Monitoring Health Concerns Related to Marijuana in Colorado: 2016

Changes in Marijuana Use Patterns, Systematic Literature Review, and Possible Marijuana-Related Health Effects

CDPHE
COLORADO
Department of Public Health & Environment

colorado.gov/cdphe/marijuana-health-report

Presented to the Colorado State Board of Health, the Colorado Department of Revenue, and the Colorado General Assembly on Monday, January 30, 2017 by the Retail Marijuana Public Health Advisory Committee pursuant to 25-1.5-110, C.R.S.

This report has been reviewed by Larry Wolk, MD, MSPH, Executive Director and Chief Medical Officer, Colorado Department of Public Health and Environment

Retail Marijuana Public Health Advisory Committee

The Retail Marijuana Public Health Advisory Committee was established per Senate Bill 13-283 and 25-1.5-110, C.R.S. Duties of the Committee are to review the currently available scientific literature and data on health effects of marijuana use and data on patterns of marijuana use, on an ongoing basis. This document summarizes health topics and data reviewed beginning in 2014 with updates conducted through 2016. As a committee, we agree that reported findings reflect current science. Public health messages were developed by the committee to accurately communicate scientific findings. Recommendations reported were developed by the committee with the goal of protecting consumers of marijuana and the general public.

25-1.5-110, C.R.S. Monitor health effects of marijuana

"The department shall monitor changes in drug use patterns, broken down by county and race and ethnicity, and the emerging science and medical information relevant to the health effects associated with marijuana use. The department shall appoint a panel of health care professionals with expertise in cannabinoid physiology to monitor the relevant information. The panel shall provide a report by January 31, 2015, and every two years thereafter to the state Board of Health, the Department of Revenue, and the General Assembly. The department shall make the report available on its web site. The panel shall establish criteria for studies to be reviewed, reviewing studies and other data, and making recommendations, as appropriate, for policies intended to protect consumers of marijuana or marijuana products and the general public. The department may collect Colorado-specific data that reports adverse health events involving marijuana use from the all-payer claims database, hospital discharge data, and behavioral risk factors."

HISTORY: Source: L. 2013: Entire section added, (SB 13-283), ch. 332, p. 1894, § 10, effective May 28.L. 2016: Entire section amended, (SB 16-090), ch. 45, p. 107, § 1, effective August 10.

Retail Marijuana Public Health Advisory Committee members

Chairman: Mike Van Dyke, PhD, CIH, Chief, Environmental Epidemiology, Occupational Health and Toxicology Branch

Shireen Banerji, PharmD, DABAT, Clinical Manager, Rocky Mountain Poison Center

Laura Borgelt, PharmD, Associate Dean and Professor, Departments of Clinical Pharmacy and Family Medicine, University of Colorado Anschutz Medical Campus

Russell Bowler, MD, PhD, Professor of Medicine, National Jewish Health and University of Colorado

Ashley Brooks-Russell, PhD, MPH, Assistant Professor, Colorado School of Public Health; Member, Injury Prevention, Education and Research Program

Ken Gershman, MD, MPH, Manager, Medical Marijuana Research Grants Program Colorado Department of Public Health and Environment

Heath Harmon, MPH, Director of Health Divisions, Boulder County Public Health

Rebecca Helfand, PhD, Director of Data and Evaluation, Office of Behavioral Health, Colorado Department of Human Services

Sharon Langendoerfer, MD, Retired Pediatrician and Neonatologist, Denver Health Medical Center

Andrew Monte, MD, Emergency Medicine Physician, Medical Toxicologist, University of Colorado and Rocky Mountain Poison and Drug Center

Kristina T. Phillips, PhD, Clinical Psychologist, Professor, School of Psychological Sciences, University of Northern Colorado

Judith Shlay, MD, MSPH, Interim Director, Denver Public Health; Professor of Family Medicine, University of Colorado School of Medicine

Christian Thurstone, MD, Psychiatrist and Medical Director of Addiction Services, Denver Health; Associate Professor of Psychiatry, University of Colorado

George Sam Wang, MD, Assistant Professor of Pediatrics, Department of Pediatrics, Section of Emergency Medicine and Medical Toxicology, University of Colorado Anschutz Medical Campus and Children's Hospital Colorado; Volunteer Faculty, Rocky Mountain Poison and Drug Center

Tista Ghosh, MD, MPH, Deputy Chief Medical Officer and Director of Health Programs, Colorado Department of Public Health and Environment (Alternate Member)

Colorado Department of Public Health and Environment technical staff

Mike Van Dyke, PhD, CIH, Chief, Environmental Epidemiology, Occupational Health and Toxicology Branch

Daniel I. Vigil, MD, MPH, Manager, Marijuana Health Monitoring and Research Program

Katelyn E. Hall, MPH, Statistical Analyst, Marijuana Health Monitoring and Research Program

Elyse Contreras, MPH, Coordinator, Marijuana Health Monitoring and Research Program

Rowena Crow, MD, Statistical Analyst, Marijuana Health Monitoring and Research Program

Additional authors

Amy Anderson Mellies, MPH, Health Data Analyst, Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Lisa Barker, MPH, Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment

Kevin Berg, MA, GIS Epidemiologist, Environmental Epidemiology, Colorado Department of Public Health and Environment

Kirk Bol, MSPH, Manager, Vital Statistics and Disease Registry Branch, Colorado Department of Public Health and Environment

Alvin C. Bronstein, MD, Rocky Mountain Poison Center; University of Colorado

Todd Carlson, MD, Internal Medicine Resident, University of Colorado

Teresa Foo, MD, MPH, Marijuana Clinical Guidelines Coordinator, Colorado Department of Public Health and Environment; Clinical Instructor, University of Colorado

David Goff Jr., MD, PhD, FACP, FAHA, Dean and Professor, Colorado School of Public Health

Alison Grace Bui, MPH, Epidemiologist, Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Christopher H. Domen, PhD, ABPP-CN, Assistant Professor, Department of Neurosurgery, University of Colorado School of Medicine

Renee M. Johnson, PhD, MPH, Associate Professor, Department of Mental Health, Johns Hopkins Bloomberg School of Public Health

Ashley Juhl, MSPH, Maternal and Child Health Epidemiologist, Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Leonardo Kattari, MSW, Healthy Kids Colorado Survey Coordinator, Prevention Services Division, Colorado Department of Public Health and Environment

Mike Kosnett, MD, MPH, Associate Clinical Professor, Division of Clinical Pharmacology and Toxicology, Department of Medicine, University of Colorado School of Medicine, Department of Environmental and Occupational Health, Colorado School of Public Health

Bruce Mendelson, MPA, Denver Office of Drug Strategy, University of Colorado

Madeline Morris, BS, Graduate Student, Colorado School of Public Health

Allison Rosenthal, MPH, Applied Epidemiology Fellow, Substance Abuse Mental Health Services Administration and Council of State and Territorial Epidemiologists

Anne Schiffmacher, MPH, Maternal and Child Health Data Analyst, Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Kim Siegel, MD, MPH, Occupational Medicine Resident, University of Colorado

Rickey Tolliver, MPH, Chief, Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Michael F. Wempe, PhD, Associate Research Professor, Department of Pharmaceutical Sciences, University of Colorado Anschutz Medical Campus

Other contributors

Alejandro Azofeifa, DDS, MSc, MPH

Shannon Barbare

Rio Chowdhury

Erin Flynn, MPH

Rachel K. Herlihy, MD, MPH

Diana Herrero, MS

Ali Maffey, MSW

Mark Salley

Megan Snow, MS, CHES

Jan Stapleman

Community Epidemiology and Program Evaluation Group, Colorado School of Public Health

Substance Abuse and Mental Health Services Administration (SAMHSA), National Survey on Drug Use and Health (NSDUH) analysis team

Public meeting attendees

Contact

marijuanainfo@state.co.us

Press contact

Mark Salley
Director, Office of Communicatoins
Colorado Department of Public Health and Environment
mark.salley@state.co.us
303-692-2013

Monitoring Health Concerns Related to Marijuana in Colorado: 2016

Table of Contents

Executive Summary	i - x
Section1: Monitoring Changes in Marijuana Use Patterns	1
Background and Summary of Key Findings	2 - 6
Behavioral Risk Factor Surveillance Survey (BRFSS)	7 - 26
Child Health Survey (CHS)	27 - 36
Healthy Kids Colorado Survey (HKCS)	37 - 60
Pregnancy Risk Assessment Monitoring System (PRAMS)	61 - 70
Section 2: Scientific Literature Review on Potential Health Effects of Marijuana Use	71
Background and Summary of Key Findings	72 - 80
Systematic Literature Review Process	81 - 92
Marijuana Use Among Adolescents and Young Adults	93 - 108
Marijuana Use and Cancer	109 - 118
Marijuana Use and Cardiovascular Effects	119 - 126
Marijuana Dose and Drug Interactions	127 - 144
Marijuana Use and Driving	145 - 156
Marijuana Use and Gastrointestinal and Reproductive Effects	157 - 164
Marijuana Use and Injury	165 - 178
Marijuana Use and Neurological, Cognitive and Mental Health Effects	179 - 192
Marijuana Use During Pregnancy and Breastfeeding	193 - 208
Marijuana Use and Respiratory Effects	209 - 220
Unintentional Marijuana Exposures in Children	221 - 228
Section 3: Monitoring Possible Marijuana-Related Health Effects in Colorado	229
Background and Summary of Key Findings	230 - 234
Rocky Mountain Poison and Drug Center (RMPDC) Data	235 - 246
Colorado Hospital Association (CHA) Data	247 - 270
Retail Marijuana Public Health Advisory Committee 2015-2016 Membership Roster	271 - 278
Glossary	279 - 286

Monitoring Health Concerns Related to Marijuana in Colorado: 2016

Executive Summary

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public
Health & Environment

Retail Marijuana Public Health Advisory Committee Members 2015-2016

Chairman: Mike Van Dyke, PhD, CIH, Chief, Environmental Epidemiology, Occupational Health and Toxicology Branch

Laura Borgelt, PharmD, Associate Dean and Professor, Departments of Clinical Pharmacy and Family Medicine, University of Colorado Anschutz Medical Campus

Russell Bowler, MD, PhD, Professor of Medicine, National Jewish Health and University of Colorado

Shireen Banerji, PharmD, DABAT, Clinical Manager, Rocky Mountain Poison Center

Ashley Brooks-Russell, PhD, MPH, Assistant Professor, Colorado School of Public Health; Member, Injury Prevention, Education and Research Program

Ken Gershman, MD, MPH, Manager, Medical Marijuana Research Grants Program Colorado Department of Public Health and Environment

Heath Harmon, MPH, Director of Health Divisions, Boulder County Public Health

Sharon Langendoerfer MD, Retired Pediatrician and Neonatologist, Denver Health Medical Center

Andrew Monte, MD, Emergency Medicine Physician, Medical Toxicologist, University of Colorado and Rocky Mountain Poison and Drug Center

Judith Shlay, MD, MSPH, Interim Director, Denver Public Health; Professor of Family Medicine, University of Colorado School of Medicine

George Sam Wang, MD, Assistant Professor of Pediatrics, Department of Pediatrics, Section of Emergency Medicine and Medical Toxicology, University of Colorado Anschutz Medical Campus and Children's Hospital Colorado; Volunteer Faculty, Rocky Mountain Poison and Drug Center

Rebecca Helfand, PhD, Director of Data and Evaluation, Office of Behavioral Health, Colorado Department of Human Services

Kristina Phillips, PhD, Clinical Psychologist, Professor, School of Psychological Sciences, University of Northern Colorado

Christian Thurstone, MD, Psychiatrist and Medical Director of Addiction Services, Denver Health; Associate Professor of Psychiatry, University of Colorado

Tista Ghosh, MD, MPH, Deputy Chief Medical Officer and Director of Health Programs, Colorado Department of Public Health and Environment (Alternate Member)

Introduction

When Colorado became one of the first two states in the nation to legalize retail marijuana, the Colorado Legislature mandated that the Colorado Department of Public Health and Environment (CDPHE) study the potential public health effects of marijuana. Though medical marijuana has been legal in Colorado since 2000, it was largely viewed as an individual doctor/patient decision outside the scope of public health policy. However, the legalization of retail (non-medical) marijuana and the potential for greater availability of marijuana in the community prompted a closer look at potential health effects on the population at large.

Legalized retail marijuana presents a paradigm shift, grouping marijuana with other legal substances like alcohol, tobacco and prescription drugs, as opposed to illicit drugs like cocaine and heroin. As with alcohol, tobacco and prescription drugs, misuse of marijuana can have serious health consequences. The standard public health approaches to alcohol, tobacco and prescription drugs are to monitor use patterns and behaviors, health care use, potential health effects, and emerging scientific literature to guide the development of policies or consumer education strategies to prevent serious health consequences. This report presents information on marijuana use patterns, potential health effects and the most recent scientific findings associated with marijuana use, with a key objective of helping facilitate evidence-based policy decisions and science-based public education campaigns.

In 25-1.5-110, C.R.S., the Colorado Department of Public Health and Environment (CDPHE) was given statutory responsibility to:

- "… monitor changes in drug use patterns, broken down by county and race and ethnicity, and the emerging science and medical information relevant to the health effects associated with marijuana use."
- "… appoint a panel of health care professionals with expertise in cannabinoid physiology to monitor the relevant information."
- "… collect Colorado-specific data that reports adverse health events involving marijuana use from the all-payer claims database, hospital discharge data, and behavioral risk factors."

