Use Through Health Care, Research, and Public Policy. *J Adolesc Heal*. 2012;50(5):431-436. doi:10.1016/j.jadohealth.2011.12.033

18. Bostwick JM. Blurred Boundaries: The Therapeutics and Politics of Medical Marijuana. *Mayo Clin Proc*. 2012;87(2):172-186. doi:10.1016/j.mayocp.2011.10.003

19. Pacula RL, Chriqui JF, Reichmann DA, Terry-McElrath YM. State medical marijuana laws: understanding the laws and their limitations. *J Public Health Policy*. 2002;23(4):413-439. http://www.ncbi.nlm.nih.gov/pubmed/12532682.

20. Courtwright DT, Belenko SR. Drugs and Drug Policy in America: A Documentary History. *Am J Leg Hist*. 2000;44(3):317. doi:10.2307/3113869

21. Mikuriya TH. Marijuana in medicine: past, present and future. *Calif Med*. 1969;110(1):34-40. http://www.ncbi.nlm.nih.gov/pubmed/4883504.

22. Bridgeman MB, Abazia DT. Medicinal cannabis: history, pharmacology, and implications for the acute care setting. *Pharm Ther*. 2017;42(3):180-188. doi:10.1177/2045125312457586

23. David F. Musto. Opium, Cocaine and Marijuana in American History. *Sci Am*. 1991;265(1):40-47. https://www.jstor.org/stable/24936977?seq=1#page_scan_tab_contents.

24. Gieringer DH. The Forgotten Origins of Cannabis Prohibition in California. *Contemp Drug Probl*. 1999;26(2):237-288. doi:10.1177/009145099902600204

25. Diversion Control Division, Drug Enforcement Administration (DEA) USD of J (DOJ). Title 21 United States Code (USC) Controlled Substances Act. https://www.deadiversion.usdoj.gov/21cfr/21usc/. Accessed October 16, 2018.

26. U.S. Drug Enforcement Agency. Drug Scheduling. webpage. https://www.dea.gov/drug-scheduling. Accessed October 16, 2018.

27. Jeffrey Miron. *The Effect of Marijuana Decriminalization on the Budgets of Massachusetts Governments, With a Discussion of Decriminalization's Effect on Marijuana Use: An Update of Miron (2002a)*. Cambridge, MA; 2008. https://scholar.harvard.edu/files/miron/files/decrim_update_2007-1.pdf.

28. National Conference of State Legislatures. Marijuana Overview. webpage. http://www.ncsl.org/research/civil-and-criminal-justice/marijuana-overview.aspx. Accessed October 16, 2018.

29. Centers for Disease Control and Prevention. *Methodology of the Youth Risk Behavior Surveillance System — 2013*. Vol 62.; 2013.

30. Osborne J, Osborne JW. Bringing Balance and Technical Accuracy to Reporting Odds Ratios and the Results of Logistic Regression Analyses. *Best Pract Quant Methods*. 2006;11(7). doi:10.4135/9781412995627.d30

31. Centers for Disease Control and Prevention CDC. *Youth Risk Behavior Survey: Data Summary & Trends Report, 2007-2017*.; 2018.

32. Miech RA, Johnston L, O'Malley PM, Bachman JG, Schulenberg J, Patrick ME. Trends in use of marijuana and attitudes toward marijuana among youth before and after decriminalization: The case of California 2007–2013. *Int J Drug Policy*. 2015;26(4):336-344. doi:10.1016/j.drugpo.2015.01.009

33. Johnson JK. Elucidating the Impact of Adolescent Marijuana Use. *J Adolesc Heal*. 2018;63(2):129-130. doi:10.1016/j.jadohealth.2018.06.002

34. Carliner H, Brown QL, Sarvet AL, Hasin DS. Cannabis use, attitudes, and legal status in the U.S.: A review. *Prev Med (Baltim)*. 2017;104:13-23. doi:10.1016/j.ypmed.2017.07.008

35. Choo EK, Benz M, Zaller N, et al. The Impact of State Medical Marijuana Legislation on Adolescent Marijuana Use. *J Adolesc Heal*. 2014;55(2):160-166. doi:10.1016/j.jadohealth.2014.02.018

36. Hasin DS, Wall M, Keyes KM, et al. Medical marijuana laws and adolescent marijuana use in the USA from 1991 to 2014: Results from annual, repeated cross-sectional surveys. *The Lancet Psychiatry*. 2015;2(7):601-608. doi:10.1016/S2215-0366(15)00217-5

37. Johnson J, Hodgkin D, Harris SK. The design of medical marijuana laws and adolescent use and heavy use of marijuana: Analysis of 45 states from 1991 to 2011. *Drug Alcohol Depend*. 2017;170:1-8. doi:10.1016/j.drugalcdep.2016.10.028

38. Sarvet AL, Wall MM, Fink DS, et al. Medical marijuana laws and adolescent marijuana use in the United States: a systematic review and meta-analysis. *Addiction*. 2018;113(6):1003-1016. doi:10.1111/add.14136

39. Lynne-Landsman SD, Livingston MD, Wagenaar C. A. Effects of State Medical Marijuana Laws on Adolescent Marijuana Use . *Am J Public Health*. 2013;103(8):1500-1506. http://ajph.aphapublications.org/doi/abs/10.2105/ajph.2012.301117.

40. Cerdá M, Wall M, Feng T, et al. Association of State Recreational Marijuana Laws With Adolescent Marijuana Use. *JAMA Pediatr*. 2017;171(2):142. doi:10.1001/jamapediatrics.2016.3624

41. Brooks-Russell A, Ma M, Levinson AH, et al. Adolescent Marijuana Use, Marijuana-Related Perceptions, and Use of Other Substances Before and After Initiation of Retail Marijuana Sales in Colorado (2013–2015). *Prev Sci*. 2019;20(2):185-193. doi:10.1007/s11121-018-0933-2

42. Reed J. *Impacts of Marijuana Legalization in Colorado A Report Pursuant to Senate Bill 13 - 283*.; 2018. https://www.colorado.gov/pacific/dcj-ors.

43. Single EW. The Impact of Marijuana Decriminalization: An Update. *J Public Health Policy*. 1989;10(4):456. doi:10.2307/3342518

44. Melchior M, Nakamura A, Bolze C, et al. Does liberalisation of cannabis policy influence levels of use in adolescents and young adults? A systematic review and meta-analysis. *BMJ Open*. 2019;9(7):e025880. doi:10.1136/bmjopen-2018-025880

45. Shi Y, Lenzi M, An R. Cannabis liberalization and adolescent cannabis use: A cross-national study in 38 countries. *PLoS One*. 2015;10(11):1-15. doi:10.1371/journal.pone.0143562

46. Blevins CE, Marsh E, Banes KE, Stephens RS, Walker DD, Roffman RA. The Implications of Cannabis Policy Changes in Washington on Adolescent Perception of Risk, Norms, Attitudes, and Substance Use. *Subst Abus Res Treat*. 2018;12:117822181881549. doi:10.1177/1178221818815491

47. Rusby JC, Westling E, Crowley R, Light JM. Legalization of recreational marijuana and community sales policy in Oregon: Impact on adolescent willingness and intent to use, parent use, and adolescent use. *Psychol Addict Behav*. 2018;32(1):84-92. doi:10.1037/adb0000327

48. Graves JM, Whitehill JM, Miller ME, Brooks-Russell A, Richardson SM, Dilley JA. Employment and Marijuana Use Among Washington State Adolescents Before and After Legalization of Retail Marijuana. *J Adolesc Heal*. March 2019. doi:10.1016/j.jadohealth.2018.12.027

49. Sobesky M, Gorgens K. Cannabis and adolescents: Exploring the substance misuse treatment provider experience in a climate of legalization. *Int J Drug Policy*. 2016;33:66-74. doi:10.1016/j.drugpo.2016.02.008

50. Borodovsky JT, Lee DC, Crosier BS, et al. U.S. cannabis legalization and use of vaping and edible products among youth. *Drug Alcohol Depend*. 2017;177(December 2016):299-306. doi:10.1016/j.drugalcdep.2017.02.017

51. Zimmerman GM, Farrell C. Parents, Peers, Perceived Risk of Harm, and the Neighborhood: Contextualizing Key Influences on Adolescent Substance Use. *J Youth Adolesc*. 2017;46(1):228-247. doi:10.1007/s10964-016-0475-5

52. Harper S, Strumpf EC, Kaufman JS. Do Medical Marijuana Laws Increase Marijuana Use? Replication Study and Extension. *Ann Epidemiol*. 2012;22(3):207-212. doi:10.1016/j.annepidem.2011.12.002

53. Wall MM, Poh E, Cerdá M, Keyes KM, Galea S, Hasin DS. Adolescent Marijuana Use from 2002 to 2008: Higher in States with Medical Marijuana Laws, Cause Still Unclear. *Ann Epidemiol*. 2011;21(9):714-716. doi:10.1016/j.annepidem.2011.06.001

54. Schuermeyer J, Salomonsen-Sautel S, Price RK, et al. Temporal trends in marijuana attitudes, availability and use in Colorado compared to non-medical marijuana states: 2003–11. *Drug Alcohol Depend*. 2014;140:145-155. doi:10.1016/j.drugalcdep.2014.04.016

55. Fleming CB, Guttmannova K, Cambron C, Rhew IC, Oesterle S. Examination of the Divergence in Trends for Adolescent Marijuana Use and Marijuana-Specific Risk Factors in Washington State. *J Adolesc Heal*. 2016;59(3):269-275. doi:10.1016/j.jadohealth.2016.05.008

56. Guttmannova K, Skinner ML, Oesterle S, White HR, Catalano RF, Hawkins JD. The Interplay Between Marijuana-Specific Risk Factors and Marijuana Use Over the Course of Adolescence. *Prev Sci*. 2019;20(2):235-245. doi:10.1007/s11121-018-0882-9

57. Pacula RL, Powell D, Heaton P, Sevigny EL. Assessing the Effects of Medical Marijuana Laws on Marijuana Use: The Devil is in the Details. *J Policy Anal Manag*. 2015;34(1):7-31.

58. Bull SS, Brooks-Russell A, Davis JM, Roppolo R, Corsi K. Awareness, Perception of

Risk and Behaviors Related to Retail Marijuana Among a Sample of Colorado Youth. *J Community Health*. 2017;42(2):278-286. doi:10.1007/s10900-016-0253-z

59. Roditis ML, Halpern-Felsher B. Adolescents' Perceptions of Risks and Benefits of Conventional Cigarettes, E-cigarettes, and Marijuana: A Qualitative Analysis. *J Adolesc Heal*. 2015;57(2):179-185. doi:10.1016/j.jadohealth.2015.04.002

60. Estoup AC, Moise-Campbell C, Varma M, Stewart DG. The Impact of Marijuana Legalization on Adolescent Use, Consequences, and Perceived Risk. *Subst Use Misuse*. 2016;51(14):1881-1887. doi:10.1080/10826084.2016.1200623

61. Braymiller JL, Masters LD, Linden-Carmichael AN, Lanza ST. Contemporary Patterns of Marijuana Use and Attitudes Among High School Seniors: 2010–2016. *J Adolesc Heal*. 2018;63(4):394-400. doi:10.1016/j.jadohealth.2018.06.005

62. Lipari RN, Ahrnsbrak RD, Pemberton MR, Porter JD. Risk and Protective Factors and Estimates of Substance Use Initiation: Results from the 2016 National Survey on Drug Use and Health. *CBHSQ Data Rev*. 2017;(September). http://www.ncbi.nlm.nih.gov/pubmed/29431965.

63. Wadsworth E, Hammond D. Differences in patterns of cannabis use among youth: Prevalence, perceptions of harm and driving under the influence in the USA where non-medical cannabis markets have been established, proposed and prohibited. *Drug Alcohol Rev*. 2018;37(7):903-911. doi:10.1111/dar.12842

64. Harpin SB, Brooks-Russell A, Ma M, James KA, Levinson AH. Adolescent Marijuana Use and Perceived Ease of Access Before and After Recreational Marijuana Implementation in Colorado. *Subst Use Misuse*. 2018;53(3):451-456. doi:10.1080/10826084.2017.1334069

65. Parker MA, Anthony JC. A prospective study of newly incident cannabis use and cannabis risk perceptions: Results from the United States Monitoring the Future study, 1976–2013. *Drug Alcohol Depend*. 2018;187(March):351-357. doi:10.1016/j.drugalcdep.2018.03.012

66. Chen L-Y, Martins SS, Strain EC, Mojtabai R, Storr CL. Sex and Age Differences in Risk Factors of Marijuana Involvement During Adolescence. *Addict Disord Their Treat*. 2018;17(1):29-39. doi:10.1097/ADT.0000000000000120

67. Wen H, Hockenberry JM, Druss BG. The Effect of Medical Marijuana Laws on Marijuana-Related Attitude and Perception Among US Adolescents and Young Adults. *Prev Sci*. 2019;20(2):1-9. doi:10.1007/s11121-018-0903-8

68. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME. Key Findings on Adolescent Drug Use. *Monit Futur Natl Surv Results Drug Use 1975-2017*.

2019:1-104. doi:10.1093/rfs/hhh001

69. Substance Abuse and Mental Health Services Administration. *Results from the 2016 National Survey on Drug Use and Health: Detailed Tables*. Rockville, MD, MD; 2017. https://www.samhsa.gov/data/sites/default/files/NSDUH-DetTabs-2016/NSDUH-DetTabs-2016.pdf.

70. Terry-McElrath YM, O'Malley PM, Patrick ME, Miech RA. Risk is still relevant: Time-varying associations between perceived risk and marijuana use among US 12th grade students from 1991 to 2016. *Addict Behav*. 2017;74(2):13-19. doi:10.1016/j.addbeh.2017.05.026

71. Hughes A, Lipari RN, Williams M. *The CBHSQ Report: State Estimates of Adolescent Marijuana Use and Perceptions of Risk of Harm from Marijuana Use: 2013 and 2014*. Rockville, MD, MD; 2015. http://www.ncbi.nlm.nih.gov/pubmed/27030866.

72. Shrier LA, Ross CS, Blood EA. Momentary Positive and Negative Affect Preceding. *J Stud Alcohol Drugs*. 2014.

73. Salas-Wright CP, Oh S, Goings TC, Vaughn MG. Trends in Perceived Access to Marijuana Among Adolescents in the United States: 2002–2015. *J Stud Alcohol Drugs*. 2017;78(5):771-780. doi:10.15288/jsad.2017.78.771

74. King KA, Merianos AL, Vidourek RA. Characteristics of Marijuana Acquisition Among a National Sample of Adolescent Users. *Am J Heal Educ*. 2016;47(3):126-135. doi:10.1080/19325037.2016.1157535

75. Friese B, Grube JW. Legalization of medical marijuana and marijuana use among youths. *Drugs Educ Prev Policy*. 2013;20(1):33-39. doi:10.3109/09687637.2012.713408

76. Wadsworth E, Hammond D. International differences in patterns of cannabis use among youth: Prevalence, perceptions of harm, and driving under the influence in Canada, England & United States. *Addict Behav*. 2019;90(July 2018):171-175. doi:10.1016/j.addbeh.2018.10.050

77. Martins SS, Mauro CM, Santaella-Tenorio J, et al. State-level medical marijuana laws, marijuana use and perceived availability of marijuana among the general U.S. population. *Drug Alcohol Depend*. 2016;169(10):26-32. doi:10.1016/j.drugalcdep.2016.10.004

78. Shah A, Stahre M. Marijuana Use Among 10th Grade Students — Washington, 2014. *Morb Mortal Wkly Rep*. 2016;65(50-51).

79. Boyd CJ, Veliz PT, McCabe SE. Adolescents' Use of Medical Marijuana: A Secondary Analysis of Monitoring the Future Data. *J Adolesc Heal*. 2015;57(2):241-244. doi:10.1016/j.jadohealth.2015.04.008

80. Osilla KC, Pedersen ER, Ewing BA, Miles JN, Ramchand R, D'Amico EJ. The effects of employment among adolescents at-risk for future substance use. *Addict Behav*. 2014;9(38). http://proxy.lib.sfu.ca/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=104302059&site=ehost-live.

81. Thurstone C, Lieberman SA, Schmiege SJ. Medical marijuana diversion and associated problems in adolescent substance treatment. *Drug Alcohol Depend*. 2011;118(2-3):489-492. doi:10.1016/j.drugalcdep.2011.03.031

82. Friese B, Slater MD, Annechino R, Battle RS. Teen Use of Marijuana Edibles: A Focus Group Study of an Emerging Issue. *J Prim Prev*. 2016;37(3):303-309. doi:10.1007/s10935-016-0432-9

83. Stanley LR, Swaim RC, Dieterich SE. The Role of Norms in Marijuana Use Among American Indian Adolescents. *Prev Sci*. 2017;18(4):406-415. doi:10.1007/s11121-017-0768-2

84. Wu L-T, Swartz MS, Brady KT, Hoyle RH. Perceived cannabis use norms and cannabis use among adolescents in the United States. *J Psychiatr Res*. 2015;64:79-87. doi:10.1016/j.jpsychires.2015.02.022

85. Paschall MJ, Grube JW, Biglan A. Medical Marijuana Legalization and Marijuana Use Among Youth in Oregon. *J Prim Prev*. 2017;38(3):329-341. doi:10.1007/s10935-017-0476-5

86. Kosterman R, Bailey JA, Guttmannova K, et al. Marijuana Legalization and Parents' Attitudes, Use, and Parenting in Washington State. *J Adolesc Heal*. 2016;59(4):450-456. doi:10.1016/j.jadohealth.2016.07.004

87. Miech RA, Johnston LD, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME. *Monitoring the Future National Survey Results on Drug Use, 1975-2017: Volume I, Secondary School Students*. Ann Arbor, Michigan; 2018. http://monitoringthefuture.org/pubs.html#monographs.

88. Center for Behavioral Health Statistics and Quality. *Results from the 2017 National Survey on Drug Use and Health: Detailed Tables*. Rockville, MD; 2018.

89. Merianos AL, Rosen BL, Montgomery L, Barry AE, Smith ML. Impact of Perceived Risk and Friend Influence on Alcohol and Marijuana Use Among Students. *J Sch Nurs*. 2017;33(6):446-455. doi:10.1177/1059840517717591

90. Walker DD, Neighbors C, Rodriguez LM, Stephens RS, Roffman RA. Social norms and self-efficacy among heavy using adolescent marijuana smokers. *Psychol Addict Behav*.

2011;25(4):727-732. doi:10.1037/a0024958

91. Hohman ZP, Crano WD, Siegel JT, Alvaro EM. Attitude Ambivalence, Friend Norms, and Adolescent Drug Use. *Prev Sci*. 2014;15(1):65-74. doi:10.1007/s11121-013-0368-8

92. Malmberg M, Overbeek G, Vermulst AA, Monshouwer K, Vollebergh WAM, Engels RCME. The theory of planned behavior: Precursors of marijuana use in early adolescence? *Drug Alcohol Depend*. 2012;123(1-3):22-28. doi:10.1016/j.drugalcdep.2011.10.011

93. Johnson RM, Brooks-Russell A, Ma M, et al. Usual Modes of Marijuana Consumption Among High School Students in Colorado. *J Stud Alcohol Drugs*. 2016;77(4):580-588. doi:10.15288/jsad.2016.77.580

94. Williams K. What's the Difference Between Joints, Blunts, and Spliffs? Leafly. https://www.leafly.com/news/cannabis-101/whats-the-difference-between-joints-blunts-and-spliffs. Published 2015. Accessed October 4, 2019.

95. Williams K. The Different Ways to Smoke and Consume Cannabis. Leafly. https://www.leafly.com/news/cannabis-101/the-complete-list-of-cannabis-delivery-methods. Accessed January 4, 2019.

96. Leafly. What Is Kief and How Can You Use It? https://www.leafly.com/news/cannabis-101/what-is-kief. Accessed January 4, 2019.

97. Bennett P. What Is Hash and How Does It Relate to Cannabis? Leafly. https://www.leafly.com/news/cannabis-101/what-is-hashish. Accessed January 4, 2019.

98. Rahn B. Explore the Diverse World of Cannabis Oil and Concentrates. Leafly. https://www.leafly.com/news/cannabis-101/the-great-wide-world-of-cannabis-concentrates. Published 2014.

99. MOCA Modern Cannabis. Concentrates. https://moderncann.com/concentrates/. Accessed January 4, 2019.

100. Peters EN, Bae D, Barrington-Trimis JL, Jarvis BP, Leventhal AM. Prevalence and Sociodemographic Correlates of Adolescent Use and Polyuse of Combustible, Vaporized, and Edible Cannabis Products. *JAMA Netw Open*. 2018;1(5):e182765. doi:10.1001/jamanetworkopen.2018.2765

101. Anderson RP, Zechar K. Lung injury from inhaling butane hash oil mimics pneumonia. *Respir Med Case Reports*. 2019;26(November 2018):171-173. doi:10.1016/j.rmcr.2019.01.002

102. Coffey C, Patton GC. Cannabis Use in Adolescence and Young Adulthood. *Can J*

Psychiatry. 2016;61(6):318-327. doi:10.1177/0706743716645289

103. Giroud C, de Cesare M, Berthet A, Varlet V, Concha-Lozano N, Favrat B. E-cigarettes: A review of new trends in cannabis use. *Int J Environ Res Public Health*. 2015;12(8):9988-10008. doi:10.3390/ijerph120809988

104. Barrus D, Capogrossi K, Cates S, et al. *Tasty THC: Promises and Challenges of Cannabis Edibles*. Vol 2015. Research Triangle Park, NC; 2016. doi:10.3768/rtipress.2016.op.0035.1611

105. Greydanus DE, Hawver EK, Greydanus MM, Merrick J. Marijuana: Current Concepts. *Front Public Heal*. 2013;1(October):1-17. doi:10.3389/fpubh.2013.00042

106. Stogner JM, Miller BL. The Dabbing Dilemma: A Call for Research on Butane Hash Oil and Other Alternate Forms of Cannabis Use. *Subst Abus*. 2015;36(4):393-395. doi:10.1080/08897077.2015.1071724

107. Sampasa-Kanyinga H, Hamilton HA, LeBlanc AG, Chaput J-P. Cannabis use among middle and high school students in Ontario: a school-based cross-sectional study. *C Open*. 2018;6(1):E50-E56. doi:10.9778/cmajo.20170159

108. Friese B, Slater MD, Battle RS. Use of Marijuana Edibles by Adolescents in California. *J Prim Prev*. 2017;38(3):279-294. doi:10.1007/s10935-017-0474-7

109. Chan GCK, Hall W, Freeman TP, Ferris J, Kelly AB, Winstock A. User characteristics and effect profile of Butane Hash Oil: An extremely high-potency cannabis concentrate. *Drug Alcohol Depend*. 2017;178:32-38. doi:10.1016/j.drugalcdep.2017.04.014

110. Morean ME, Kong G, Camenga DR, Cavallo DA, Krishnan-Sarin S. High School Students' Use of Electronic Cigarettes to Vaporize Cannabis. *Pediatrics*. 2015;136(4):611-616. doi:10.1542/peds.2015-1727

111. Kenne DR, Fischbein RL, Tan ASL, Banks M. The Use of Substances Other Than Nicotine in Electronic Cigarettes Among College Students. *Subst Abus Res Treat*. 2017;11. doi:10.1177/1178221817733736

112. Al-Zouabi I, Stogner JM, Miller BL, Lane ES. Butane hash oil and dabbing: insights into use, amateur production techniques, and potential harm mitigation. *Subst Abuse Rehabil*. 2018;Volume 9:91-101. doi:10.2147/SAR.S135252

113. Johnson RM, Fairman B, Gilreath T, et al. Past 15-year trends in adolescent marijuana use: Differences by race/ethnicity and sex. *Drug Alcohol Depend*. 2015;155(24):8-15. doi:10.1016/j.drugalcdep.2015.08.025

114. Kenne DR, Fischbein RL, Tan ASL, et al. Butane hash oil and dabbing: insights into use,

amateur production techniques, and potential harm mitigation. *Subst Abuse Rehabil*. 2017;178(November 2018):171-173. doi:10.1016/j.drugalcdep.2017.04.014

115. National Institute on Drug Abuse (NIDA). Marijuana. 2019. https://www.drugabuse.gov/drugs-abuse/marijuana. Accessed March 6, 2019.