Based on this charge, CDPHE has appointed a 14-member committee, the Retail Marijuana Public Health Advisory Committee (RMPHAC), to review scientific literature on the health effects of marijuana and Colorado-specific health outcome and use pattern data. Members of this committee (see Retail Marijuana Public Health Advisory Committee membership roster) consist of individuals in the fields of public health, medicine, epidemiology and medical toxicology who demonstrate expertise related to marijuana through their work, training or research. This committee was charged with the duties as outlined in C.R.S. 25-1.5-110 to "… establish criteria for studies to be reviewed, reviewing studies and other data, and making recommendations, as appropriate, for policies intended to protect consumers of marijuana or marijuana products and the general public." The committee began meeting in May 2014 and in January 2015 published the first edition of this report. The overall goal of the committee was to implement an unbiased and transparent process for evaluating scientific literature as well as marijuana use and health outcome data. The committee was particularly interested in ensuring quality information is shared about the known physical and mental health effects associated with marijuana use – and also about what is unknown at present. The official committee bylaws are included in the Appendix, Retail Marijuana Public Health Advisory Committee Bylaws.

Monitoring changes in marijuana use patterns

This report includes detailed information about marijuana use patterns in Colorado that has been gathered using several prominent population-based surveys. These surveys are:

1. The Behavioral Risk Factor Surveillance System survey, a survey of adults sponsored by the U.S. Centers for Disease Control and Prevention (CDC).
2. The Child Health Survey, a survey of adults with children ages 1-14 years old in their home about the children's health and environment.
3. The Healthy Kids Colorado Survey of middle and high school students, a collaboration of CDPHE, Colorado Department of Education, and Colorado Department of Human Services.
4. The Pregnancy Risk Assessment Monitoring System survey, a survey of women who recently gave birth.

The data available at this time cannot answer all of the important questions about whether or how marijuana use patterns may be changing as a result of legalization. However, they do provide important insights into marijuana use in adults and vulnerable populations such as pregnant women, youth, and those with racial, ethnic, and sexual orientation disparities. A summary of key trends:

Encouraging trends

- For adults and adolescents, past-month marijuana use has not changed since legalization either in terms of the number of people using or the frequency of use among users.
- Based on the most comprehensive data available, past month marijuana use among Colorado adolescents is nearly identical to the national average.
- We have not identified any **new** disparities in marijuana use by age, gender, race, ethnicity or sexual orientation since legalization.
- Daily or near-daily marijuana use among adults is much lower than daily or near-daily alcohol or tobacco use. Among adolescents, past month marijuana use is lower than past month alcohol use.

Trends to continue monitoring

- About 6 percent of pregnant women use marijuana while pregnant. This percentage is higher among those with unintended pregnancies as well as younger mothers or those with less education.
- At least 14,000 children in Colorado are at risk of accidentally eating marijuana products that are not safely stored and at least 16,000 are at risk of being exposed to secondhand marijuana smoke in the home.
- More than 5 percent of high school students use marijuana daily or near daily. This rate has remained stable since at least 2005.
- Past month marijuana use among adults in Colorado is higher than the national average. In Colorado, one in four adults age 18-25 reported past month marijuana use and one in eight use daily or near-daily. These numbers have been consistent since legalization.
- There continue to be disparities in marijuana use based on race/ethnicity for adolescents and sexual orientation for both adults and adolescents.
- While past month marijuana use among adults and adolescents was stable for most regions in Colorado, adult use in the Northwest Colorado region increased from 2014 to 2015.
- More than 1-in-3 adolescents who use marijuana first use it by age 14, supporting prevention efforts aimed at children before they enter ninth grade.

Scientific literature review on potential health effects of marijuana use

The committee used a standardized systematic literature review process to search and grade the existing scientific literature on health effects of marijuana. Findings were synthesized into evidence statements that summarize the quantity and quality of supporting scientific evidence. These evidence statements were classified as follows:

- Substantial evidence - indicates robust scientific findings that support an association between marijuana use and the outcome.
- Moderate evidence - indicates that scientific findings support an association between marijuana use and the outcome, but these findings have some limitations.
- Limited evidence - indicates modest scientific findings that support an association between marijuana use and the outcome, but these findings have significant limitations.
- Mixed evidence - indicates both supporting and non-supporting scientific findings for an association between marijuana use and the outcome with neither direction dominating.
- Body of research failing to show an association - indicates that the topic has been researched without evidence of an association; is further classified as a limited, moderate or substantial body of research.
- Insufficient evidence - indicates that the outcome has not been sufficiently studied to conclude whether or not there is an association between marijuana use and the outcome.

The committee also translated these evidence statements into plain language so the public can understand them when used in public health messages. In addition, the committee was asked to develop public health recommendations based on potential concerns identified through the review process and to articulate research gaps based on common limitations of existing research. All of these were presented to the full committee during open public meetings that offered opportunities for stakeholder input. Final statements, recommendations, and research gaps were formally approved by a majority vote of the committee.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. Another limitation of the available research data is that most studies did not or could not measure the THC level (potency) of marijuana used by subjects, nor which other cannabinoids were present. There are diverse products now available in Colorado, many of which are likely higher in potency than the marijuana used by study subjects for much of the literature reviewed.

The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Marijuana use among adolescents and young adults

The committee reviewed the relationships between adolescent and young adult marijuana use and cognitive abilities, academic performance, mental health and future substance use. Weekly marijuana use by adolescents is associated with impaired learning, memory, math and reading, even 28 days after last use. Weekly use is also associated with failure to graduate from high school. Adolescents and young adults who use marijuana are more likely to experience psychotic symptoms as adults, such as hallucinations, paranoia, delusional beliefs and feeling emotionally unresponsive. Evidence shows that marijuana users can become addicted to marijuana and that treatment for marijuana addiction can decrease use and dependence. Additionally, marijuana users who quit have lower risks of cognitive and mental health outcomes than those who continue to use.

Marijuana use and cancer

The committee reviewed different forms of cancer relative to marijuana use, as well as the chemicals released in marijuana smoke and vapor. Strong evidence shows that marijuana smoke contains many of the same cancer-causing chemicals found in tobacco smoke. However, there is conflicting research for whether or not a higher cumulative level of marijuana smoking is associated with lung cancer. Limited evidence suggests an association between marijuana use and both testicular and prostate cancers. On the other hand, the limited evidence available concerning cancers of the bladder, head and neck suggests that they might not have any association with marijuana use.

Marijuana use and cardiovascular effects

The committee reviewed myocardial infarction, stroke and death from cardiovascular causes, relative to marijuana use. There is a moderate level of scientific evidence that marijuana use increases risk for some forms of stroke in individuals younger than 55 years of age, and more limited evidence that marijuana use may increase risk for heart attack. Research is lacking concerning other cardiovascular events and conditions, including death.

Marijuana dose and drug interactions

The committee reviewed THC (tetrahydrocannabinol, the main psychoactive component of marijuana) levels relative to marijuana dose and method of use, the effects of secondhand marijuana smoke, drug-drug interactions involving marijuana, and relationships between marijuana and opioid use. One very important finding is that it can take up to four hours after consuming an edible marijuana product to reach the peak THC blood concentration and feel the full effects. There is credible evidence of clinically important drug-drug interactions between marijuana and multiple medications, including some anti-seizure medications and a common blood-thinner. Data about potential interactions are lacking for many drugs at this time and likely to evolve substantially over coming years. Finally, there is some evidence that opioid pain medication overdose deaths are lower in states with legal medical marijuana than would be expected based on trends in states without legal medical marijuana. There is conflicting evidence for whether or not marijuana use is associated with a decrease in opioid use among chronic pain patients or individuals with a history of problem drug use.

Marijuana use and driving

The committee reviewed driving impairment and motor vehicle crash risk relative to marijuana use, as well as evidence indicating how long it takes for impairment to resolve after marijuana use. They found that the risk of a motor vehicle crash increases among drivers with recent marijuana use. Furthermore, the higher the blood THC level, the higher the motor vehicle crash risk. In addition, using alcohol and marijuana together increases impairment and the risk of a motor vehicle crash more than using either substance alone. For less than weekly marijuana users, using marijuana containing 10 milligrams or more of THC is likely to impair the ability to safely drive, bike, or perform other safety-sensitive activities. Less than weekly users should wait at least six hours after smoking or eight hours after eating or drinking marijuana to allow time for impairment to resolve.

Marijuana use and gastrointestinal or reproductive effects

The committee reviewed gastrointestinal diseases, particularly cyclic vomiting, and infertility or abnormal reproductive function. Evidence shows that long-time, daily or near daily marijuana use is associated with cyclic vomiting, which has been called cannabinoid hyperemesis syndrome. In such cases, stopping marijuana use may relieve the vomiting. There is conflicting research for whether or not marijuana use is associated with male infertility or abnormal reproductive function, and research is lacking on female reproductive function related to marijuana use.

Marijuana use and injury

The committee reviewed workplace, recreational and other non-driving injuries, burns from hash-oil extraction or failed electronic smoking devices, and physical dating violence. Evidence shows that marijuana use may increase the risk of workplace injury while impaired, but is unclear for other types of non-driving related injury. There have been many reports of severe burns resulting from home-extraction of butane hash-oil leading to explosions, and cases of electronic smoking devices exploding, leading to trauma and burns. Concerning dating violence, adolescent girls who use marijuana may be more likely to commit physical violence against their dating partners, and adolescent boys who use marijuana may be more likely to be victims of physical dating violence.

Marijuana use and neurological, cognitive and mental health effects

The committee reviewed the potential relationships between marijuana use and cognitive impairment, mental health disorders and substance abuse. Strong evidence shows that daily or near daily marijuana users are more likely to have impaired memory lasting a week or more after quitting. An important acute effect of THC is psychotic symptoms, such as hallucinations, paranoia and delusional beliefs during intoxication. These symptoms are worse with higher doses. Daily or near daily marijuana use is associated with developing a psychotic disorder such as schizophrenia. Finally, evidence shows that marijuana users can become addicted to marijuana and that treatment for marijuana addiction can decrease use and dependence.

Marijuana use during pregnancy and breastfeeding

The committee reviewed adverse birth outcomes, effects of prenatal marijuana use on exposed offspring later in childhood or adolescence and effects of marijuana use by a breastfeeding mother. Biological evidence shows that THC passes through the placenta to the fetus, so that the unborn child is exposed to THC if the mother uses marijuana, and that THC passes through breast milk to a breastfeeding child. Marijuana use during pregnancy may be associated with an increased risk of heart defects or stillbirth. Stronger evidence was found for effects that are seen months or years after birth if a child's mother used marijuana while pregnant with the child. These include decreased growth and impaired cognitive function and attention. Decreased academic ability or increased depression symptoms may also occur.

Marijuana use and respiratory effects

The committee reviewed respiratory diseases like chronic obstructive pulmonary disorder (COPD), chronic bronchitis and asthma, respiratory infections and lung function relative to smoked marijuana. They also reviewed potential health effects of vaporized marijuana. Strong evidence shows an association between daily or near-daily marijuana use and chronic bronchitis. Additionally, daily or near daily marijuana use may be associated with bullous lung disease and pneumothorax in individuals younger than 40 years of age. Research is lacking concerning any possible association between marijuana use and COPD, emphysema or respiratory infections. Smokers who switch from marijuana smoking to marijuana vaporizing may have fewer respiratory symptoms and improved pulmonary function. Finally, a notable effect of acute use is a short-term improvement in lung airflow.

Unintentional marijuana exposures in children

The committee reviewed unintentional marijuana exposure relative to marijuana legalization and child-resistant packaging. They found strong evidence that more unintentional marijuana exposures of children occur in states with increased legal access to marijuana, and that the exposures can lead to significant clinical effects requiring hospitalization. Additionally, evidence shows that child resistant packaging prevents exposure to children from potentially harmful substances, such as THC.

Monitoring possible marijuana-related health effects

This report includes detailed information about population-based health effects of legalized marijuana in Colorado, using two primary public health datasets:

1. Exposure calls to the Rocky Mountain Poison and Drug Center, typically used as a surrogate data source to determine the potential for adverse health effects from exposure to chemicals and drugs.
2. Hospital and emergency department data provided by the Colorado Hospital Association, which collects data from participating hospitals in the state of Colorado.

The data presented here provide important insights into the yearly volume, trends over time and nature of marijuana exposure calls to the poison center among different age groups and the rates of hospitalizations and emergency department visits for which a marijuana-related billing code was used. A summary of key trends:

Encouraging trends

- Marijuana exposure calls to the poison center appear to be decreasing since 2015, including unintentional exposures in children ages 0-8 years.
- The overall rate of emergency department visits with marijuana-related billing codes dropped 27 percent from 2014 to 2015 (2016 data is not available yet).

Trends to continue monitoring

- Marijuana exposure calls to the poison center continue to be higher in years after medical marijuana commercialization (2010-2016) than in previous years (2000-2009), including calls about children 0-8 years old with unintentional marijuana exposure.
- Edible marijuana products were involved in about 40 percent of marijuana exposure calls to the poison center. For children 0-8 years old, calls about edible marijuana were twice as common as calls about smokeable marijuana.
- The overall rate of hospitalizations with marijuana-related billing codes has increased each year since 2008.

- Among young adults (ages 18-25 years) in 2014 and 2015, about 8 percent of all hospitalizations and 2 percent of all emergency department visits had a marijuana-related billing code. This was higher than the rate among other age groups, and likely reflects the higher rate of marijuana use in this age group.
- Disparities in hospitalizations and emergency department visits also existed by sex and race, with higher rates among males and blacks across all time periods.
- Hospitalizations with marijuana-related billing codes are nine times more likely to have a primary mental health diagnosis compared to those without marijuana-related billing codes.