116. Johnson LD, O'Malley PM, Bachman JG, Schulenberg JE. *Monitoring the Future National Survey Results on Drug Use: 2012 Overview, Key Findings on Adolescent Drug Use.*; 2013.

117. US Food and Drug Administration. Results from 2018 National Youth Tobacco Survey show dramatic increase in e-cigarette use among youth over past year. https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm625917.htm. Published 2018. Accessed February 4, 2019.

118. Institute for Social Research University of Michigan, Miech R. National Adolescent Drug Trends in 2017: Findings Released Marijuana Use Edges Upward. https://goo.gl/w78A5e. Published 2017.

119. Glenza J. More US teens are vaping than smoking cigarettes, study finds. *Guard*. 2017. https://www.theguardian.com/society/2017/dec/13/e-cigarettes-vaping-more-teens-cigarettes-study.

120. Schauer GL, Peters EN. Correlates and trends in youth co-use of marijuana and tobacco in the United States, 2005–2014. *Drug Alcohol Depend*. 2018;185(May 2017):238-244. doi:10.1016/j.drugalcdep.2017.12.007

121. Subbaraman MS. Substitution and Complementarity of Alcohol and Cannabis: A Review of the Literature. *Subst Use Misuse*. 2016;51(11):1399-1414. doi:10.3109/10826084.2016.1170145

122. Subbaraman MS, Kerr WC. Simultaneous Versus Concurrent Use of Alcohol and Cannabis in the National Alcohol Survey. *Alcohol Clin Exp Res*. 2015;39(5):872-879. doi:10.1111/acer.12698

123. Tzilos GK, Reddy MK, Caviness CM, Anderson BJ, Stein MD. Getting higher: Co-occurring drug use among marijuana-using emerging adults. *J Addict Dis*. 2014;33(3):202-209. doi:10.1080/10550887.2014.950024

124. Ramo DE, Liu H, Prochaska JJ. Tobacco and marijuana use among adolescents and young adults: A systematic review of their co-use. *Clin Psychol Rev*. 2012;32(2):105-121. doi:10.1016/j.cpr.2011.12.002

125. Guttmannova K, Lee CM, Kilmer JR, et al. Impacts of Changing Marijuana Policies on Alcohol Use in the United States. *Alcohol Clin Exp Res*. 2016;40(1):33-46.

doi:10.1111/acer.12942

126. Subramaniam P, McGlade E, Yurgelun-Todd D. Comorbid Cannabis and Tobacco Use in Adolescents and Adults. *Curr Addict Reports*. 2016;3(2):182-188. doi:10.1007/s40429-016-0101-3

127. Gubner NR, Thrul J, Kelly OA, Ramo DE. Young adults report increased pleasure from smoking cigarettes when drinking alcohol but not when using marijuana. *Addict Res Theory*. 2018;26(1):71-76. doi:10.1080/16066359.2017.1311877

128. Jones JD, Calkins ME, Scott JC, Bach EC, Gur RE. Cannabis Use, Polysubstance Use, and Psychosis Spectrum Symptoms in a Community-Based Sample of U.S. Youth. *J Adolesc Heal*. 2017;60(6):653-659. doi:10.1016/j.jadohealth.2017.01.006

129. Berg CJ, Payne J, Henriksen L, et al. Reasons for Marijuana and Tobacco Co-use Among Young Adults: A Mixed Methods Scale Development Study. *Subst Use Misuse*. 2018;53(3):357-369. doi:10.1080/10826084.2017.1327978

130. Ramo DE, Delucchi KL, Liu H, Hall SM, Prochaska JJ. Young adults who smoke cigarettes and marijuana: Analysis of thoughts and behaviors. *Addict Behav*. 2014;39(1):77-84. doi:10.1016/j.addbeh.2013.08.035

131. Wang JB, Ramo DE, Lisha NE, Cataldo JK. Medical marijuana legalization and cigarette and marijuana co-use in adolescents and adults. *Drug Alcohol Depend*. 2016;166:32-38. doi:10.1016/j.drugalcdep.2016.06.016

132. Patrick ME, Kloska DD, Terry-McElrath YM, Lee CM, O'Malley PM, Johnston LD. Patterns of simultaneous and concurrent alcohol and marijuana use among adolescents. *Am J Drug Alcohol Abuse*. 2018;44(4):441-451. doi:10.1080/00952990.2017.1402335

133. O'Hara RE, Armeli S, Tennen H, O'Hara RE. Alcohol and cannabis use among college students: Substitutes or complements? *Addict Behav*. 2016;58:1-6. doi:10.1016/j.addbeh.2016.02.004.Alcohol

134. Palamar JJ, Griffin-Tomas M, Kamboukos D. Reasons for recent marijuana use in relation to use of other illicit drugs among high school seniors in the United States. *Am J Drug Alcohol Abuse*. 2015;41(4):323-331. doi:10.3109/00952990.2015.1045977

135. Banks DE, Rowe AT, Mpofu P, Zapolski TCB. Trends in typologies of concurrent alcohol, marijuana, and cigarette use among US adolescents: An ecological examination by sex and race/ethnicity. *Drug Alcohol Depend*. 2017;179(24):71-77. doi:10.1016/j.drugalcdep.2017.06.026

136. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME. *Monitoring the Future National Survey Results on Drug Use 1975-2018: Overview, Key*

Findings on Adolescent Drug Use.; 2019.

137. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME. *2017 Overview Key Findings on Adolescent Drug Use*.; 2018.

138. Moss HB, Chen CM, Yi H ye. Early adolescent patterns of alcohol, cigarettes, and marijuana polysubstance use and young adult substance use outcomes in a nationally representative sample. *Drug Alcohol Depend*. 2014;136(1):51-62. doi:10.1016/j.drugalcdep.2013.12.011

139. Ghosh TS, Van Dyke M, Maffey A, Whitley E, Erpelding D, Wolk L. Medical marijuana's public health lessons--implications for retail marijuana in Colorado. *N Engl J Med*. 2015;372(11):991-993. doi:10.1056/NEJMp1500043

140. Pacula RL, Kilmer B, Wagenaar AC, Chaloupka FJ, Caulkins JP. Developing Public Health Regulations for Marijuana: Lessons From Alcohol and Tobacco. *Am J Public Health*. 2014;104(6):1021-1028. doi:10.2105/AJPH.2013.301766

141. Nurse J, Edmondson-Jones P. A framework for the delivery of public health: an ecological approach. *J Epidemiol Community Health*. 2007;61(6):555-558. doi:10.1136/jech.2005.039073

142. Ostaszewski K. Inadequate Models of Adolescent Substance Use Prevention: Looking for Options to Promote Pro-Social Change and Engagement. *Subst Use Misuse*. 2015;50(8-9):1097-1102. doi:10.3109/10826084.2015.1010897

143. Bacio GA, Estrada Y, Huang S, Martínez M, Sardinas K, Prado G. Ecodevelopmental predictors of early initiation of alcohol, tobacco, and drug use among Hispanic adolescents. *J Sch Psychol*. 2015;53(3):195-208. doi:10.1016/j.jsp.2015.02.001

144. Shrier LA, Scherer EB. It depends on when you ask: motives for using marijuana assessed before versus after a marijuana use event. *Addict Behav*. 2014;39(12):1759-1765. doi:10.1016/j.addbeh.2014.07.018

145. Frieden T, Briss P, Stephens J, Thacker S. *Youth Risk Behavior Surveillance - United States, 2009*. Atlanta, GA; 2010.

146. Brellenthin AG, Lee D-C. Physical Activity and the Development of Substance Use Disorders: Current Knowledge and Future Directions. *Prog Prev Med (New York, NY)*. 2018;3(3). doi:10.1097/pp9.0000000000000018

147. Dunn MS. Association between Physical Activity and Substance Use Behaviors among High School Students Participating in the 2009 Youth Risk Behavior Survey. *Psychol Rep*. 2014;114(3):675-685. doi:10.2466/18.06.pr0.114k28w7

148. Kempf C, Llorca PM, Pizon F, Brousse G, Flaudias V. What's new in addiction prevention in young people: A literature review of the last years of research. *Front Psychol*. 2017;8(JUL):1-16. doi:10.3389/fpsyg.2017.01131

149. Crippa JA, Zuardi AW, Martín-Santos R, et al. Cannabis and anxiety: a critical review of the evidence. *Hum Psychopharmacol Clin Exp*. 2009;24(7):515-523. doi:10.1002/hup.1048

150. Colorado Retail Marijuana Public Health Advisory Committee. *Monitoring Health Concerns Related to Marijuana in Colorado*.; 2018.

151. Valdebenito S, Ttofi M, Eisner M. Prevalence rates of drug use among school bullies and victims: A systematic review and meta-analysis of cross-sectional studies. *Aggress Violent Behav*. 2015;23:137-146. doi:10.1016/j.avb.2015.05.004

152. Ttofi MM, Farrington DP, Lösel, F., Crago R V., Theodorakis N. School bullying and drug use later in life: A meta-analytic investigation. *Sch Psychol Q*. 2016;31(1):8-27.

153. Doumas DM, Midgett A, Johnston AD. Substance Use and Bullying Victimization Among Middle and High School Students: Is Positive School Climate a Protective Factor? *J Addict Offender Couns*. 2017;38(1):2-15. doi:10.1002/jaoc.12025

154. Stone AL, Becker LG, Huber AM, Catalano RF. Review of risk and protective factors of substance use and problem use in emerging adulthood. *Addict Behav*. 2012;37(7):747-775. doi:10.1016/j.addbeh.2012.02.014

155. Johnson RM, LaValley M, Schneider KE, Musci RJ, Pettoruto K, Rothman EF. Marijuana use and physical dating violence among adolescents and emerging adults: A systematic review and meta-analysis. *Drug Alcohol Depend*. 2017;174(24):47-57. doi:10.1016/j.drugalcdep.2017.01.012

156. Committee on the Health Effects of Marijuana. *The Health Effects of Cannabis and Cannabinoids*.; 2017. doi:10.17226/24625

157. Latimer W, Zur J. Epidemiologic Trends of Adolescent Use of Alcohol, Tobacco, and Other Drugs. *Child Adolesc Psychiatr Clin N Am*. 2010;19(3):451-464. doi:10.1016/j.chc.2010.03.002

158. Draucker CB, Mazurczyk J. Relationships between childhood sexual abuse and substance use and sexual risk behaviors during adolescence: An integrative review. *Nurs Outlook*. 2013;61(5):291-310. doi:10.1016/j.outlook.2012.12.003

159. Duncan AE, Ph D, Sartor CE, et al. The association between cannabis abuse and dependence and childhood physical and sexual abuse: Evidence from an offspring of twins design. *Addiction*. 2008;103(6):990-997. doi:10.1111/j.1360-0443.2008.02210.x.The

160. Palmer RHC, Young SE, Hopfer CJ, et al. Developmental epidemiology of drug use and abuse in adolescence and young adulthood: Evidence of generalized risk. *Drug Alcohol Depend*. 2009;102(1-3):78-87. doi:10.1016/j.drugalcdep.2009.01.012

161. Chen D, Wu L-T. Association Between Substance Use and Gun-Related Behaviors. *Epidemiol Rev*. 2016;38(1):mxv013. doi:10.1093/epirev/mxv013