These data should be interpreted carefully, keeping in mind that observed increases have many potential explanations including: changes in the amount or type of marijuana use in Colorado, changes in physician screening or reporting related to marijuana, increased honesty in reporting marijuana use to health care providers after legalization, and changes in coding practices by hospitals and emergency departments. In addition, possible marijuana-related cases accounted for 3 percent of hospitalizations and less than 1 percent of emergency department visits in Colorado in 2015. More data and time are needed to determine if the observed increases are a direct and sustained result of changes in Colorado marijuana use.

Public health recommendations

The committee made a number of public health recommendations interspersed throughout this report. It recommends Colorado support research to fill important gaps in public health knowledge and continue improving and standardizing data about marijuana use history and health effects in public health surveillance, medical care settings and research.

Collection and in-depth analysis of data regarding marijuana use should be continued using population-based surveys such as the Behavioral Risk Factors Surveillance System, the Healthy Kids Colorado Survey and Pregnancy Risk Assessment Monitoring System. Colorado also should continue to develop, improve and expand tools to monitor marijuana use patterns, such as CDPHE's Cannabis Users' Survey on Health.

CDPHE should continue using poison center and hospital data to monitor trends in potential marijuana health effects and assess the impact over time, especially among groups with higher rates of marijuana use. For the poison center, this includes implementing a surveillance protocol currently being developed and conducting more detailed data collection and analysis of unintentional marijuana exposures, especially in children under 9 years old. In order to better assess potential health impacts, data on hospitalizations and emergency department visits related to marijuana should be further explored. This includes continuing analysis of primary diagnoses in relation to marijuana-related billing codes and targeted projects like CDPHE's collaboration to evaluate ski-related injuries and marijuana.

In addition, improved testing methods and documentation are needed in relation to motor vehicle crashes and driving under the influence of drugs (DUID). Evaluation of death certificate and coroner's report data should continue, to determine how it can best be used in monitoring for potential marijuana-related deaths.

Public education on potential health effects of marijuana is important, particularly related to the effects of use during pregnancy, adolescent use, driving after using and unsafe storage around children. Dispensaries and industry should continue to partner with public health to disseminate education about these topics of highest concern. Education for health care providers on the known health effects of marijuana use may encourage more open dialogue between providers and patients.

Research gaps

Important research gaps related to the population-based health effects of marijuana use were identified during the literature and data review process. These research gaps were based on common limitations of existing research, exposures or outcomes not sufficiently studied, or issues important to public education or policymaking. These research gaps provide an important framework for continuing to prioritize research related to marijuana use and public health. The committee strongly recommends that Colorado support research to fill these important gaps in public health knowledge. While outside the scope of this committee's duties, the committee also recognizes that more research is needed on the potential therapeutic benefits of marijuana.

A common theme among the research gaps was the need for studies with better defined marijuana-use histories and practices. This should include frequency, amount, potency, and method of marijuana use, length of abstinence, and a standardized method for documenting cumulative lifetime marijuana exposure. A key need is to separately evaluate effects for less frequent users versus daily or near-daily users. Researchers should consider evaluating separately by age group, sex or other characteristics when the health effect being studied could differ among groups - for example, by age for cardiovascular effects or by sex for mental health effects.

Research gaps particularly important to public health and safety include: 1) Additional research using marijuana with THC levels consistent with currently available products; 2) Research on impairment in marijuana users who use more than weekly and may have developed tolerance; 3) Research to identify improved testing methods for impairment either through alternate biological testing methods or physical tests of impairment; and 4) Research to better characterize the pharmacokinetics/pharmacodynamics, potential drug interactions, health effects, and impairment related to newer methods of marijuana use such as edibles and vaporizing as well as other cannabinoids such as cannabidiol (CBD).

Section 1

Monitoring Changes in Marijuana Use Patterns

Retail Marijuana Public Health Advisory Committee

Background

The Colorado Department of Public Health and Environment (CDPHE) was given statutory (In 25-1.5-110, C.R.S.) responsibility to:

- "… monitor changes in drug use patterns, broken down by county and race and ethnicity, and the emerging science and medical information relevant to the health effects associated with marijuana use."

Patterns of drug use are typically determined by using population-based surveys that ask specific questions about substance use. Colorado has created and manages several population-based surveys to assess the prevalence of a variety of health conditions and behaviors of specific populations. In addition, there are a few national surveys that collect state level data on marijuana use. The data from these surveys are compiled here to meet the reporting requirements set forth in 25-1.5-110, C.R.S. These data also have been presented to the Retail Marijuana Public Health Advisory Committee, which was charged with the duties outlined in 25-1.5-110, C.R.S. to "…establish criteria for studies to be reviewed, reviewing studies and other data, and making recommendations, as appropriate, for policies intended to protect consumers of marijuana or marijuana products and the general public." Reviewing marijuana use patterns in Colorado provides important insight to the committee members as they consider public health recommendations.

Data sources

Adult use: Behavioral Risk Factor Surveillance System (BRFSS)

The Behavioral Risk Factor Surveillance System (BRFSS) is a telephone survey of adults ages 18 years and older, sponsored by the U.S. Centers for Disease Control and Prevention (CDC). It is the nation's premier system of health-related telephone surveys that collect data from U.S. residents regarding their health-related risk behaviors, chronic health conditions and safety practices. CDPHE, in a cooperative agreement with CDC, manages and administers BRFSS in Colorado. In 2014 and 2015, Colorado added questions on marijuana use to the state-level BRFSS.

Marijuana in homes with children: Child Health Survey (CHS)

The Child Health Survey (CHS) is a telephone survey conducted among respondents to the BRFSS Survey who have children ages 1-14 in their home. Adult respondents answer questions about their children and the home environment. This annual survey provides data on a wide range of health issues and risk factors affecting children and youth in Colorado. Since 2014, questions about marijuana use and storage in the home have been included in the survey.

Adolescent and young adult use: Healthy Kids Colorado Survey (HKCS)

The Healthy Kids Colorado Survey (HKCS) collects health information from public high school and middle school students. It is a voluntary, anonymous survey, completed by students individually in their classrooms and parents are notified ahead of time. HKCS is a collaboration of CDPHE, Colorado Department of Education and Colorado Department of Human Services. This survey includes the questions on the national Youth Risk Behavioral Surveillance Survey (YRBSS). HKCS has included questions on marijuana since 1999.

Adolescent and adult use: National Survey on Drug Use and Health (NSDUH)

The Substance Abuse and Mental Health Services Administration (SAMHSA) tracks national and state level data on tobacco, alcohol, marijuana, and illicit drug use through the National Survey on Drug Use and Health (NSDUH). This survey is completed by in-person interview at the respondent's home, and includes one or two residents who are at least 12 years old. Although the survey design differs from BRFSS and HKCS, it can be used for comparisons of state and national marijuana use estimates. This report does not have a NSDUH-specific chapter, but NSDUH data are included for comparison in the BRFSS and HKCS chapters.

Use during pregnancy: Pregnancy Risk Assessment Monitoring System (PRAMS)

The Pregnancy Risk Assessment Monitoring System (PRAMS) is a mailed survey of women who recently gave birth. It is sponsored by the Centers for Disease Control and Prevention (CDC). It provides data not available from other sources about pregnancy and the first few months after delivery, and allows CDC and states to monitor changes in maternal and child health indicators, such as unintended pregnancy, prenatal care, breastfeeding, infant health, smoking and alcohol use. In 2014, Colorado added questions about marijuana use before, during and after pregnancy to the state-level PRAMS.

Each of these surveys only collects self-reported information, so there is no way to confirm whether each respondent has answered truthfully. These types of surveys have been validated in various studies, which indicate most people do answer truthfully. Consistency in methodology from year to year for each of the surveys provides confidence that trends over time can be effectively monitored.

Key details about all five surveys

Survey	Population and ages studied	Years	Data collection method
BRFSS	Adults age 18 and up	2014-2015	Telephone survey
CHS	Parents of children age 1-14	2014-2015	Telephone survey
HKCS	Adolescents and young adults age 11-18	1999-2015	In-school paper survey
NSDUH	Adolescents and adults age 12 and up	1971-2015	In-person, at home survey
PRAMS	Pregnant and recently pregnant women	2014	Mailed paper survey

Summary of key findings

The most prominent findings from all surveys are described below. For additional results and details, see the individual chapters for BRFSS (page 9), CHS(page 29), HKCS (page 39) and PRAMS (page 63).

Trends in adult marijuana use in Colorado

In 2015, BRFSS data showed an estimated 13% of Colorado adults ages 18 and up had used marijuana in the past-month. The NSDUH estimate for past-month use differs, at 17%. However, neither survey showed a statistical change from 2014 to 2015. According to NSDUH data, adult use in Colorado continued to be higher than the national average, which was 8%. BRFSS in 2015 showed past-month adult marijuana use in Colorado was highest among those 18-25 years old (26%); males (17%); and those who reported gay, lesbian, bisexual or other sexual orientation (37%). None of these groups saw a statistical change in use between 2014 and 2015. Northwest Colorado saw an increase in past-month use from 2014 (10%) to 2015 (16%), while other regions had no statistical change.

In 2015, 6% of adults reported using marijuana daily or near-daily. This was lower than daily or near-daily alcohol (22%) or tobacco use (16%). Of 18- to 25-year old marijuana users, 50% report using daily or near-daily (13% of all 18- to 25-year olds). Among adult past-month marijuana users, 79% smoke, 30% “vape” and 33% use edibles. Respondents could report using more than one method, which 50% of users did. Finally, approximately 2% of adults drove a vehicle in the past 30 days after using marijuana.

Trends in adolescent marijuana use in Colorado

HKCS results from 2015 indicate approximately 21% of Colorado high school students had used marijuana in the past-month. This is not statistically different from 2013 (20%) and is nearly identical to national estimates from YRBSS (22%). From 2005-2015, past-month use fluctuated between approximately 20% and 25%, with no clear trend. The most recent NSDUH data for high school age adolescents (14- to 17-year olds) is from 2012-2014 and shows 17% past-month use. This compares with the 2013 HKCS estimate of 19%. According to HKCS in 2015, past-month adolescent marijuana use was nearly identical among males and females (21%). Comparing grade levels, use was highest among juniors (26%) and seniors (28%). As with adults, students identifying as gay, lesbian, or bisexual were more likely to report past-month use (35%) than those identifying as heterosexual (20%). Use is higher among Hispanics (24%) and multiple or other races (28%) than among whites (20%).

In 2015, past-month marijuana use among high school students in Colorado (21%) was lower than past-month alcohol use (30%) and higher than past-month tobacco use (9%). Smoking marijuana is the most popular method of use among high school students, with 87% reporting it as their usual method of use. Edibles dropped from 5% in 2013 to 2% in 2015. In 2015, 27% of past-month high school users (more than 5% of all high school students) used daily or near-daily. Concerning age of first use, 41% of high school seniors who had ever used marijuana said they first used it by age 14 or before and another 43% had first used by age 16. 2015 data also showed that 8% of Colorado middle school students had ever used marijuana and 4% used within the past-month.

Marijuana in Colorado homes with children

In 2015, CHS data showed 8% of adults with children 1-14 years old in the home had marijuana or marijuana products in or around the home. In 82% of these homes, marijuana was stored safely, while in 18% it was potentially stored unsafely. It is estimated that approximately 14,000 homes in Colorado with children 1-14 years old had marijuana in the home with potentially unsafe storage.

For 2014 and 2015 together, 3% of adults with children 1-14 years old in the home reported marijuana being used inside the home. Of these, 83% reported the marijuana was smoked, vaporized, or dabbed. It is estimated that approximately 16,000 homes in Colorado had children 1-14 years old with possible exposure to secondhand marijuana smoke or vapor in the home.

Trends in marijuana use during pregnancy and breastfeeding in Colorado

PRAMS results from 2014 show 11% of new mothers had used marijuana shortly before their pregnancy and 6% of new mothers used it during their pregnancy. By comparison, 13% used alcohol and 6% used tobacco during pregnancy. A 2016 article reported use during pregnancy was approximately 4% nationally (see PRAMS chapter for details), an estimate that is not statistically different from PRAMS results for Colorado. According to PRAMS, use during pregnancy in Colorado was statistically higher among women 20-24 years old (13%) than among women 25-34 years old (4%) or women 35 years old or older (3%). It also was higher among women with less than a 12th-grade education (16%) than among women with some college (4%). Use during pregnancy was lower among women who intended to become pregnant (4%) than women with unintended pregnancies (9%). Finally, approximately 5% of new mothers used marijuana after pregnancy when they were also breastfeeding.

Discussion

The citizens of Colorado exhibit behaviors much more complex than any survey can capture. Currently available data cannot answer all the important questions we have about whether or not marijuana use patterns are changing as a result of legalization. The data presented here provide important insights into marijuana use in adults as well as vulnerable populations such as pregnant women; youth; and those with racial, ethnic and sexual orientation disparities.

Encouraging trends

- For adults and adolescents, past-month marijuana use has not changed since legalization either in terms of the number of people using or the frequency of use among users.
- Based on the most comprehensive data available, past-month marijuana use among Colorado adolescents is nearly identical to the national average.
- We have not identified any **new** disparities in marijuana use by age, gender, race, ethnicity or sexual orientation since legalization.
- Daily or near-daily marijuana use among adults is much lower than daily or near-daily alcohol or tobacco use. Among adolescents, past month marijuana use is lower than past month alcohol use.

Trends to continue monitoring

- About 6 percent of pregnant women choose to use marijuana while pregnant. This percentage is higher among those with unintended pregnancies as well as younger mothers or those with less education.
- At least 14,000 children in Colorado are at risk of accidentally eating marijuana products that are not safely stored, and at least 16,000 are at risk of being exposed to secondhand marijuana smoke in the home.

- More than 5 percent of high school students use marijuana daily or near daily. This rate has remained stable since at least 2005.
- Past-month marijuana use among adults in Colorado is higher than the national average. In Colorado, one in four adults ages 18-25 reported past-month marijuana use and one in eight use daily or near-daily. These numbers have been consistent since legalization.
- There continued to be disparities in marijuana use based on race/ethnicity for adolescents and sexual orientation for both adults and adolescents.
- While past-month marijuana use among adults and adolescents was stable for most regions in Colorado, adult use in the Northwest Colorado region increased from 2014 to 2015.
- More than 1-in-3 adolescents who use marijuana first use it by age 14, supporting prevention efforts aimed at children before they enter ninth grade.

Recommendations and future directions

1. Continue assessing prevalence of marijuana use via large Colorado-based surveys including the Pregnancy Risk Assessment Monitoring System, Healthy Kids Colorado Survey, and the Behavioral Risk Factor Surveillance System. Data from surveys identify trends in use patterns that can be used to inform and target education and prevention strategies. National surveys do not have a sufficient Colorado sample size to fully address patterns of use by age, race/ethnicity, and any county or regional catchment. Continued surveys using the same methodology can act as a feedback loop to ensure marijuana policies and education campaigns are effective.
2. Continue to develop, improve and expand tools to monitor marijuana use patterns. Results from the Cannabis Users Survey on Health (CUSH) will be reported in spring 2017. CUSH is a survey created by CDPHE to gather more detailed information about adult marijuana use, including methods, amounts and frequency of use; reasons for using; how it is purchased or obtained; concurrent use with other substances; and any adverse effects experienced. CDPHE is collaborating with other states and national organizations to expand use of this survey to other states.
3. Continue in-depth analyses of existing survey data to assess risk and protective factors for marijuana use, including changes in the perception of harm from marijuana use.
4. Continue collaboration with other state and national agencies to identify data that might add additional detail on use patterns in specific populations or geographic areas in the state.

Section 1

Monitoring Changes in Marijuana Use Patterns

Chapter 1

Behavioral Risk Factor Surveillance System (BRFSS) 2014-2015 Survey Results

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Katelyn E. Hall, MPH
Statistical Analyst
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Amy Anderson Mellies, MPH
Health Data Analyst
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Alison Grace Bui, MPH
Epidemiologist
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Rickey Tolliver, MPH
Chief
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health, and Toxicology Branch, Colorado Department of Public Health and Environment

Reviewer

Shireen Banerji, PharmD, DABAT
Clinical Manager, Rocky Mountain Poison Center

The BRFSS survey and marijuana use in Colorado

The Behavioral Risk Factor Surveillance System (BRFSS) collects data on adult, individual-level behavioral health risk factors associated with leading causes of premature mortality and morbidity. It is the nation's premier system of health-related telephone surveys that collect state data about U.S. residents regarding their health-related risk behaviors, chronic health conditions, and safety practices. By collecting behavioral health risk data at the state and local level, BRFSS has become a powerful tool for targeting and building health promotion activities.[1]

Colorado participates in BRFSS using core and optional modules, and it is able to add 'state-added' questions to customize data collection to topics most relevant to Coloradans. In 2014 and 2015 Colorado added questions on marijuana use to the BRFSS (Table 1).[2] These questions have begun to give insight into marijuana use patterns among Colorado's adult population.

For additional survey details and information about analysis methods, see Appendix B.

Survey questions

Table 1. Behavioral Risk Factor Surveillance System questions asked of Colorado adults about marijuana use and methods of marijuana use, 2014-2015.

1. Have you ever used marijuana or hashish? (all respondents were asked) a. Yes b. No c. Don't Know/Not Sure	2014/2015
2. How old were you the first time you used marijuana or hashish? (only ever users were asked) a. Age: _______ b. Don't Know/Not Sure	2014/2015
3. During the past 30 days on how many days did you use marijuana or hashish? (only ever users were asked) a. Number of Days: ________ b. None c. Don't Know/Not Sure	2014/2015
4. During the past 30 days, how many times did you drive a car or other vehicle when you had been using marijuana or hashish? (only current users were asked) a. Number of days ________ b. Don't Know/Not Sure	2014/2015
5. On the days that you did use marijuana, how many times per day did you use it on average? (only current users were asked) a. Number of times: ________ b. None c. Don't know/Not sure	2015
6. During the past 30 days, how did you use marijuana? For each of the following methods please say YES if it does apply or NO if it does not apply or Don't know/Not sure. (only current users were asked) a. Was it vaporized? (e-cigarette-like vaporizer) b. Was it smoked? (in a joint, bong, pipe, blunt) c. Was it eaten in food? (in brownies, cakes, cookies, candy) d. Was it consumed in a beverage? (tea, cola, alcohol) e. Was it dabbed? f. Was it used in some other way? _______________ (specify)	2015

The National Survey on Drug Use and Health

The Substance Abuse and Mental Health Services Administration (SAMHSA) tracks national and state level data on tobacco, alcohol, marijuana, and illicit drugs including non-medical use of prescription drugs through the National Survey on Drug Use and Health (NSDUH).[3] National and Colorado past 30 day marijuana use estimates from the NSDUH survey were compared with the Colorado BRFSS past 30 day marijuana use estimate (Figure 2).

Definitions

Current use – having used marijuana or hashish on at least one day in the past 30 days (answered at least ‘1 day in the past 30 days’ on question 3) (Table 1)

Dabbing - a method of marijuana use where a "dab" (small amount) of marijuana concentrate is placed on a pre-heated surface, creating concentrated marijuana vapor to be inhaled.

Daily or near daily use - having used marijuana or hashish on twenty to thirty days in the past 30 days (answered ‘20-30 days in the past 30 days’ on question 3) (Table 1)

Ever use – having used marijuana or hashish at least once in their lifetime (answered ‘Yes’ on question 1) (Table 1)

Monthly use - having used marijuana or hashish on one to three days in the past 30 days (answered ‘1-3 days in the past 30 days’ on question 3) (Table 1)

Vaping (vaporization of marijuana) - a method of marijuana use where marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

Weekly use - having used marijuana or hashish on four to nineteen days in the past 30 days (answered ‘4-19 days in the past 30 days’ on question 3) (Table 1)

How to interpret survey results

Respondents to the BRFSS survey are a sample of Colorado adults. The percent of survey respondents selecting a specific answer might not be exactly the same as if all adults in Colorado were surveyed. Therefore, the survey results are estimates, and each has a range of possible values (also called margin of error, confidence interval, or 95% CI). These ranges are very important when comparing two estimates, and the following terms are used throughout this report:

‘Not statistically different’- Typically, if the ranges of possible values *overlap* for two different survey results (like two different years, or male vs. female), we cannot be confident that there is a true difference between the two (also called ‘not statistically significant.’) In some cases, an additional statistical test is done to confirm.

‘Statistically higher’ or ‘statistically lower’- If the ranges of possible values *do not overlap* for two different results, we CAN be confident that there is a true difference between the two (also called ‘statistically significant.’)

On the figures in this report, these ranges of possible values are indicated by black bars. In footnotes, they are referred to by the statistical term ‘95% CI.’

Results

Results are displayed in Figures 1-13 below.

Trends in marijuana use in Colorado

Ever marijuana use among Colorado adults was estimated at 49.3% in 2015. Survey results indicated that there were no statistical differences in ever marijuana use from 2014 (48.8%) to 2015 (49.3%). Current marijuana use among adults was estimated at 13.4% from 2015 BRFSS (Figure 1). The 2015 NSDUH estimate for current use was statistically higher, at 17.1% (Figure 2). Neither survey showed a statistical difference in current use from 2014 to 2015 (Figure 2). NSDUH estimates of current marijuana use among Colorado adults from 2006-2015 were statistically higher than the national estimates for adult current marijuana use for each year (Figure 2). Monthly, weekly, and daily or near daily marijuana use among adults in 2015 was 3.5%, 3.6%, and 6.3% respectively. In both 2014 and

2015, daily or near daily marijuana use was statistically higher than monthly or weekly marijuana use (Figure 3). Comparing across years within each level of use, there were no statistical differences between 2014 and 2015 (Figure 3). In 2015, 2.1% of adults drove a vehicle in the past 30 days when using marijuana (Figure 4). This was not statistically higher than in 2014 (2.5%).

Current marijuana use in Colorado by age, gender, race & ethnicity, and sexual orientation

In both 2014 and 2015, current marijuana use was lower among adults 35 years and older (9.3%, 10.3%) than among those 18-25 (27.5%, 26.1%) or 26-34 years of age (19.8%, 18.3) (Figure 5). Comparing across years within each age category, there were no statistical differences between 2014 and 2015 (Figure 5). In both 2014 and 2015, current marijuana use was higher among males (17.2%, 16.9%) than females (10.0%, 10.0%) (Figure 6). Comparing across years within each gender, there were no statistical differences in current marijuana use from 2014 to 2015 (Figure 6). There also were no statistical differences in current marijuana use estimates from 2014 to 2015 within any of the race/ethnicity groups: Hispanic, White, Black, Multiracial, or Other Race (Figure 7). In both 2014 and 2015, current marijuana use was higher among those who reported Gay, Lesbian, Bisexual, or Other sexual orientation (30.1%,36.9%) compared to those who reported Heterosexual orientation (12.9%, 12.4%) (Figure 8). Comparing across years within each sexual orientation category, there were no statistical differences in current marijuana use from 2014 to 2015 (Figure 8).

Current marijuana use in Colorado by region

In 2015, the range of current marijuana use was 11.2% to 17.0% across regions compared to 10.3% to 15.1% in 2014. The Northwest region of Colorado had a statistical increase in current marijuana use from 10.3% in 2014 to 16.0% in 2015 (Figure 9). There were no statistical differences in current marijuana use from 2014 to 2015 in all other regions (Figure 9).

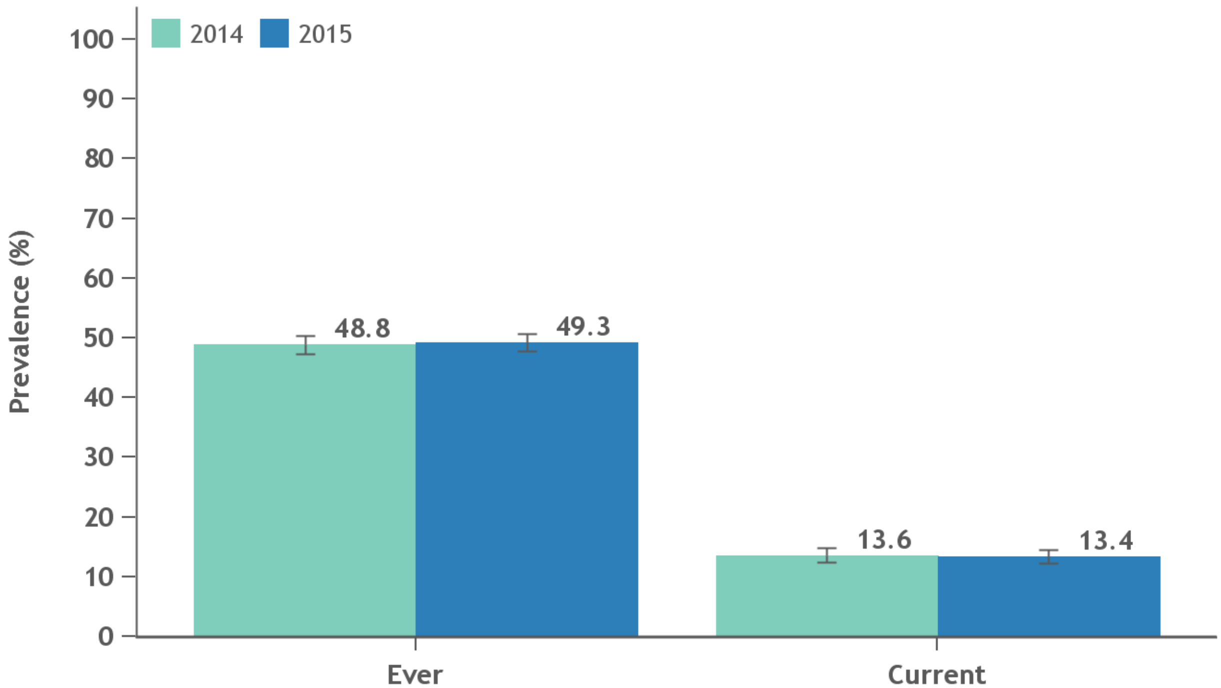
Daily or near daily marijuana use in Colorado

In both 2014 and 2015, daily or near daily marijuana use (6.0%, 6.3%) among adults was lower than daily or near daily alcohol (22.8%, 21.8%) or tobacco use (15.9%, 15.6%) (Figure 10). Comparing across years within each substance, there were no statistical differences between 2014 and 2015 (Figure 10). In both 2014 and 2015, daily or near daily marijuana use was lower among adults 35 years and older (3.6%, 4.8%) than among those 18-25 (13.3%, 13.1%) or 26-34 years of age (9.9%, 8.4%) (Figure 11). Comparing across years within each age group, there were no statistical differences in daily or near daily marijuana use between 2014 and 2015 (Figure 11).

Methods of marijuana use

Data on methods of use were only available for 2015. Dabbing was reported less among current users aged 35 years and older (7.0%) than among those 18-25 (36.0%) or 26-34 (25.2%) years of age (Figure 12). There were no statistical differences between age groups in the number of adults who smoked, vaporized, or ate/drank marijuana (Figure 12). Approximately half of adults who currently use marijuana reported using it through multiple methods (49.9%), which was statistically higher than all other reported methods of marijuana use (Figure 13). Only smoked (40.4%) was the next most commonly reported method of use after multiple methods followed by only vaporized (5.8%), only ate/drank (3.6%) and only dabbed (0.3%) in the past 30 days (Figure 13).