162. Schepis TS, Desai RA, Cavallo DA, et al. Gender Differences in Adolescent Marijuana Use and Associated Psychosocial Characteristics. *J Addict Med*. 2011;5(1):65-73. doi:10.1097/ADM.0b013e3181d8dc62

163. Malmberg M, Overbeek G, Monshouwer K, Lammers J, Vollebergh WAM, Engels RCME. Substance use risk profiles and associations with early substance use in adolescence. *J Behav Med*. 2010;33(6):474-485. doi:10.1007/s10865-010-9278-4

164. Serafini G, Pompili M, Innamorati M, et al. The Association between Cannabis Use, Mental Illness, and Suicidal Behavior: What is the Role of Hopelessness? *Front Psychiatry*. 2013;4(October 2012):1-5. doi:10.3389/fpsyt.2013.00125

165. Primack BA, Kraemer KL, Fine MJ, Dalton MA. Media Exposure and Marijuana and Alcohol Use Among Adolescents. *Subst Use Misuse*. 2009;44(5):722-739. doi:10.1080/10826080802490097

166. Nguyen NN, Newhill CE. The role of religiosity as a protective factor against marijuana use among African American, White, Asian, and Hispanic adolescents. *J Subst Use*. 2016;21(5):547-552. doi:10.3109/14659891.2015.1093558

167. Dunlop SM, Romer D. Adolescent and Young Adult Crash Risk: Sensation Seeking, Substance Use Propensity and Substance Use Behaviors. *J Adolesc Heal*. 2010;46(1):90-92. doi:10.1016/j.jadohealth.2009.06.005

168. Terry-McElrath YM, O'Malley PM, Johnston LD. Alcohol and Marijuana Use Patterns Associated With Unsafe Driving Among U.S. High School Seniors: High Use Frequency, Concurrent Use, and Simultaneous Use. *J Stud Alcohol Drugs*. 2015;75(3):378-389. doi:10.15288/jsad.2014.75.378

169. Ritchwood TD, Ford H, DeCoster J, Sutton M, Lochman JE. Risky sexual behavior and substance use among adolescents: A meta-analysis. *Child Youth Serv Rev*. 2015;52(4):74-88. doi:10.1016/j.childyouth.2015.03.005

170. El-Menshawi M, Castro G, Rodriguez de la Vega P, Ruiz Peláez JG, Barengo NC. First Time Cannabis Use and Sexual Debut in U.S. High School Adolescents. *J Adolesc Heal*. 2019;64(2):194-200. doi:10.1016/j.jadohealth.2018.08.018

171. Hanna RC, Perez JM, Ghose S. Cannabis and development of dual diagnoses: A literature

review. *Am J Drug Alcohol Abuse*. 2017;43(4):442-455. doi:10.1080/00952990.2016.1213273

172. Bradley BJ, Greene AC. Do health and education agencies in the united states share responsibility for academic achievement and health? A review of 25 years of evidence about the relationship of adolescents' academic achievement and health behaviors. *J Adolesc Heal*. 2013;52(5):523-532. doi:10.1016/j.jadohealth.2013.01.008

173. Moller I. C, Tait J. R, Byrne G. D. Deliberate Self-Harm, Substance Use, and Negative Affect in Nonclinical Samples: A Systematic Review. *Subst Abus*. 2013;34(2):188-207. doi:10.1080/08897077.2012.693462

174. Marshal MP, Friedman MS, Stall R, et al. Sexual orientation and adolescent substance use: A meta-analysis and methodological review. *Addiction*. 2008;103(4):546-556. doi:10.1111/j.1360-0443.2008.02149.x

175. Corliss HL, Rosario M, Wypij D, Wylie SA, Frazier AL, Austin SB. Sexual orientation and drug use in a longitudinal cohort study of U.S. adolescents. *Addict Behav*. 2010;35(5):517-521. doi:10.1016/j.addbeh.2009.12.019

176. Dermody SS, McGinley J, Eckstrand K, Marshal MP. Sexual minority female youth and substance use disparities across development. *J LGBT Youth*. April 2019:1-16. doi:10.1080/19361653.2019.1598313

177. Kidd JD, Jackman KB, Wolff M, Veldhuis CB, Hughes TL. Risk and Protective Factors for Substance Use Among Sexual and Gender Minority Youth: a Scoping Review. *Curr Addict Reports*. 2018;5(2):158-173. doi:10.1007/s40429-018-0196-9

178. Kwan M, Bobko S, Faulkner G, Donnelly P, Cairney J. Sport participation and alcohol and illicit drug use in adolescents and young adults: a systematic review of longitudinal studies. *Addict Behav*. 2014. doi:10.1016/j.addbeh.2013.11.006

179. Borges G, Bagge CL, Orozco R. A literature review and meta-analyses of cannabis use and suicidality. *J Affect Disord*. 2016;195:63-74. doi:10.1016/j.jad.2016.02.007

180. Lee SS, Humphreys KL, Flory K, Liu R, Glass K. Prospective association of childhood attention-deficit/hyperactivity disorder (ADHD) and substance use and abuse/dependence: A meta-analytic review. *Clin Psychol Rev*. 2011;31(3):328-341. doi:10.1016/j.cpr.2011.01.006

181. Jones SE, Lollar DJ. Relationship Between Physical Disabilities or Long-term Health Problems and Health Risk Behaviors or Conditions Among US High School Students. *J Sch Health*. 2008;78(5).

182. Qadeer RA, Wong FC, MacKillop J, Ferro MA. A Comparative Study of Substance Use

in Young Adolescents With and Without Chronic Health Conditions. *J Child Adolesc Subst Abus*. 2018;27(5-6):297-304. doi:10.1080/1067828X.2018.1512026

183. To WT, Neirynck S, Vanderplasschen W, Vanheule S, Vandevelde S. Substance use and misuse in persons with intellectual disabilities (ID): Results of a survey in ID and addiction services in Flanders. *Res Dev Disabil*. 2014;35(1):1-9. doi:10.1016/j.ridd.2013.10.015

184. Day C, Lampraki A, Ridings D, Currell K. Intellectual disability and substance use/misuse: a narrative review. *J Intellect Disabil Offending Behav*. 2016;7(1):25-34. doi:10.1108/JIDOB-10-2015-0041

185. McNamara JK, Willoughby T. A Longitudinal Study of Risk-Taking Behavior in Adolescents with Learning Disabilities. *Learn Disabil Res Pract*. 2010;25(1):11-24.

186. Evans MK, Clinkinbeard SS, Simi P. Learning Disabilities and Delinquent Behaviors among Adolescents: A Comparison of Those with and without Comorbidity. *Deviant Behav*. 2015;36(3):200-220. doi:10.1080/01639625.2014.924361

187. Seymour J. The Impact of Public Health Awareness Campaigns on the Awareness and Quality of Palliative Care. *J Palliat Med*. 2018;21(S1):30-36. doi:10.1089/jpm.2017.0391

XII. Appendices

Appendix I: Acronyms

Acronym	Meaning
BHO	Butane Hash Oil
CBD	Cannabidiol
CNB	Cannabis Control Commission
CSA	Controlled Substance Act
CUD	Cannabis Use Disorder
DEA	Drug Enforcement Agency
DESE	Department of Elementary and Secondary Education
GPA	Grade Point Average
HKC	Healthy Kids Colorado
ID	Identification
LGBT	Lesbian, Gay, Bisexual, Transgender
MA	Massachusetts
MTF	Monitoring the Future
NA	Not Applicable
NLSY	National Longitudinal Study of Youth
NSDUH	National Survey of Drug Use and Health
OR	Odds Ratio
PSU	Primary Sampling Unit
SBIRT	Screening, Brief Intervention, and Referral to Treatment
STD	Sexually Transmitted Disease
STEP Act	An Act Relative to Substance Use, Treatment, Education and Prevention
THC	Tetrahydrocannabinol
US	United States
WHKS	Washington Healthy Youth Survey
YRBS	Youth Risk Behavior Survey

Appendix II: YRBS Supplementary Data

Table II.1. MA High Schoolers Cannabis Use by Year, YRBS 2007-2017

Year	Lifetime Use	Past 30-Day Use	Heavy Use (≥20 times,)[a]
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Year			
2007	41.0 (37.8- 44.3)	24.3 (21.5- 27.1)	6.5 (5.2- 7.8)
2009	42.3 (38.7- 45.9)	26.9 (24.4- 29.4)	8.4 (6.5- 10.4)
2011	43.3 (39.8- 46.8)	28.0 (25.2- 30.8)	9.2 (7.8- 10.7)
2013	41.3 (38.4- 44.2)	24.8 (22.7- 26.9)	7.3 (6.0- 8.6)
2015	41.1 (37.8- 44.5)	24.9 (22.0- 27.7)	6.6 (5.0- 8.3)
2017	38.1 (34.1- 42.1)	24.2 (21.5- 26.9)	5.6 (4.4- 6.7)

Table II.2. MA High Schoolers Cannabis Use by Year and Grade, YRBS 2007-2017

Year	Lifetime Use	Past 30-Day Use	Heavy Use (≥20 times,)[a]
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
2007			
9th Grade	26.6 (21.6- 31.6)	15.1 (11.4- 18.8)	2.2 (1.0- 3.4)
10th Grade	38.0 (32.6- 43.5)	22.6 (17.2- 27.9)	6.4 (3.4- 9.4)
11th Grade	47.5 (40.2- 54.7)	29.0 (23.3- 34.7)	7.7 (4.8- 10.7)
12th Grade	54.2 (49.6- 58.8)	32.0 (27.4- 36.4)	10.2 (7.5- 12.8
2009			
9th Grade	30.6 (25.9- 36.3)	19.0 (14.9- 23.1)	4.6 (3.1- 6.2)
10th Grade	38.4 (31.7- 45.1)	24.7 (19.9- 29.4)	7.8 (5.2- 10.4)
11th Grade	47.4 (42.5- 52.3)	29.9 (25.0- 34.7)	9.0 (6.2- 11.9)
12th Grade	54.4 (47.8- 60.9)	35.3 (30.4- 20.2)	12.7 (8.1- 17.2)
2011			
9th Grade	31.7 (25.1- 38.3)	20.6 (15.8- 25.3)	6.0 (3.2- 8.9)
10th Grade	38.2 (31.9- 44.5)	25.6 (19.7- 31.6)	6.6 (3.9- 9.3)
11th Grade	50.2 (45.9- 54.5)	32.3 (28.5- 36.2)	12.2 (9.4- 14.9)
12th Grade	55.3 (48.4- 62.2)	34.8 (29.1- 40.1)	12.5 (9.5- 15.4)
2013			
9th Grade	26.2 (21.7- 30.8)	16.0 (12.4- 19.5)	4.1 (1.8- 6.5)
10th Grade	39.8 (32.4- 47.1)	25.3 (20.1- 30.5)	8.3 (4.7- 11.9)
11th Grade	47.7 (42.3- 53.1)	28.6 (23.5- 33.6)	7.4 (4.4- 10.3)
12th Grade	53.0 (47.6- 58.5)	30.3 (24.3- 36.2)	9.5 (6.1- 12.9)
2015			
9th Grade	23.3 (18.1- 28.5)	13.8 (10.3- 17.4)	2.4 (1.1- 3.6)
10th Grade	40.5 (35.1- 45.8)	23.6 (18.3- 28.9)	5.0 (2.6- 7.5)
11th Grade	46.6 (41.1- 52.2)	29.4 (24.5- 34.3)	8.5 (5.1- 11.9)
12th Grade	55.2 (48.7- 61.7)	33.3 (28.0- 38.7)	10.9 (7.2- 14.7)
2017			
9th Grade	19.4 (15.9- 23.0)	12.1 (9.8 (14.4)	2.2 (1.1- 3.3)
10th Grade	35.4 (30.9- 39.8)	22.6 (18.4- 26.7)	3.8 (1.8- 5.7)
11th Grade	45.6 (40.3- 50.8)	29.8 (25.4- 34.2)	7.5 (5.2- 9.7)
12th Grade	54.1 46.5- 61.7)	33.2 (27.6- 28.9)	9.2 (6.6- 11.7)

Table II.3. MA High Schoolers Cannabis Use by Demographics, YRBS 2007-2017

Demographics	Lifetime Use	Past 30-Day Use	Heavy Use (≥20 times)[a]
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Gender			
Female	39.4 (37.9- 40.8)	22.6 (21.5- 23.7)	4.5 (4.1- 4.9)
Male	44.1 (42.5- 45.8)	28.5 (27.2- 29.8)	10.2 (9.4- 11.0)
Race (2007-2017)			
White	41.9 (40.1- 43.7)	26.5 (25.2- 27.8)	7.4 (6.8- 8.0)
Black	40.4 (36.9- 43.9)	24.3 (21.5- 27.1)	8.1 (6.1- 10.0)
Hispanic	43.2 (40.9- 45.5)	24.9 (23.5- 26.2)	7.0 (5.9- 8.1)
American Indian/ Alaskan Native	54.6 (44.2- 65.0)	42.7 (30.5- 55.0)	19.8 (10.5- 29.2)
Asian	20.1 (15.6- 24.7)	10.7 (7.4- 14.0)	3.0 (1.4- 4.5)
Native Hawaiian/ Pacific Islander	36.5 (26.9- 46.1)	27.5 (19.4- 35.6)	13.0 (6.3- 19.8)

Table II.4. MA High Schoolers Cannabis Use by Demographics by Year, YRBS 2007-2017

Demographics	Lifetime Use	Past 30-Day Use	Past 30- Day Heavy Use (≥20 times)[a]
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Gender			
2007			
Female	38.8 (34.8- 42.9)	21.2 (18.0- 24.3)	3.8 (2.8- 4.8)
Male	43.5 (40.0- 46.9)	27.8 (24.5- 31.1)	9.3 (7.5- 11.1)
2009			
Female	38.4 (34.5- 42.2)	22.8 (19.9- 25.6)	5.8 (4.0- 7.7)
Male	46.4 (42.6- 50.2)	31.4 (28.0- 34.7)	11.1 (8.8- 13.7)
2011			
Female	37.8 (34.1- 41.5)	23.1 (19.8- 26.4)	5.2 (3.9- 6.4)
Male	48.5 (44.3- 52.6)	32.6 (29.7- 35.4)	13.4 (11.5- 15.3)
2013			
Female	39.1 (35.8- 42.4)	21.8 (19.4- 24.3)	4.1 (3.1- 5.1)
Male	43.1 (35.8- 42.4)	27.6 (24.2- 31.0)	10.1 (7.9- 12.4)
2015			
Female	40.2 (36.6- 43.8)	23.0 (19.7- 26.2)	4.3 (2.8-5.8)
Male	41.6 (37.3- 45.9)	26.3 (23.1- 29.6)	9.0 (6.7- 11.3)
2017			
Female	38.4 (34.0- 42.7)	23.2 (19.8- 26.5)	3.0 (1.9- 4.1)
Male	37.5 (32.9- 42.1)	24.9 (21.5- 28.4)	8.1 (6.3- 9.8)
Race/Ethnicity			
2007			
White	41.7 (37.8- 45.6)	25.3 (22.2- 28.4)	6.5 (5.1- 7.9)
Black	43.0 (36.2- 49.8)	25.5 (17.8- 33.1)	8.3 (3.3- 13.4)
Hispanic	38.0 (32.5 (43.4)	19.4 (15.5- 23.2)	5.8 (3.2- 8.3)
American Indian/ Alaskan Native	55.5 (21.0-90.0)	46.0 (13.2- 78.8)	30.6 (1.8- 59.5)
Asian	24.2 (15.1- 33.3)	10.8 (5.3 (16.4)	2.2 (0.0- 4.5)
Native Hawaiian/ Pacific Islander	33.5 (2.4- 64.6)	8.0 (0.0- 26.1)	8.0 (0.0- 26.1)
2009			
White	43.9 (39.5- 48.2)	28.3 (25.2- 31.5)	8.8 (6.4- 11.3)
Black	37.1 (29.1- 45.2)	25.0 (17.0- 33.0)	6.4 (2.5- 10.2)

Hispanic	40.9 (34.4- 47.4)	21.9 (18.3- 25.5)	7.4 (4.2- 10.7)
American Indian/ Alaskan Native	66.7 (44.6- 88.8)	46.6 (21.2- 72.0)	22.3 (0.0- 45.3)
Asian	22.9 (14.6- 31.2)	14.1 (7.7- 20.6)	4.9 (1.4- 8.5)
Native Hawaiian/ Pacific Islander	32.4 (11.8- 53.1)	37.1 (15.8- 58.5)	22.1 (2.5- 41.6)
2011			
White	44.1 (39.8- 48.4)	28.7 (25.3- 32.1)	9.2 (7.5- 11.0)
Black	44.3 (34.2- 54.5)	29.9 (22.2- 37.5)	13.0 (8.2- 17.8)
Hispanic	42.6 (37.0- 48.1)	25.5 (21.1- 29.8)	7.0 (4.4- 9.7)
American Indian/ Alaskan Native	61.3 (33.7- 88.9)	50.1 (19.7- 80.4)	27.3 (0.2- 54.3)
Asian	22.2 (10.6- 33.9)	13.9 (6.5- 21.3)	3.5 (0.0- 7.1)
Native Hawaiian/ Pacific Islander	44.3 (24.1- 64.5)	39.9 (22.9- 57.0)	9.6 (0.0- 21.3)
2013			
White	41.7 (38.6- 44.9)	26.1 (23.4- 28.8)	7.5 (6.1- 9.0)
Black	41.7 (33.3- 50.1)	23.0 (17.0- 29.0)	8.0 (4.9- 11.0)
Hispanic	49.3 (43.9- 54.7)	27.1 (22.4- 31.8)	7.3 (4.3- 10.3)
American Indian/ Alaskan Native	67.2 (34.6- 99.7)	58.8 (26.6- 91.0)	34.5 (0.0- 71.9)
Asian	13.9 (7.8- 20.0)	4.2 (0.0- 7.7)	1.3 (0.0- 3.4)
Native Hawaiian/ Pacific Islander	32.4 (1.8- 62.9)	28.9 (1.3- 56.5)	28.9 (1.3- 56.5)
2015			
White	40.4 (36.8- 44.1)	24.9 (21.7- 28.1)	6.2 (4.2- 8.2)
Black	42.4 (36.3- 48.5)	21.2 (15.5 (26.9)	6.9 (3.9- 10.0)
Hispanic	46.9 (41.8- 52.0)	27.2 (23.5- 30.9)	8.3 (5.9- 10.7)
American Indian/ Alaskan Native	53.4 (26.5- 80.2)	41.6 (14.3- 68.8)	7.8 (0.0- 23.3)
Asian	25.8 (11.4- 40.1)	15.2 (5.4- 25.0)	5.4 (0.4- 10.4)
Native Hawaiian/ Pacific Islander	30.1 (0.0- 69.6)	9.6 (0.0- 22.7)	3.0 (0.0- 9.4)
2017			
White	39.5 (34.4- 44.6)	25.5 (22.1- 28.9)	5.8 (4.3- 7.3)
Black	33.1 (26.4- 39.9)	21.6 (15.5- 27.7)	6.1 (2.7- 9.4)
Hispanic	41.6 (35.1- 48.1)	26.7 (21.3- 32.1)	6.2 (3.8- 8.6)
American Indian/ Alaskan Native	21.3 (5.9- 36.8)	18.0 (4.0- 31.9)	1.1 (0.0- 3.7)
Asian	16.1 (7.2- 25.1)	9.0 (4.1- 13.9)	1.4 (0.0- 3.2)
Native Hawaiian/ Pacific Islander	37.9 (12.4- 63.4)	13.8 (0.0-32.7)	NA

Appendix III: Associated Risk Factors Justification

This section draws on literature reviews whenever possible to provide a brief sense of current literature findings and justification for the logistical regression variables analyzed.

Table III.1. Risk and Protective Factors in the Literature

Concept/Measure	Evidence of Association
Active physically	A review (2018) identified mixed finding in regard to whether physical activity is associated with cannabis use among youth.[146] In an analysis of the 2009 YRBS, Dunn 2014 found high levels of physical activity (5-7 days/week) and sports participation in two or more teams was a protective factor against cannabis use for females but not males.[147]
Adult Support	In a scoping literature review of recent addiction findings Kempf et al. 2017 report adult support, and particularly parental support, may be protective against substance use in youth.[148]
Anxiety	"The Health Effects of Cannabis and Cannabinoids" report (2017) found that there is limited evidence of an association between cannabis use and anxiety, but there is moderate evidence linking regular cannabis use to social anxiety disorder. Another literature review reports acute anxiety symptoms are a potential side effect of cannabis use, and found that chronic users have higher levels of anxiety disorders.[149] However, the review notes the relationship and any potential causality between these factors is unknown.[149] In gray literature, the Colorado Retail Marijuana Public Health Advisory Committee reviewed the literature and found mixed evidence as to whether adolescent and young adults who use cannabis were more likely than non-users to develop anxiety symptoms.[150]
Bullying	Two meta-analyses found there is an association between substance use and those who bully and those who are bullied among youth.[151,152] A recent study, found this association persists for high schoolers and cannabis use, however it was not observed among middle schoolers.[153] More broadly, there is evidence for an association between externalizing behaviors (*i.e. outward negative behaviors, such as aggression, conduct problems, etc.)* and cannabis use.[154]

Dating violence	In a metanalysis and review of cannabis use and dating violence, Johnson et al. 2017 found there is an association between physical dating violence victimization and perpetration among adolescences and young adults.[155]
Depression	"The Health Effects of Cannabis and Cannabinoids" report (2017) found that cannabis use does not appear to increase likelihood of developing depression.[156] In the gray literature, the Colorado Retail Marijuana Public Health Advisory Committee reviewed the literature and found mixed evidence as to whether adolescent and young adults who use cannabis were more likely than non-users to develop depression.[150] Researchers have documented an association between depression and cannabis use.[157]
Forced sex/rape	A review of childhood sexual abuse found that most studies saw an association between and substance use and disorders, however some studies found no association.[158] In a study of the children of U.S. veteran twins, Duncan et al. 2008 found childhood sexual assault increased risk of cannabis use disorder controlling for genetic and family risk, gender, and alcohol and conduct problems.[159] In this sample, childhood physical assault did not have the same association.[159]
Generalized risk	Rather than specific risk factors for specific substances, there are general risk factors that apply to use of substances.[160] Therefore, risk factors that put youth at risk for cannabis, tobacco, and alcohol use rather than one or the other substance.[160] This suggests reducing risk factors for any substance may have an impact in reducing use of other substances, potentially maximizing prevention efforts.
Gun and weapon behaviors	In a literature review and metanalyses, Chen and Wu 2016 found most studies found an association between substance use (not necessarily cannabis or youth specific) and gun behaviors; However, after controlling for confounding variables, researchers reached mixed conclusions as to whether an association remained.[161] In many samples, the association between substance use and gun behaviors disappeared after controlling for mental health problems.[161] No literature reviews assessing weapon behaviors and cannabis use were identified. In a study of Connecticut high schoolers in public school, Schepis et al. 2011 found carrying a weapon in past 30 days and a past year fight were associated with lifetime cannabis use among males and females.[162]