Figure 1. Ever and current marijuana use among Colorado adults (18+ years), 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Ever Use was marijuana use at least once in a lifetime. Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

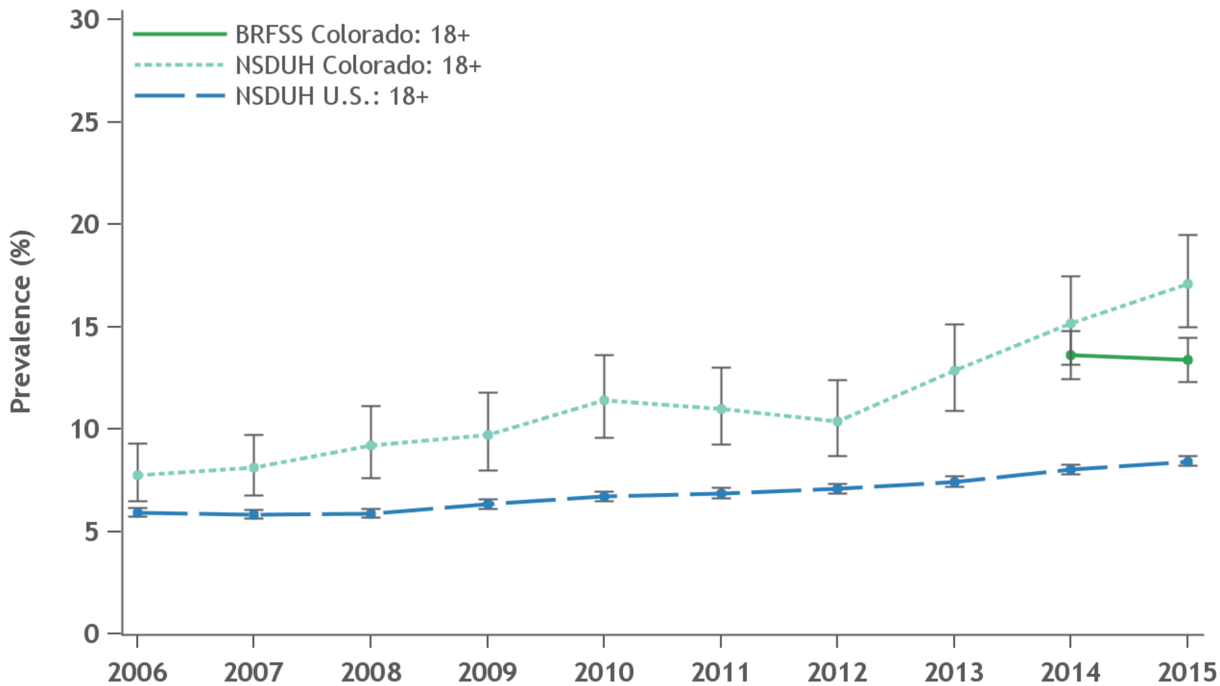
- Ever marijuana use among Colorado adults (18+ years) was not statistically different from 2014 to 2015.[a]
- Current marijuana use (marijuana use at least once in the past 30 days) among adults was not statistically different from 2014 to 2015.[b]

[a] Ever marijuana use 2014 vs. 2015: X^2= 0.15, p=0.7017

[b] Current marijuana use 2014 vs. 2015: X^2= 0.07, p=0.7922

For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.1.

Figure 2. Current marijuana use among adults (18+ years): NSDUH 2006-2015 and BRFSS 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Daily or Near Daily Use is defined as using 20-30 days in the past 30 days (marijuana or alcohol) or reporting everyday or someday use (smoking tobacco).
‡Data Source: Substance Abuse and Mental Health Services Administration, National Survey on Drug Use and Health (NSDUH) 2006-2014. Colorado Behavioural Risk Factors Surveillance System (BRFSS) 2014-2015

Major findings

- BRFSS estimated current marijuana use among Colorado adults was not statistically different from 2014 to 2015.[c]
- NSDUH estimated current marijuana use among Colorado adults was not statistically different from 2014 to 2015.[d]
- In 2015, the NSDUH estimate for current marijuana use among Colorado adults was statistically higher than the BRFSS estimate.[e]
- NSDUH estimates of current marijuana use among Colorado adults from 2006-2015 were statistically higher than the national estimates for adult current marijuana use for each year.[f]

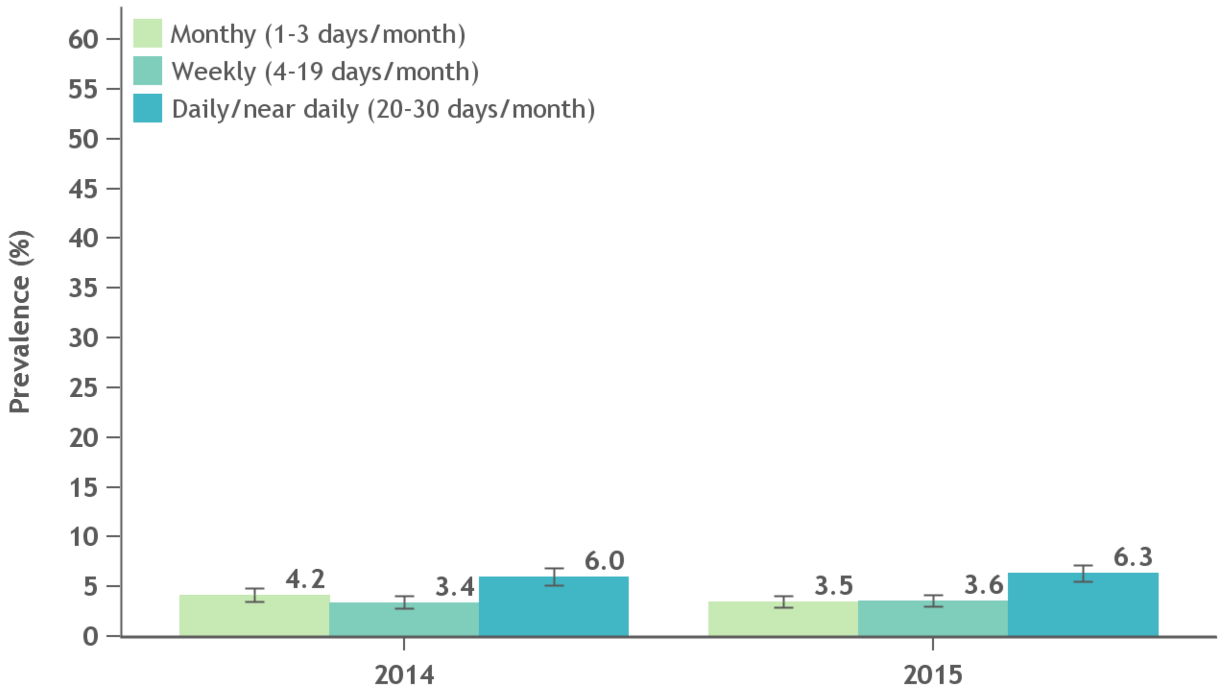
[c] Current marijuana use (BRFSS): 2014 13.6% (95% CI 12.4-14.8%), 2015 13.4% (95% CI 12.3-14.5%)
[d] Current marijuana use (NSDUH): 2014 15.2% (95% CI 13.1-17.5%), 2015 17.1% (95% CI 15.0-19.5%)

[e] Current marijuana use: 2014 BRFSS 13.6% (95% CI 12.4-14.8%), 2014 NSDUH 15.2% (95% CI 13.1-17.5%), 2015 BRFSS 13.4% (95% CI 12.3-14.5%), 2015 NSDUH 17.1% (95% CI 15.0-19.5%)

[f] See Appendix B, Table B.2 for Colorado & National NSDUH estimates from 2006-2015

For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.2.

Figure 3. Monthy, weekly, and daily or near daily marijuana use among Colorado adults (18+ years), 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Monthy use was using marijuana 1-3 days in the past 30 days, weekly use was using marijuana 4-19 days in the past 30 days, and daily or near daily use was using marijuana 20 or more days in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

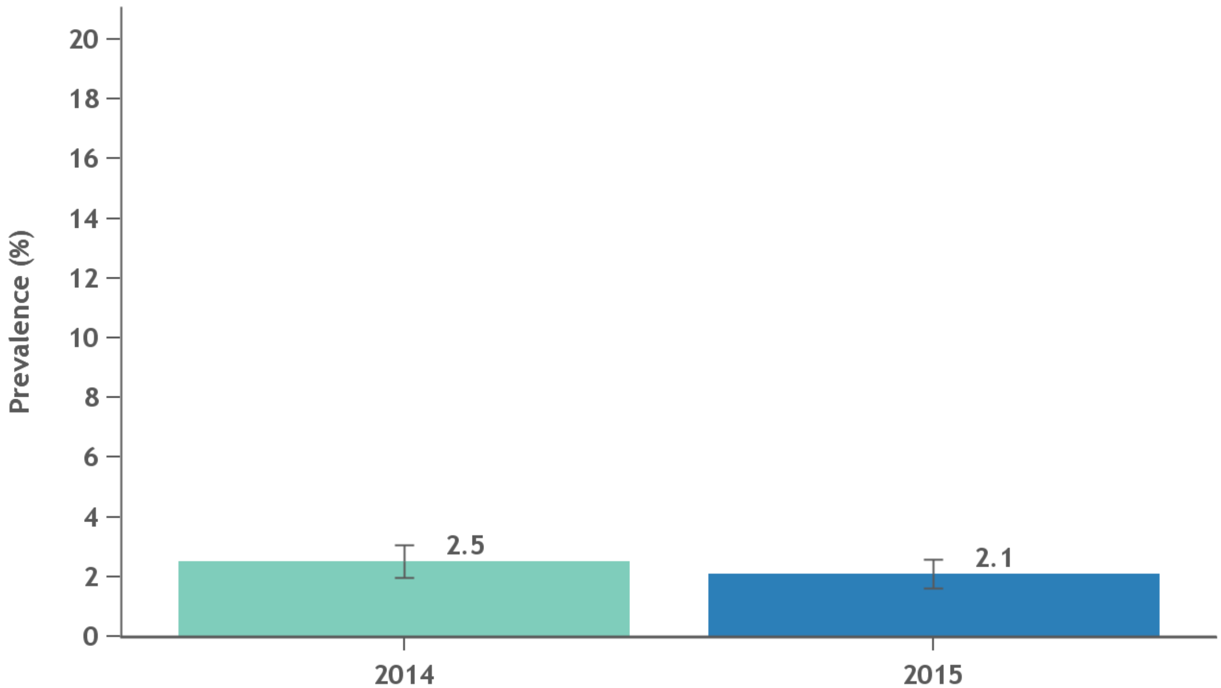
- In both 2014 and 2015, daily or near daily marijuana use among adults was statistically higher than monthly or weekly marijuana use.[g]
- Comparing across years within each level of use, there were no statistical differences between 2014 and 2015.[h]

[g] In 2014: daily/near daily 6.0% (95% CI 5.2-6.9%), monthly 4.2% (95% CI 3.5-4.8%), weekly 3.4% (95% CI: 2.8-4.0%). In 2015: daily/near daily 6.3% (95% CI 5.5-7.2%), monthly 3.5% (95% CI 2.9-4.0%), weekly 3.6 (95% CI 3.0-4.2%).

[h] Monthly, weekly and daily/near daily use 2014 vs. 2015: X^2= 2.56, p=0.4636

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.3.

Figure 4. Colorado adults (18+ years) who drove a vehicle when using marijuana in the past 30 days, 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use was marijuana use at least once in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

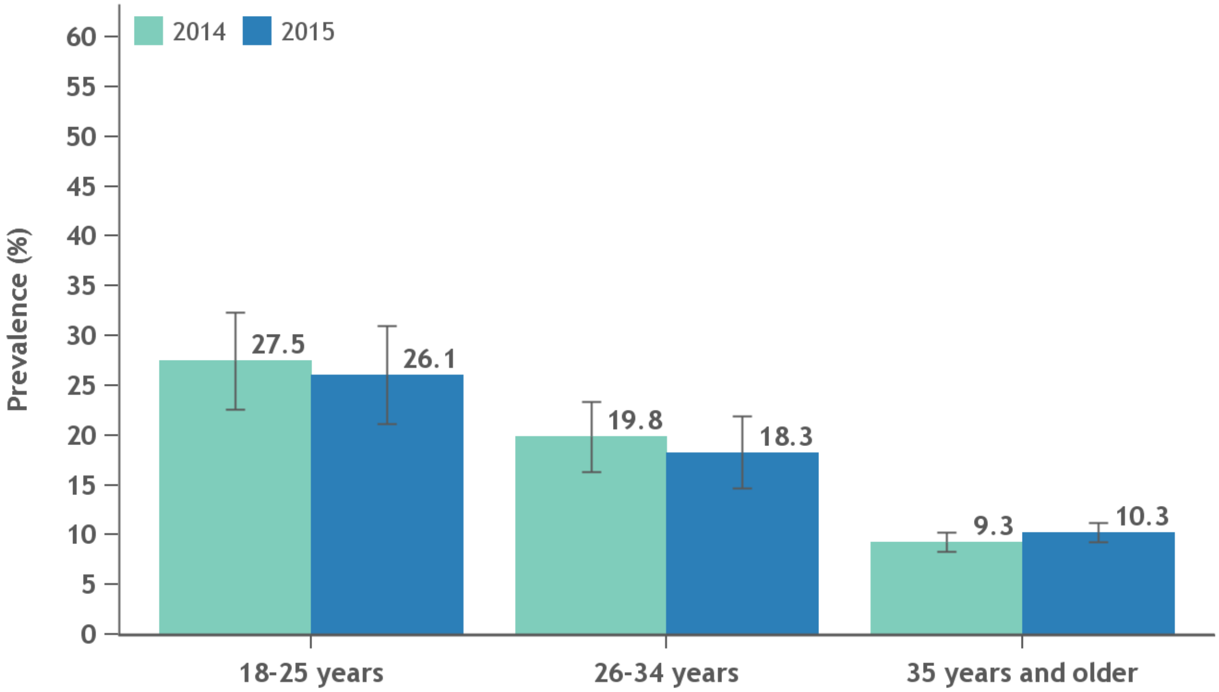
Major findings

- The prevalence of Colorado adults who drove a vehicle when using marijuana in the past 30 days was not statistically different from 2014 to 2015.[i]

[i] Drove a vehicle when using marijuana, 2014 vs. 2015: X^2= 1.26, p=0.2609

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.4.