Hopelessness	While no literature reviews were identified, a study of Dutch 11-15 year-olds found that hopelessness was associated with lifetime use of cannabis and use of more than one substance.[163] Serafini et al. 2013 suggest screening for hopelessness could act as a prevention measure for cannabis use, along with other adverse associated outcomes (e.g. suicide).[164]
Other substance use	In a review of risk and protective factors for different substance use, Latimer et al. 2010 found past cigarette, alcohol, and other substance use are risk factors associated with youth cannabis use.[157]
Play video games	While no literature reviews were identified, Primack et al. 2009 examined media exposure and cannabis and alcohol use, authors found playing video games for more than a half hour per day compared to those who did not play or played for less than 30 minutes/day was a protective factor against lifetime cannabis use.[165]
Religious involvement	In review of protective factors, Stone et al. 2012 identified youth religiosity was associated with a lower likelihood of using substances in emerging adulthood, including cannabis.[154] Nguyen and Newhill 2016 additionally found religiosity held as a protective factor across measured racial/ethnicity youth cohorts in a 2013 NSDUH sample.[166]
Risky driving behaviors	While no literature reviews were identified, Dunlop and Romer 2010 found car crash risk was associated with youth substance use generally (*rather than specific to once substance or another*).[167] Authors suggested that youth who are bigger sensation seekers take more risks (*e.g. risky driving, substance use*).[167] Likewise, Terry-McElrath et al. 2014 identified an association (not causation) between alcohol and cannabis youth and unsafe driving.[168] In this sample, youth who used alcohol almost also always while they were using cannabis had the most unsafe driving behaviors after alcohol and cannabis use.[168]
Risky sexual behaviors	In a meta-analysis, Ritchwood et al. 2015 found cannabis use was associated (in a small to moderate range) with risky sexual behaviors in youth.[169] Interestingly, the review found few differences between different substances suggesting any substance use may be associated with risky sexual behavior.[169] These associations were stronger for younger adolescences, females, and Hispanic, White, and Asian youth.[169] Others have found more sexual partners, less condom use, and sex at an earlier are associated with cannabis use in youth.[157,170]

Schizophrenia and other psychoses	"*The Health Effects of Cannabis and Cannabinoids*" report (2017) reports an association between cannabis use and developing schizophrenia or other psychoses that is stronger for heavy users.[156] Other reviews also report an association between cannabis use and psychosis.[171] In the gray literature, the Colorado Retail Marijuana Public Health Advisory Committee reviewed the literature and found substantial evidence that daily or near daily use by youth is associated with future psychosis disorders and future psychotic symptoms.[150] They also found substantial evidence that youth cannabis users were more likely to have psychotic symptoms compared to non-users, with increasing effects for more heavy use.[150]
School performance (A's and B's)	In review, Bradley et al. 2013, found all association between higher academic achievement (*e.g. GPA, grades (e.g. A's and B's*), testing scores, graduating) and less likelihood of substance use.[172] Feeling connected ones school may also act as a protective factor against substance use.[154]
Self-harm	A literature review of self-harm and substance use found an association exists, but few papers examined cannabis use specifically.[173]
Sexual minority youth (*e.g. LGBTQ*)	LGBTQ youth are at a greater risk of substance use, including cannabis, than their heterosexual and non-LGBTQ peers.[174] In a meta-analysis, Marshal et al. 2008 found LBGTQ youth had a 2.58 times greater odds of having ever used cannabis compared to their straight peers.[174] These disparities appear largest for females and particularly bisexual females.[174–176] In a review of risk and protective factors for sexual minority youth, Kidd et al. 2018 identified stigma, victimization, bullying, violence, PTSD symptoms as risk factors for cannabis use.[177] Higher socioeconomic status, feeling connected to school, self-esteem, parental attachment, and anti-discrimination polices were protective factors against sexual minority youth cannabis use.[177]
Sports Team Involvement	A systematic review (2014) identified mixed findings as to whether cannabis use and sport involvement are associated among youth and young adults.[178]
Suicidality	"*The Health Effects of Cannabis and Cannabinoids*" report (2017) found that heavy cannabis users have increased likelihood of suicidal thoughts

	compared to nonusers.[156] Another literature review does not find evidence that acute cannabis use is linked to risk for suicidality, but does find some evidence for an association between chronic cannabis use and suicidality.[179] However, this review emphasizes major gaps and limitations, noting that this research is in its very early stages.[179] In the gray literature, the Colorado Retail Marijuana Public Health Advisory Committee reviewed the literature and found limited evidence that youth and young adult cannabis users are more likely to have suicidal thoughts or attempts compared to non-users.[150]
Watch television	While no literature reviews were identified, Primack et al. 2009 examined media exposure and cannabis and alcohol use, authors found no association between watching television for more than an hour per day and lifetime cannabis use compared to those who did not watch or watched for an hour or less per day.[165]
Youth with Disabilities	Research suggests students with disabilities and chronic health conditions may be at a greater risk of substance use. However, there are major knowledge gaps in this literature base. In a meta-analysis, Lee et al. 2011 found that those with ADHD more likely than those without ADHD to have ever used cannabis, and to develop a cannabis use disorder.[180] An older analysis of national YRBS data (2005) found youth who reported a physical disability or long-term health problem had slightly higher odds (OR=1.2 CI: 1.01-1.4) of current cannabis use than their peers.[181] However, a Canadian study of youth with chronic conditions found no difference in lifetime illicit substance use among compared to youth without chronic conditions.[182] While there is very limited research on those with intellectual disabilities, researchers suggest these individuals may be at higher risk of negative outcomes from substance use.[183,184] No literature reviews specific to youth with a learning disability were identified, however a Canadian longitudinal found youth with a learning disability used cannabis more often than peers without a learning disability.[185] In contrast, Evans et al. 2013 found no difference between cannabis use among students with learning disabilities and their peers without learning disabilities after controlling for a number of variables.[186]

Appendix IV: Sensitivity Analyses

Table IV.1. Risk and Protective Factors Adjusting for Cannabis Policy Enactment: Youth Cannabis Use—Lifetime Use

Cannabis	Decriminalization		Medical Cannabis Policy		Adult-Use Cannabis Policy	
	Adjusted[+] OR	(95% CI)	Adjusted[+] OR	(95% CI)	Adjusted[+] OR	(95% CI)
Risk/Protective Factors and Cannabis Use						
Disability						
Learning Disability	(N/A) [a]	(N/A) [a]	1.33**	(1.12-1.58)	1.33**	(1.11-1.58)
Physical Disability	(N/A) [a]	(N/A) [a]	1.14*	(1.02-1.28)	1.14*	(1.02-1.27)
Driving Behaviors						
Ride with driver who had been drinking (past 30-day)	3.91***	(3.58-4.28)	3.91***	(3.59-4.26)	3.88***	(3.56-4.23)
Drive after drinking alcohol (past 30-day)	1.67***	(1.50-1.87)	2.14***	(1.93-2.38)	1.75***	(1.56-1.96)
Text or email while driving (past 30-day)	(N/A) [a]	(N/A) [a]	(N/A)[a]	(N/A) [a]	3.65***	(3.19-4.17)
Talk on cell phone while driving (past 30-day)	(N/A) [a]	(N/A) [a]	(N/A) [a]	(N/A) [a]	3.24**	(2.78-3.85)
Weapon carrying/exposure, violence, and bullying						
Carry weapon (past 30-day)	3.59***	(3.22-4.01)	3.58***	(3.21-4.00)	3.58***	(3.21-3.99)
Carry weapon on school property (past 30-day)	4.64***	(3.64-5.92)	4.60***	(3.60-5.88)	4.60***	(3.61-5.87)
Carry gun (past 30-day)	4.46***	(3.43-5.82)	4.45***	(3.42-5.79)	4.45***	(3.42-5.80)
Threatened or injured with weapon on school property (past 12- month)	3.32***	(2.78-3.97)	3.30***	(2.75-3.96)	3.31***	(2.77-3.96)
Physical fight (past 12- month)	3.91***	(3.55-4.31)	3.92***	(3.54-4.33)	3.88***	(3.53-4.27)
Sexual and Dating Violence						
Physically forced to have sex (lifetime)	2.62***	(1.91-3.58)	2.62***	(1.91-3.58)	2.64***	(1.93-3.63)
Physically forced to have sex or physical dating violence (lifetime)	2.84***	(2.58-3.12)	2.82***	(2.57-3.10)	2.83***	(2.58-3.10)
Support, Hopelessness, and Suicide Behaviors						
Hopelessness (past 12- month)	2.21***	(2.00-2.44)	2.22***	(2.01-2.45)	2.22***	(2.01-2.45)
Consider suicide (past 12- month)	2.35***	(2.06-2.68)	2.35***	(2.06-2.68)	2.35***	(2.06-2.68)

Plan suicide (past 12- month)	2.08***	(1.86-2.33)	2.08***	(1.86-2.33)	2.08***	(1.86-2.33)
Attempt suicide (past 12- month)	2.73***	(2.31-3.23)	2.72***	(2.29-3.23)	2.71***	(2.29-3.22)
Treated for suicide attempt (past 12-month)	3.19***	(2.35-4.32)	3.18***	(2.34-4.32)	3.18***	(2.34-4.32)
Purposely hurt yourself (past 12-month)	2.34***	(2.11-2.60)	2.34***	(2.11-2.60)	2.34***	(2.11-2.59)
Sexual Orientation and Behaviors						
Sexual intercourse (lifetime)	7.16***	(6.49-7.89)	7.17***	(6.50-7.92)	7.11***	(6.45-7.84)
Age first sexual intercourse encounter	1.24***	(1.22-1.27)	1.24***	(1.21-1.26)	1.24***	(1.22-1.27)
Sex partners (past 90-days)	2.43***	(2.30-2.57)	2.43***	(2.31-2.57)	2.43***	(2.30-2.56)
Alcohol or drug use before sexual intercourse last time	12.30***	(10.29-14.70)	12.23***	(10.20-14.66)	12.23***	(10.20-14.66)
Condom use last sexual encounter	3.21***	(2.87-3.58)	3.19***	(2.85-3.58)	3.19***	(2.85-3.57)
Ever been or gotten someone pregnant (lifetime)	4.50***	(3.68-5.49)	4.45***	(3.64-5.45)	4.47***	(3.66-5.47)
Ever been tested for any Sexually Transmitted Disease(s) (STDs) (lifetime)	2.73***	(2.49-2.99)	2.72***	(2.48-2.98)	2.73***	(2.49-3.00)
Sexuality- Heterosexual ("straight")	0.49***	(0.42-0.56)	0.48***	(0.42-0.56)	0.48***	(0.42-0.55)
Sexuality- Gay, Lesbian, or Bisexual	2.05***	(1.78-2.37)	2.06***	(1.79-2.38)	2.08***	(1.81-2.39)
Other Risk/Protective Factors						
Any adult support (family or other)	0.59***	(0.51-0.68)	0.58***	(0.50-0.67)	0.58***	(0.50-0.67)
Physically active (past week)	0.95	(0.86-1.05)	0.96	(0.86-1.06)	0.95	(0.86-1.05)
Sports team involvement (past 12-month)	0.94	(0.85-1.03)	0.94	(0.86-1.03)	(N/A) [a]	(N/A) [a]
Play video games on average school day	0.88**	(0.81-0.96)	0.89**	(0.82-0.97)	0.89**	(0.82-0.97)
Watch TV on average school day	0.96	(0.88-1.04)	0.95	(0.88-1.03)	(N/A) [a]	(N/A) [a]
Grades are A's and B's	0.34***	(0.30-0.38)	0.34***	(0.30-0.38)	0.34***	(0.31-0.38)

[+]Adjusted for: (1) Year of data collection [2007-2017]; (2) Sex [1- Female; 2- Male; Missing], and (3) Race/Ethnicity [1- Am Indian/Alaska Native; 2- Asian, 3- Black or African American, 4- Native Hawaiian/Other PI, 5- White, 6- Hispanic/Latino, 7- Multiple-Hispanic, 8- Multiple-Non-Hispanic]

*p<0.05; **p<.01; ***p<.001

[a]NA refers to measures that were not included in survey instrument during one or more policy intervention (*e.g. measure only included in post decriminalization survey years, 2013-2017*

Table IV.2. Risk and Protective Factors Adjusting for Cannabis Policy Enactment: Youth Cannabis Use—Past 30-Day Use

Cannabis	Decriminalization		Medical Cannabis Policy		Adult-Use Cannabis Policy	
	Adjusted+ OR	(95% CI)	Adjusted+ OR	(95% CI)	Adjusted+ OR	(95% CI)
Risk/Protective Factors and Cannabis Use						
Disability						
Learning Disability	(N/A) [a]	(N/A) [a]	1.33***	(1.13-1.56)	1.32**	(1.11-1.55)
Physical Disability	(N/A) [a]	(N/A) [a]	1.12	(.96-1.31)	1.11	(.95-1.30)
Driving Behaviors						
Ride with driver who had been drinking (past 30-day)	4.12***	(3.76-4.50)	4.1***	(3.76-4.47)	4.09***	(3.77-4.45)
Drive after drinking alcohol (past 30-day)	1.69***	(1.53-1.88)	2.31***	(2.03-2.62)	1.77***	(1.59-1.96)
Text or email while driving (past 30-day)	(N/A) [a]	(N/A) [a]	(N/A) [a]	(N/A) [a]	2.73***	(2.32-3.22)
Talk on cell phone while driving (past 30-day)	(N/A) [a]	(N/A) [a]	(N/A) [a]	(N/A) [a]	2.67***	(2.22-3.20)
Weapon carrying/exposure, violence, and bullying						
Carry weapon (past 30-day)	3.53***	(3.15-3.97)	3.51***	(3.12-3.94)	3.51***	(3.13-3.94)
Carry weapon on school property (past 30-day)	4.69***	(3.84-5.71)	4.63***	(3.80-5.65)	4.64***	(3.81-5.65)
Carry gun (past 30-day)	4.52***	(3.39-6.03)	4.51***	(3.38-6.00)	4.51***	(3.38-6.01)
Threatened or injured with weapon on school property (past 12- month)	3.32***	(2.70-4.08)	3.30***	(2.68-4.07)	3.32***	(2.70-4.08)
Physical fight (past 12- month)	3.82***	(3.49-4.18)	3.81***	(3.49-4.16)	3.80***	(3.48-4.14)
Sexual and Dating Violence						
Physically forced to have sex (lifetime)	2.42***	(1.84-3.18)	2.42***	(1.84-3.18)	2.43***	(1.83-3.21)
Physically forced to have sex or physical dating violence (lifetime)	2.49***	(2.24-2.75)	2.47***	(2.23-2.73)	2.47***	(2.24-2.74)
Support, Hopelessness, and Suicide Behaviors						
Hopelessness (past 12- month)	2.02***	(1.81-2.24)	2.02***	(1.82-2.25)	2.02***	(1.82-2.25)
Consider suicide (past 12- month)	2.32***	(2.05-2.62)	2.32***	(2.05-2.63)	2.32***	(2.05-2.62)
Plan suicide (past 12- month)	2.00***	(1.77-2.26)	2.00***	(1.77-2.27)	2.00***	(1.77-2.27)
Attempt suicide (past 12- month)	2.62***	(2.23-3.09)	2.60***	(2.21-3.07)	2.61***	(2.21-3.07)
Treated for suicide attempt (past 12-month)	3.06***	(2.32-4.01)	3.04***	(2.31-4.00)	3.04***	(2.32-4.00)

Purposely hurt yourself (past 12- month)	2.25***	(2.02-2.50)	2.25***	(2.02-2.50)	2.25***	(2.02-2.50)
Sexual Orientation and Behaviors						
Sexual intercourse (lifetime)	5.93***	(5.33-6.59)	5.91***	(5.32-6.57)	5.89***	(5.30-6.55)
Age first sexual intercourse encounter	1.19	(1.16-1.21)	1.18***	(1.15-1.21)	1.18***	(1.16-1.21)
Sex partners (past 90-days)	2.03***	(1.93-2.13)	2.03***	(1.93-2.13)	2.02***	(1.93-2.12)
Alcohol or drug use before sexual intercourse last time	8.75***	(7.58-10.11)	8.68***	(7.53-10.01)	8.71***	(7.54-10.07)
Condom use last sexual encounter	2.64***	(2.38-2.93)	2.62***	(2.36-2.91)	2.63***	(2.36-2.92)
Ever been or gotten someone pregnant (lifetime)	3.24***	(2.74-3.83)	3.20***	(2.70-3.79)	3.22***	(2.72-3.81)
Ever been tested for any Sexually Transmitted Disease(s) (STDs) (lifetime)	2.23***	(2.00-2.49)	2.23***	(2.00-2.48)	2.23***	(2.00-2.49)
Sexuality- Heterosexual ("straight")	0.51***	(0.44-0.59)	0.50***	(0.43-0.58)	0.50***	(0.43-0.58)
Sexuality- Gay, Lesbian, or Bisexual	1.97***	(1.71-2.28)	1.99***	(1.72-2.30)	1.99***	(1.72-2.31)
Other Risk/Protective Factors						
Any adult support (family or other)	0.57***	(0.51-0.64)	0.57***	(0.50-0.64)	0.57***	(0.50-0.64)
Physically active (past week)	0.96	(0.86-1.07)	0.97	(0.872-1.08)	0.97	(0.87-1.08)
Sports team involvement (past 12-month)	0.89*	(0.81-0.98)	0.89*	(0.81-0.98)	(N/A)	(N/A)
Play video games on average school day	0.94	(0.85-1.04)	0.95	(0.86-1.05)	0.95	(0.86-1.05)
Watch TV on average school day	0.94	(0.86-1.04)	0.93	(0.84-1.03)	(N/A) [a]	(N/A) [a]
Grades are A's and B's	0.34***	(0.30-0.38)	0.34***	(0.31-.38)	0.34***	(0.31-0.38)

[+]Adjusted for: (1) Year of data collection [2007-2017]; (2) Sex [1- Female; 2- Male; Missing], and (3) Race/Ethnicity [1- Am Indian/Alaska Native; 2- Asian, 3- Black or African American, 4- Native Hawaiian/Other PI, 5- White, 6- Hispanic/Latino, 7- Multiple-Hispanic, 8- Multiple-Non-Hispanic]

*p<0.05; **p<.01; ***p<.001

[a]NA refers to measures that were not included in survey instrument during one or more policy intervention (*e.g. measure only included in post decriminalization survey years, 2013-2017*)

Table IV.3. Risk and Protective Factors Adjusting for Cannabis Policy Enactment: Youth Cannabis Use—Past 30-Day Heavy Use (20≤ in past 30 days)

Cannabis	Decriminalization		Medical Cannabis Policy		Adult-Use Cannabis Policy	
	Adjusted[+] OR	(95% CI)	Adjusted[+] OR	(95% CI)	Adjusted[+] OR	(95% CI)
Risk/Protective Factors and Cannabis Use						
Disability						
Learning Disability	(N/A)[a]	(N/A)[a]	1.54**	(1.17-2.03)	1.52**	(1.15-2.02)
Physical Disability	(N/A)[a]	(N/A)[a]	1.25	(0.95-1.63)	1.22	(0.93-1.61)
Driving Behaviors						
Ride with driver who had been drinking (past 30-day)	4.70***	(4.11-5.38)	4.60***	(4.02-5.27)	4.59***	(4.03-5.23)
Drive after drinking alcohol (past 30-day)	1.75***	(1.50-2.05)	2.99***	(2.53-3.54)	1.94***	(1.65-2.27)
Text or email while driving (past 30-day)	(N/A)[a]	(N/A)[a]	(N/A)[a]	(N/A)[a]	2.26***	(1.77-2.89)
Talk on cell phone while driving (past 30-day)	(N/A)[a]	(N/A)[a]	(N/A)[a]	(N/A)[a]	2.09***	(1.61- 2.73)
Weapon carrying/exposure, violence, and bullying						
Carry weapon (past 30-day)	4.31***	(3.72-4.99)	4.26***	(3.66-4.96)	4.25***	(3.66-4.94)
Carry weapon on school property (past 30-day)	5.77***	(4.81-6.92)	5.62***	(4.69-6.74)	5.66***	(4.71-6.80)
Carry gun (past 30-day)	6.60***	(4.88-8.94)	6.54***	(4.86-8.81)	6.54***	(4.83-8.85)
Threatened or injured with weapon on school property (past 12- month)	4.16***	(3.40-5.08)	4.09***	(3.35-5.01)	4.14***	(3.41-5.03)
Physical fight (past 12- month)	4.90***	(4.43-5.42)	4.81***	(4.35-5.31)	4.79***	(4.34-5.30)
Sexual and Dating Violence						
Physically forced to have sex (lifetime)	3.24***	(2.05-5.12)	3.24***	(2.05-5.12)	3.29***	(2.05-5.27)
Physically forced to have sex or physical dating violence (lifetime)	2.86***	(2.45-3.34)	2.81***	(2.40-3.29)	2.84***	(2.42-3.32)
Support, Hopelessness, and Suicide Behaviors						
Hopelessness (past 12- month)	2.40***	(2.08-2.76)	2.41***	(2.09-2.76)	2.41***	(2.10-2.78)
Consider suicide (past 12- month)	2.42***	(2.07-2.82)	2.43***	(2.08-2.83)	2.41***	(2.07-2.81)
Plan suicide (past 12- month)	2.12***	(1.77-2.54)	2.13***	(1.78-2.56)	2.12***	(1.77-2.55)
Attempt suicide (past 12- month)	3.18***	(2.63-3.85)	3.12***	(2.58-3.78)	3.12***	(2.58-3.78)
Treated for suicide attempt (past 12- month)	4.36***	(3.25-5.86)	4.31***	(3.21- 5.79)	4.31***	(3.21-5.78)
Purposely hurt yourself (past 12- month)	2.49***	(2.06-3.02)	2.49***	(2.06-3.01)	2.49***	(2.06-3.01)

Sexual Orientation and Behaviors						
Sexual intercourse (lifetime)	8.22***	(6.64-10.17)	8.09***	(6.53-10.02)	8.11***	(6.54-10.05)
Age first sexual intercourse encounter	1.13***	(1.09-1.18)	1.13***	(1.09-1.17)	1.14***	(1.10-1.19)
Sex partners (past 90-days)	1.86***	(1.76-1.96)	1.85***	(1.75-1.95)	1.85***	(1.75-1.94)
Alcohol or drug use before sexual intercourse last time	9.48***	(8.19-10.98)	9.36***	(8.06-10.86)	9.35***	(8.05-10.87)
Condom use last sexual encounter	2.08***	(1.78-2.43)	2.05***	(1.76-2.40)	2.06***	(1.76-2.41)
Ever been or gotten someone pregnant (lifetime)	4.75***	(3.98-5.66)	4.63***	(3.88-5.51)	4.69***	(3.93-5.59)
Ever been tested for any Sexually Transmitted Disease(s) (STDs) (lifetime)	2.62***	(2.22-3.08)	2.61***	(2.22-3.07)	2.63***	(2.22-3.10)
Sexuality- Heterosexual ("straight")	0.43***	(0.36-0.52)	0.42***	(0.35-0.52)	0.42***	(0.34-0.51)
Sexuality- Gay, Lesbian, or Bisexual	2.31***	(1.91-2.81)	2.36***	(1.94-2.87)	2.39***	(1.96-2.91)
Other Risk/Protective Factors						
Any adult support (family or other)	0.45***	(0.39-0.53)	0.44***	(0.38-0.52)	0.44***	(0.38-0.52)
Physically active (past week)	0.67***	(0.57-0.80)	0.68***	(0.58-0.81)	0.68***	(0.57-0.80)
Sports team involvement (past 12-month)	0.60***	(0.52-0.69)	0.60***	(0.52-0.69)	(N/A)[a]	(N/A)[a]
Play video games on average school day	0.85**	(0.75-0.96)	0.87*	(0.77-0.98)	0.86*	(0.76-0.98)
Watch TV on average school day	0.88	(0.73-1.06)	0.86	(0.70-1.05)	(N/A)[a]	(N/A)[a]
Grades are A's and B's	0.24***	(0.20-0.29)	0.25***	(0.21-0.30)	0.25***	(0.21-0.30)