Figure 5. Current marijuana use among Colorado adults (18+ years) by age categories, 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use was marijuana use at least once in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

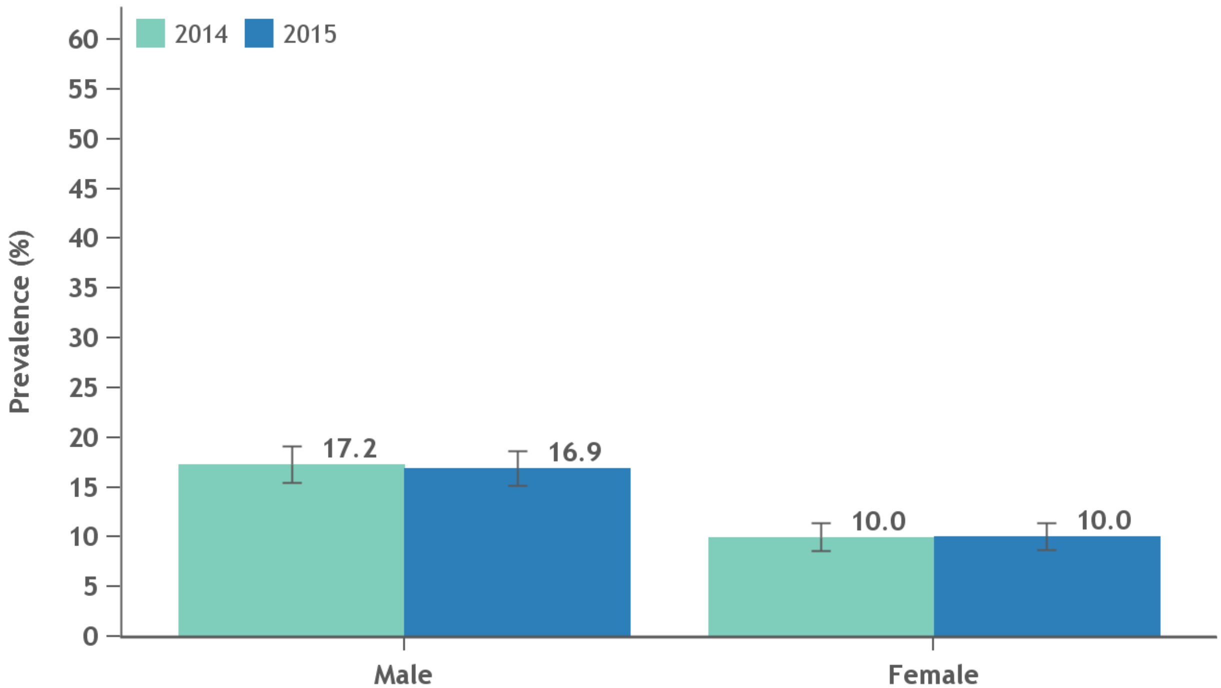
- Current marijuana use was statistically lower among adults 35 years and older than among adults 18-25 years or 26-34 years of age in both 2014 and 2015.[j]
- Comparing across years within each age category, there were no statistical differences between 2014 and 2015.[k]

[j] In 2014: 35+ years 9.3% (95% CI 8.3-10.3%), 26-34 years 19.8% (95% CI 16.3-23.4%), 18-25 years 27.5% (95% CI 22.6-32.3%). In 2015: 35+ years 10.3% (95% CI 9.3-11.2%), 18-25 years 26.1% (95% CI 21.2-31.0%), 26-34 years 18.3% (95% CI 14.7-21.9%).

[k] Current use 2014 vs. 2015: 18-25 years X^2= 0.15, p=0.6974; 26-34 years X^2= 0.36, p=0.5470; 35 years and older X^2= 1.97, p=0.1607.

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.5.

Figure 6. Current marijuana use among Colorado adults (18+ years) by gender, 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use was marijuana use at least once in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

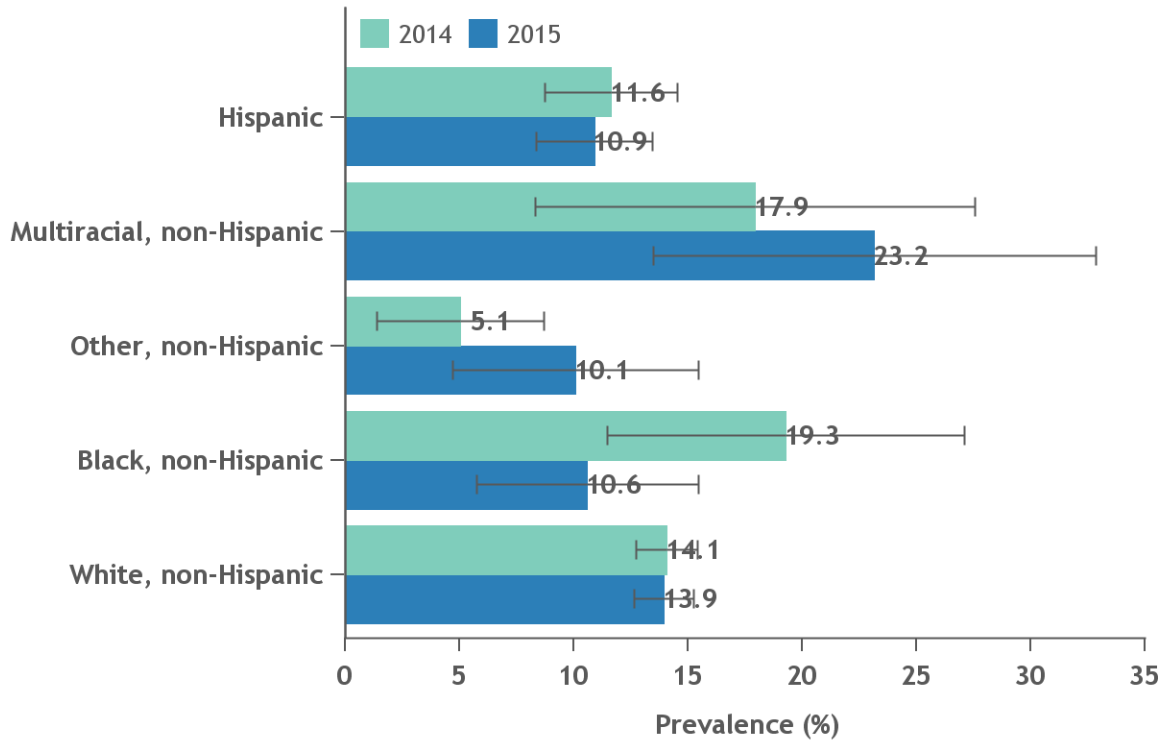
- Current marijuana use was statistically higher among male adults compared to female adults in both 2014 and 2015.[l]
- Comparing across years within each gender, there were no statistical differences in current marijuana use from 2014 to 2015.[m]

[l] In 2014: males 17.2% (95% CI 15.4-19.1%), females 10.0% (95% CI 8.6-11.4%). In 2015: males 16.9% (95% CI 15.1-18.6%), females 10.0% (95% CI 8.7-11.4%).

[m] Current use 2014 vs. 2015: adult males X^2= 0.07, p=0.7846; adult females X^2= 0.003, p=0.9509.

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.6.

Figure 7. Current marijuana use among Colorado adults (18+ years) by race and ethnicity, 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use was marijuana use at least once in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

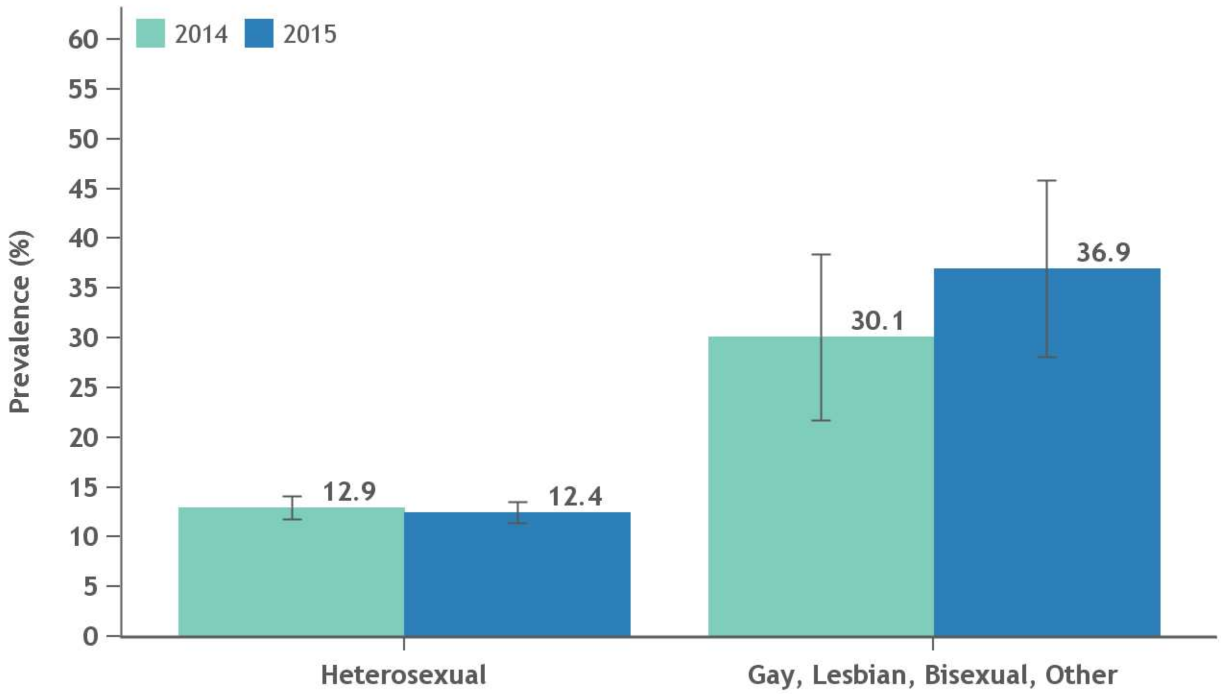
- There were no statistical differences in estimates of current marijuana use from 2014 to 2015 within any of the race/ethnicity groups: Hispanic, White, Black, Multiracial, or Other Race.[n]

---

[n] Current use 2014 vs. 2015: Hispanic X^2= 0.14, p=0.7087; multiracial X^2= 0.57, p=0.4516; other X^2= 2.30, p=0.1298; white non-Hispanic X^2= 0.02, p=0.8845; black X^2 = 3.45, p=0.0633.

For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.7.

Figure 8. Current marijuana use among Colorado adults (18+ years) by sexual orientation, 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use was marijuana use at least once in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

- Current marijuana use was higher among those who reported Gay, Lesbian, Bisexual, or Other sexual orientation compared to those who reported Heterosexual orientation in both 2014 and 2015.[o]
- Comparing across years within each sexual orientation category, there were no statistical differences in current marijuana use from 2014 to 2015.[p]

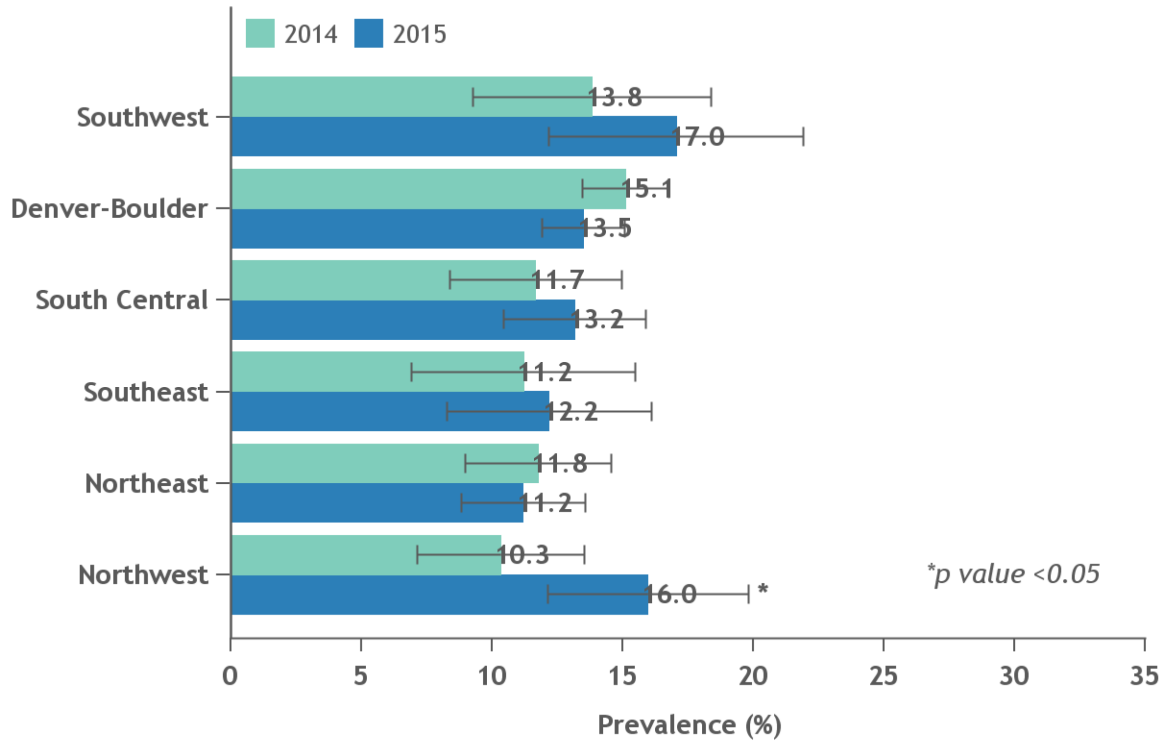
---

[o] In 2014: Gay, Lesbian, Bisexual, or Other 30.1% (95% CI 21.7-38.4%), Heterosexual 12.9% (95% CI 11.8-14.1%). In 2015: Gay, Lesbian, Bisexual, or Other 36.9% (95% CI 28.1-45.8%), Heterosexual 12.4% (95% CI 11.4-13.5%).