[+]Adjusted for: (1) Year of data collection [2007-2017]; (2) Sex [1- Female; 2- Male; Missing], and (3) Race/Ethnicity [1- Am Indian/Alaska Native; 2- Asian, 3- Black or African American, 4- Native Hawaiian/Other PI, 5- White, 6- Hispanic/Latino, 7- Multiple-Hispanic, 8- Multiple-Non-Hispanic]

*p<0.05; **p<.01; ***p<.001

[a]NA refers to measures that were not included in survey instrument during one or more policy intervention (*e.g. measure only included in post decriminalization survey years, 2013-2017*)

Appendix V: Research Agenda

Acts of 2017, Chapter 55 Section 17 (a) and (b)

(a) The commission shall develop a research agenda in order to understand the social and economic trends of marijuana in the commonwealth, to inform future decisions that would aid in the closure of the illicit marketplace and to inform the commission on the public health impacts of marijuana. The research agenda shall include, but not be limited to: (i) patterns of use, methods of consumption, sources of purchase and general perceptions of marijuana among minors, among college and university students and among adults; (ii) incidents of impaired driving, hospitalization and use of other health care services related to marijuana use, including a report of the state of the science around identifying a quantifiable level of marijuana-induced impairment of motor vehicle operation and a report on the financial impacts on the state healthcare system of hospitalizations related to marijuana; (iii) economic and fiscal impacts for state and local governments including the impact of legalization on the production and distribution of marijuana in the illicit market and the costs and benefits to state and local revenue; (iv) ownership and employment trends in the marijuana industry examining participation by racial, ethnic and socioeconomic subgroups, including identification of barriers to participation in the industry; (v) a market analysis examining the expansion or contraction of the illicit marketplace and the expansion or contraction of the legal marketplace, including estimates and comparisons of pricing and product availability in both markets; (vi) a compilation of data on the number of incidents of discipline in schools, including suspensions or expulsions, resulting from marijuana use or possession of marijuana or marijuana products; and (vii) a compilation of data on the number of civil penalties, arrests, prosecutions, incarcerations and sanctions imposed for violations of chapter 94C for possession, distribution or trafficking of marijuana or marijuana products, including the age, race, gender, country of origin, state geographic region and average sanctions of the persons charged.

(b) The commission shall incorporate available data into its research agenda, including the baseline study conducted pursuant to chapter 351 of the acts of 2016, and coordinate and form partnerships with the department of public health, the department of elementary and secondary education, the department of higher education, the executive office of public safety and security and the executive office of labor and workforce development. The commission shall annually report on the results of its research agenda and, when appropriate, make recommendations for further research or policy changes. The annual reports shall be posted online in a machine-readable format.

https://malegislature.gov/laws/sessionlaws/acts/2017/chapter55

Appendix VI: Public Awareness Campaigns

Cannabis Public Awareness Campaigns: All States

A public awareness campaign is a comprehensive effort to educate a large audience to act toward a specified goal. A public awareness campaign rooted in a public health framework serves to promote public health by creating synergy between short-term mass media campaigns and long-term localized action.[187] Massachusetts is one of seven states that has implemented a comprehensive public awareness campaign to either inform constituents of the non-medical adult-use cannabis policies and provisions within their states and/or educate youth or parents about the harms of cannabis use for adolescents whose brains are still maturing.

Table VI.1. States with Non-Medical Adult Cannabis Policies and Public Awareness Campaigns

State	Campaign Name	Website
Massachusetts	*More About Marijuana*	*www.moreaboutmj.org*
Alaska	*Get The Facts About Cannabis*	*http://dhss.alaska.gov/dph/Director/Pages/cannabis/default.aspx*
California	*Let's Talk Cannabis*	*https://www.cdph.ca.gov/Programs/DO/letstalkcannabis/Pages/LetsTalkCannabis.aspx*
Colorado	*Good to Know*	*https://www.colorado.gov/good-know*
Nevada	*Good to Know*	http://goodtoknownv.com/
Oregon	*Stay True To You*	*http://www.staytruetoyou.org/#home*
Washington	*Listen2YourSelfie*	*https://www.youcanwa.org/*

Cannabis Public Awareness Campaign: Massachusetts

Based within a public health framework, Massachusetts's cannabis public awareness campaign, *More About Marijuana*, is a collaboration between The Massachusetts Cannabis Control Commission (CNB), The Department of Public Health (DPH), and The Bureau of Substance Abuse Services (BSAS) within DPH, who contracted with MORE Advertising to collaboratively research, devise, and implement *More About Marijuana* in the Commonwealth.

The goals of the campaign are threefold:

1. Conduct research to assess the current knowledge of both:
    a. Cannabis overall; and
    b. Massachusetts Chapter 55, *An Act to Ensure the Safe Access to Cannabis* policy and provisions.
2. Develop the campaign based on research results. Research for this campaign consisted of two primary mechanisms:
    a. Focus groups with pre-group surveys; and
    b. Online ("pre" implementation) survey of Massachusetts residents 21≤. The campaign targets both the general population, as well as parents and youth. [See research methods and results below].
3. Implement the campaign to educate constituents on the varying provisions within the policy and potential harmful effects of using cannabis.

The implementation of the campaign has two waves. The first wave was implemented in August 2018 and targeted parents of youth. The second wave was implemented in winter 2019 and targeted a general audience.

Table VI.2. Public Awareness Campaign Pre/Post Questions About Youth Use

More About MJ – Youth Questions
1. If you were to keep marijuana in your home, would you store it in a locked storage area?
2. When a mother is breastfeeding, is it safe for her to use marijuana?
3. If a breastfeeding mother uses marijuana, is it possible this could have a long-term impact on her child's ability to learn?
4. When is the right time to begin to talk to your children about drugs and alcohol?
5. What approach is most effective: Let your child initiate conversations about alcohol and other drugs? Schedule a time to have a talk about alcohol and other drugs with your child? Or make it a point to have ongoing conversations about alcohol and other drugs with your child?
6. Think about your oldest child. How many conversations have you had with him or her about using alcohol and other drugs?
7. If you wanted to talk to your child about marijuana use, do you feel that you have the information and resources you need to have that conversation?
8. At what age are individuals old enough to try or use marijuana?
9. What grade would you give the state of Massachusetts so far at educating parents of youth about the legalization of marijuana (or marijuana in general)? [Grade-Point Average is calculated on a 4.0 scale, where A = 4, B = 3, C = 2, D = 1, F = 0.]
10. Which is true? The benefits and risks of using marijuana are the same for youth as they are for adults. The risks of using marijuana are greater for youth than they are for adults. The risks of using marijuana are greater for adults than they are for youth.

Table VI.3. Public Awareness Campaign Focus Group Findings About Youth Use

Focus Group Prompt	Findings	Participant Quote
Talking to kids about drugs/alcohol (generally)	• All parents reported to talking to kids early (between 3rd and 5th grade) about drugs and alcohol • Most talk to kids over time • Some want to educate about medical benefits while emphasizing recreational use is illegal until 21	"*In my opinion, I think you just need ongoing conversation. It just can't be one talk. It has to be when they're very young, and over a period of time, and just through example after example after example, and just trying to have them see on their own that this is something that could ruin your whole life."* – Participant, BHSP
What prompts parents to discuss drugs and alcohol with kids?	• A video or TV show • Photos on Snapchat of other kids vaping • Prom/special events • News reports of drug or alcohol problems • Peers who are using • Driving past people on drugs • Having kids in sports • Teens driving or being in a car with other teen drivers • Family addiction histories	"*Alcoholism and opioid addiction run in my family so I talk about genetics and predispositions often with my kids."* – Participant, GHSP
Parent Concerns	• Impact on driving • What if child's friend has cannabis but they are driving sober? • Use and accidental use of edibles	"*There's gonna be huge issues and consequences for all of us who drive the roads of Massachusetts and have children who drive the roads and are passengers. There's a lot of stuff that's going to happen. So the more education we can have about how it impairs you when you're driving, the better*

		we'll be." – Participant, GMSP
How will legalization change conversations with kids?	• Will not change conversation • Treat cannabis like alcohol discussions • May mean kids are more exposed to cannabis • May have conversations earlier and more often	
What challenges do you face taking to kids about drugs and alcohol?	• Kids do not want to listen • Hard to say do not use when they themselves use alcohol or cannabis • Fear child will rebel • Kids feel invincible • Kids learn a lot of peers/media, think they know more than parents.	"*I think the challenge, um, haven't seen the long-term effects. They don't, they don't see long-term*." - Participant, FHSP
What tools and information would you like to help you discuss marijuana with your kids?	• Youtube Videos • Scientific evidence on how cannabis affects youth brain • Potency information • Signs a kid is using • Pro/con list around use including MMJ • Comics • Social stories for kids with autism • Consequences of use, and RUIC • Strategies to talk to kids at different ages • Interaction of cannabis with medication	

Appendix VII: Public Health and Prevention in Regulations, as of July 2019

Table VII.1. Regulations—Public Health Focused Regulations: Youth Prevention

Regulation	Topic	Details
935 CMR 500.101	Plan to Prevention Diversion	Marijuana Establishments required to submit documentation around steps take to prevent diversion to minors.
935 CMR 500.105	Certification Training Class Core Curriculum	Requirement that for training around the health effects of cannabis and diversion prevention.
935 CMR 500.105	Marketing and Advertising Requirements	All provisions in this section were public health/youth prevention driven.
935 CMR 500.105	Labeling of Marijuana and Marijuana Products	Requires labeling including warning symbols created by the CNB, and health warning statements that must be included.
935 CMR 500.105	Packaging of Marijuana and Marijuana Products	Requires childproof or tamper resistant packaging, plain design so it is not appealing to children, and Keep Out Of Reach of Children warning statement.
935 CMR 500.105	Limits on Package Design	Packaging should not be attractive to minors, no use of bright colors, no semblance to any existing branded consumer products, no cartoons, not similar to products marketed to minors, no celebrities are able to be used for who appeal to minors.
935 CMR 500.110	Security Requirements for Marijuana Establishments	Positive ID of persons entering a marijuana facility, no one under the age of 21 permitted entry unless they hold a marijuana care, in which case they may be 18 or older.
935 CMR 500.110	Buffer Zone	Marijuana establishments may not be permitted to be located within 500 feet of any pre-existing public or private school K-12 unless the town/city adopts an ordinance that reduces the distance.
935 CMR 500.140	On Premises Verification of Identification for Adult-use Only Locations	IDs of everyone entering the facility must be checked to prove they are 21 or older.
935 CMR 500.140	Unauthorized Sales and Right to Refuse Sales	A retailer may refuse to sell marijuana products to someone who is unable to provide valid proof of ID or is considered to put the public at risk.
935 CMR 500.301	Unannounced Purchase for Purpose of Investigative Testing	Secret shopper program.

Table VII.2. Regulations— Public Health Focused Regulations: Other

Regulation	Topic	Details
935 CMR 500.105	Packaging of Multiple Servings	Servings must be distinct and scored so as to prevent ingestion of multiple servings or must be in single serving sizes if not permitted to be divided.
935 CMR 500.105	Record Keeping	Seed to sale tracking of products are required.
935 CMR 500.130	Marijuana Product Manufacturers	All edible products must be prepared, handled and stored in compliance with sanitations requirements "Good Manufacturing Practices for Food."
935 CMR 500.140	Consumer Education	Retailer should make available education materials about marijuana products to consumers.
935 CMR 500.140	Limitation on Sales	Marijuana Retailer may not sell more than one ounce of marijuana or five grams of marijuana concentrate to a consumer per transaction.
935 CMR 500.150	Edible Marijuana Products	Production, Sanitary Requirements, Additional Labeling and Packaging Requirements, Dosing limits.
935 CMR 500.160	Testing of Marijuana and Marijuana Products	All marijuana products must be tested by an independent testing laboratory.