[p] Current use 2014 vs. 2015: heterosexual adults X^2= 0.41, p=0.5226; gay, lesbian, bisexual, or other sexual orientation adults X^2= 1.23, p=0.2669.

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.8.

Figure 9. Current marijuana use among Colorado adults (18+ years) by regions, 2014-2015.



Produced by: EEOHT, CDPHE 2016.
†Black bars indicate margins of error (95% Confidence Intervals).
‡Current Use was marijuana use at least once in the past 30 days.
§Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

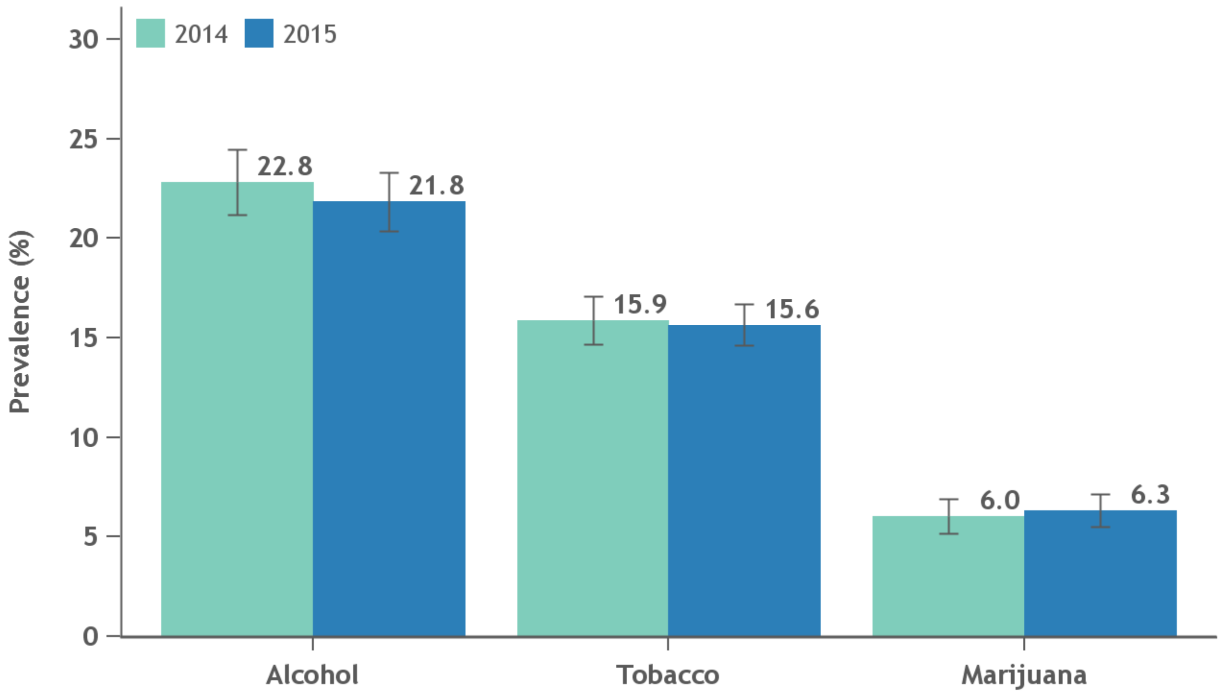
- Current marijuana use among adults in Colorado's Northwest region was statistically higher in 2015 than in 2014.[q]
- There were no statistical differences in estimates of current marijuana use from 2014 to 2015 within the other regions of Colorado: Southwest, Denver-Boulder, South Central, Southeast, or Northeast.[r]

[q] Current use among adults in the Northwest Region in 2014 vs. 2015: X^2= 4.91, p=0.027

[r] Current use 2014 vs. 2015: Southwest Region X^2= 0.89, p=0.3457; Denver-Boulder Region X^2= 1.91 p=0.1664; South Central Region X^2= 0.48, p=0.487; Southeast Region X^2= 0.11, p=0.742; Northeast Region X^2=0.09, p=0.765.

For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.9.

Figure 10. Daily or near daily use of alcohol, tobacco, and marijuana among Colorado adults (18+ years) 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Daily or Near Daily Use is defined as using 20-30 days in the past 30 days (marijuana or alcohol) or reporting everyday or someday use (smoking tobacco).
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

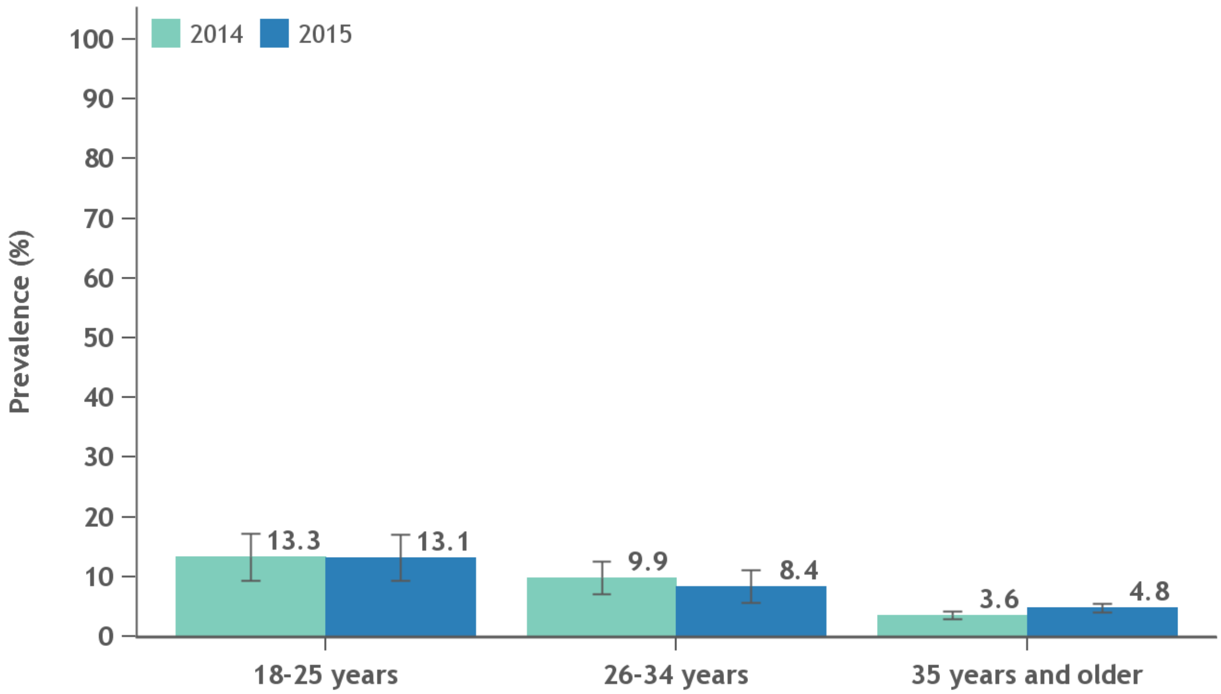
Major findings

- The prevalence of daily or near daily marijuana use among Colorado adults was statistically lower than daily or near daily alcohol or tobacco use in both 2014 and 2015.
- Comparing across years within each substance, there were no statistical differences between 2014 and 2015.[s]

[s] In 2014: Marijuana 6.0% (95% CI 5.2-6.9%), Alcohol 22.8% (95% CI 21.2-24.5%), Tobacco 15.9% (95% CI 14.7-17.1%). In 2015: Marijuana 6.3% (95% CI 5.5-7.2%), Alcohol 21.8% (95% CI 20.4-23.3%), Tobacco 15.6% (95% CI 14.6-16.7%).

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.10.

Figure 11. Daily or near daily marijuana use among Colorado adults (18+ years) by age categories, 2014-2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Daily or near daily was using marijuana 20 or more days in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

- Daily or near daily marijuana use was statistically lower among adults 35 years and older than among those 18-25 or 26-34 years of age in both 2014 and 2015.[t]
- Comparing across years within each age group, there were no statistical differences in daily or near daily marijuana use between 2014 and 2015.[u]

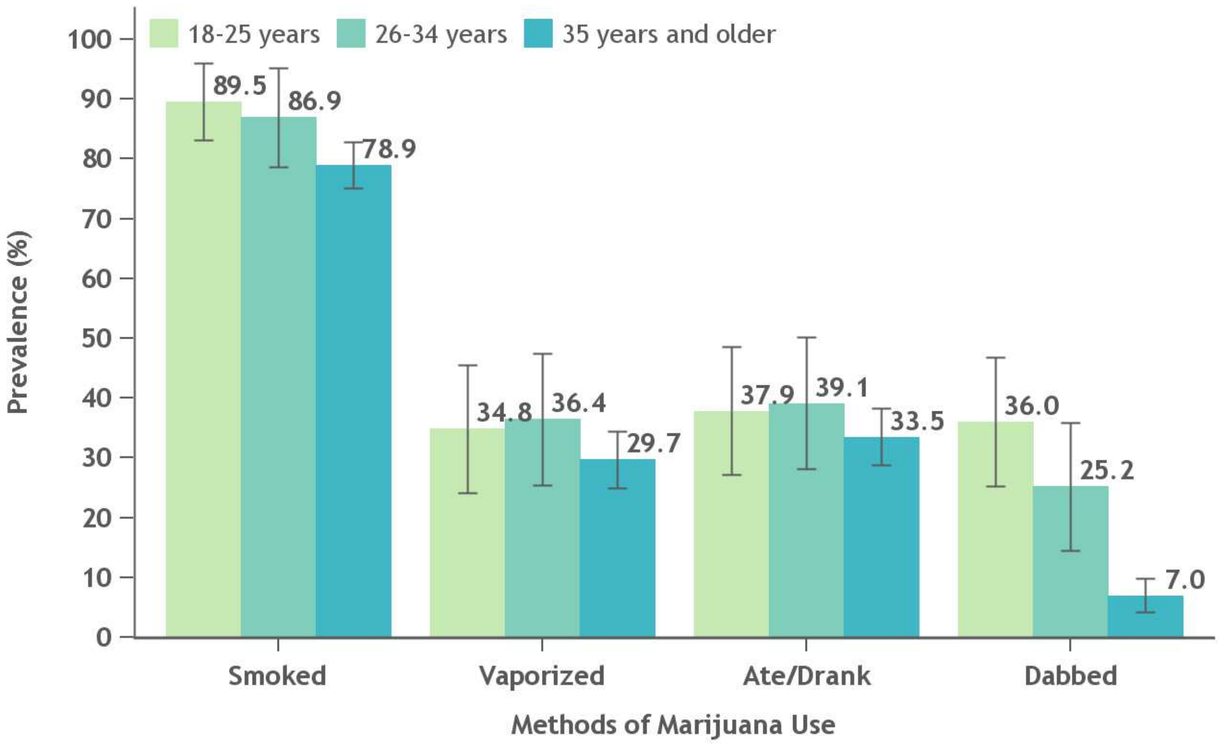
---

[t] In 2014: 35+ years 3.6% (95% CI 3.0-4.3%), 18-25 years 13.3% (95% CI 9.4-17.2%), 26-34 years 9.9% (95% CI 7.1-12.6%). In 2015: 35+ years 4.8% (95% CI 4.1-5.5%), 18-25 years 13.1% (95% CI 9.3-17.0%), 26-34 years 8.4% (95% CI 5.7-11.1%).

[u] Current use 2014 vs. 2015: 18-25 years X^2= 0.22, p=0.8991; 26-34 years X^2= 0.63, p=0.729; 35 years and older X^2= 5.86, p=0.0534.

For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.11.

Figure 12. Methods of marijuana use among Colorado adults (18+ years) who reported current use, by age categories, 2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use was marijuana use at least once in the past 30 days. Use of more than one method may have been reported in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

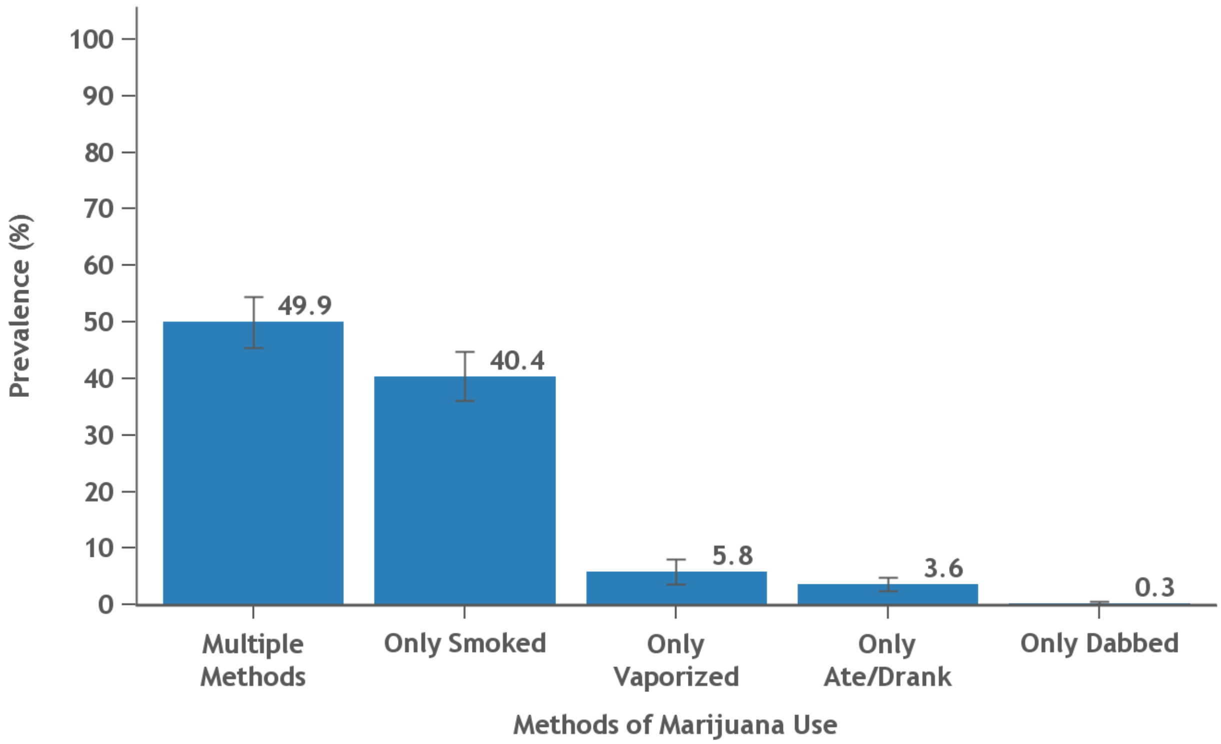
Major findings

- Reported dabbing marijuana in the past 30 days was statistically lower among Colorado adults aged 35 years and older than among those 18-25 or 26-34 years of age.[v]
- There were not statistical differences between age groups within those that smoked, vaporized, or ate/drank marijuana.[w]

[v] Dabbed: 18-25 years 36.0% (95% CI 25.3-46.7%), 26-34 years 25.2% (95% CI 14.5-35.9%), 35+ years 7.0% (95% CI 4.2-9.8%).

[w] Smoked: 18-25 years 89.5% (95% CI 83.1-95.9%), 26-34 years 86.9% (95% CI 78.6-95.2%), 35+ years 78.9% (95% CI 75.1-82.8%). Vaporized: 18-25 years 34.8% (95% CI 24.1-45.5%), 26-34 years 36.4% (95% CI 25.4-47.5%), 35+ years 29.7% (95% CI 25.0-34.5%). Ate/drank: 18-25 years 37.9% (95% CI 27.2-48.6%), 26-34 years 39.1% (95% CI 28.1-50.1%), 35+ years 33.5% (95% CI 28.7-38.2%). For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.12.

Figure 13. Methods of marijuana use among Colorado adults (18+ years) who reported current use, 2015.



Produced by: EEOHT, CDPHE 2016.
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use was marijuana use at least once in the past 30 days.
‡Data Source: Colorado Behavioral Risk Factor Surveillance System 2015.

Major findings

- Approximately half of adults who currently use marijuana use it through multiple methods.
- The prevalence of Colorado adults who used marijuana multiple methods in the past 30 days was statistically higher than those who only smoked, only vaporized, only ate/drank, and only dabbed in the past 30 days.[x]

[x] Multiple methods 49.9% (95% CI 45.4-54.5%), Only Smoked 40.4% (95% CI 36.0-44.8%), Only Vaporized 5.8% (95% CI 3.6-8.0%), Only Ate/Drank 3.6% (95% CI 2.3-4.9%), Only Dabbed 0.3% (95% CI 0.0-0.6%).

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix B. For data, see Appendix B, Table B.13.

References

1. Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System: Annual Survey Data. http://www.cdc.gov/brfss/annual_data/annual_data.htm. Accessed October 7, 2016.
2. Colorado Department of Public Health and Environment. Colorado Health and Environmental Data: Adult Health Data: Behavioral Risk Factor Surveillance System. http://www.chd.dphe.state.co.us/topics.aspx?q=Adult_Health_Data. Accessed October 7, 2016.
3. Substance Abuse and Mental Health Services Administration. National Survey on Drug Use and Health. https://nsduhweb.rti.org/respweb/homepage.cfm.

Section 1

Monitoring Changes in Marijuana Use Patterns

Chapter 2

Child Health Survey (CHS) 2014-2015 Survey Results

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Katelyn E. Hall, MPH
Statistical Analyst
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Ashley Juhl, MSPH
Maternal and Child Health Epidemiologist
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Anne Schiffmacher, MPH
Maternal and Child Health Epidemiologist
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Allison Grace Bui, MPH
Epidemiologist
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Rickey Tolliver, MPH
Chief
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health, and Toxicology Branch, Colorado Department of Public Health and Environment

Reviewer

Ashley Brooks-Russell, PhD, MPH
Assistant Professor
Injury Prevention, Education and Research Program, Colorado School of Public Health

The CHS survey and marijuana-related behaviors in Colorado

Since 2004, the Colorado Department of Public Health and Environment has conducted the Child Health Survey (CHS). This annual survey provides data on a wide range of health issues and risk factors affecting children and youth in Colorado for children ages 1-14. The CHS is conducted as a telephone survey among respondents to the Behavioral Risk Factor Surveillance System (BRFSS) Survey who have children ages 1-14 years old. Data from the CHS help to identify areas where education, resources to assist parents, policy changes or other data-informed actions can improve the health of Colorado's children.[1]

Since 2014, questions about marijuana use and storage in the home have been included in the survey (Table 1). The presence of marijuana in or around the home was evaluated using question 1, and was asked of all survey participants. Participants who answered 'YES' to this question were asked how their marijuana is stored, in question 2. Marijuana being used in the home was evaluated using question 3, and was asked of all survey participants. Participants who answered 'YES' to this question were asked how the marijuana was used inside the home in question 4. Results enable CDPHE to estimate the number of children in Colorado who may be exposed to secondhand marijuana smoke or unintentional ingestion due to unsafe storage of marijuana products in the home.

For additional survey details and information about analysis methods, see Appendix C.

Survey questions

Table 1. Child Health Survey questions about marijuana storage or use in or around the home, 2014-2015.

1. Is there any marijuana or marijuana product in or around your home right now?
    - Yes
    - No

2. Where is the marijuana that is currently in or around your home being stored? For each of the following methods please say yes if it does apply or no if it does not apply.
    - In a childproof container or packaging
    - In a locked container such as a cabinet, drawer or safe
    - In a location your child cannot access (such as out of reach)
    - Someplace else? (specify)

3. During the past 30 days, has anyone- including yourself, used marijuana or hashish inside your home?
    - Yes
    - No

4. How was the marijuana that was used inside your home consumed? For each of the following methods please say yes if it does apply or no if it does not apply.
    - It was vaporized (e-cigarette-like vaporizer)
    - It was smoked (in a joint, bong, pipe, blunt)
    - It was eaten in food (in brownies, cakes, cookies, candy)
    - It was consumed in a beverage (tea, cola, alcohol)
    - It was used in some other way (specify)
    - It was dabbed *(response option was added in 2015)*

Definitions

Dabbing – a method of marijuana use where a "dab" (small amount) of marijuana concentrate is placed on a pre-heated surface, creating concentrated marijuana vapor to be inhaled.

Possible exposure to second-hand marijuana smoke or vapor within the home - defined by combining three responses from question 4: *it was vaporized; it was smoked;* and *it was dabbed*. Dabbing was added as a response in 2015; therefore, this category could be underrepresented in 2014 because respondents who dabbed within the home may have indicated *it was used in some other way*.

Safe storage of marijuana - defined by combining three responses from question 2: *in a childproof container or packaging*; *in a locked container such as a cabinet, drawer, or safe;* and *in a location your child cannot access*. The response *someplace else* was considered potentially unsafe storage and a risk for unintentional ingestion.

Vaping (vaporization of marijuana) - a method of marijuana use where marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

How to interpret survey results

Respondents to the Child Health Survey are a sample of Colorado adults with children 1-14 years old. The percent of survey respondents selecting a specific answer might not be exactly the same as if all adults with children 1-14 years old in Colorado were surveyed. Therefore, the survey results are estimates, and each has a range of possible values (also called margin of error, confidence interval, or 95% CI). These ranges are very important when comparing two estimates, and the following terms are used throughout this report:

'Not statistically different'- Typically, if the ranges of possible values *overlap* for two different survey results (like two different years, or male vs. female), we cannot be confident that there is a true difference between the two (also called 'not statistically significant.') In some cases, an additional statistical test is done to confirm.

'Statistically higher' or 'statistically lower'- If the ranges of possible values *do not overlap* for two different results, we CAN be confident that there is a true difference between the two (also called 'statistically significant.')

On the figures in this report, these ranges of possible values are indicated by black bars. In footnotes, they are referred to by the statistical term '95% CI.'

Results

Results are displayed in Figures 1-3 below.

Marijuana in or around the home and safe storage

In 2015, 7.9% of adults with children 1-14 years old in the home reported having marijuana or marijuana products in or around the home (Figures 1 & 2). In 82.2% of these homes, marijuana was stored safely, while in 17.8% the marijuana was potentially stored unsafely (Figure 2). It was estimated that approximately 14,000 homes in Colorado with children 1-14 years old had marijuana in the home with potentially unsafe storage.

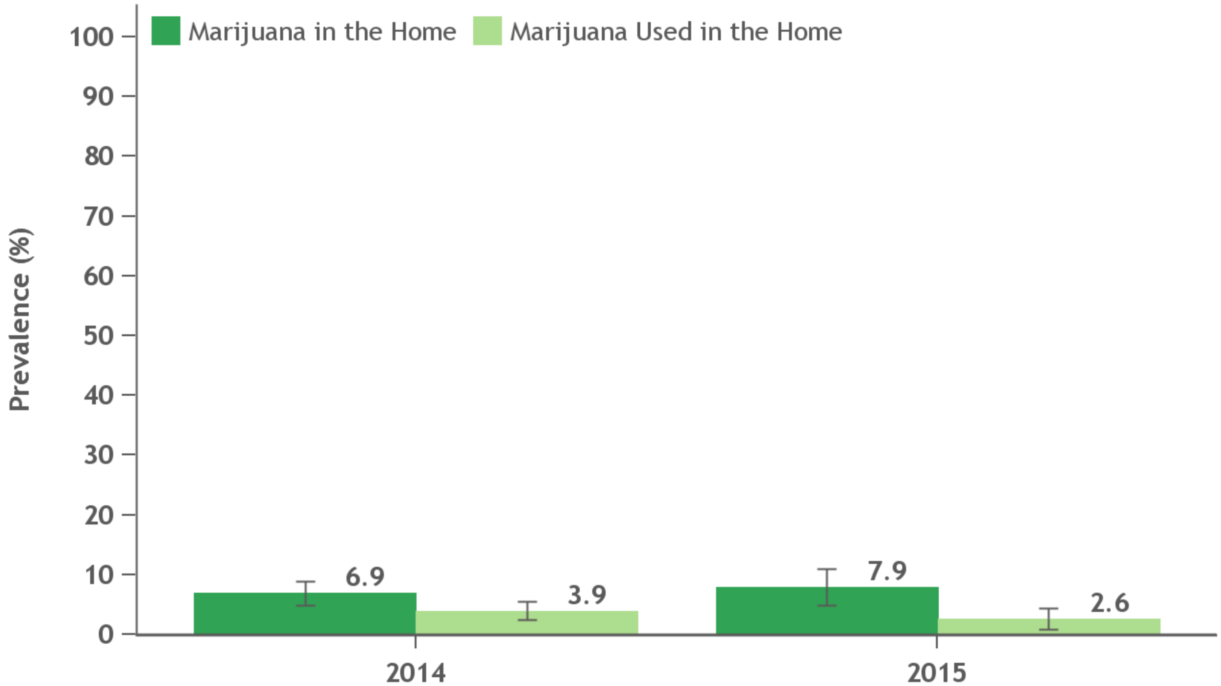
Comparing across years, there were no statistical differences from 2014 to 2015 in the prevalence of marijuana or marijuana products in or around the home (6.9%, 7.9%; Figure 1) or safe storage in homes with marijuana (86.0%, 82.2%; Figure 2). There were no differences in marijuana being in or around the home by child's age, highest household education, or household income, or difference from 2014 to 2015 (data not shown).

Marijuana used inside the home and secondhand smoke exposure

For 2014 and 2015 together, 3.2% of adults with children 1-14 years old in the home reported marijuana being used inside the home (Figure 3). Of these, 83.2% reported the marijuana was smoked, vaporized, or dabbed (Figure 3). It was estimated that approximately 16,000 homes in Colorado had children 1-14 years old with possible exposure to secondhand marijuana smoke or vapor in the home.

Comparing across years, there were no statistical differences from 2014 to 2015 in the prevalence of marijuana being used inside the home (3.9%, 2.6%; Figure 1).

Figure 1. Presence of marijuana in or around the home or used in the home where children live, 2014-2015.



Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Data Source: Colorado Child Health Survey 2014-2015 a call-back survey from BRFSS for adults with children 14 years old or younger in the home.

Major findings

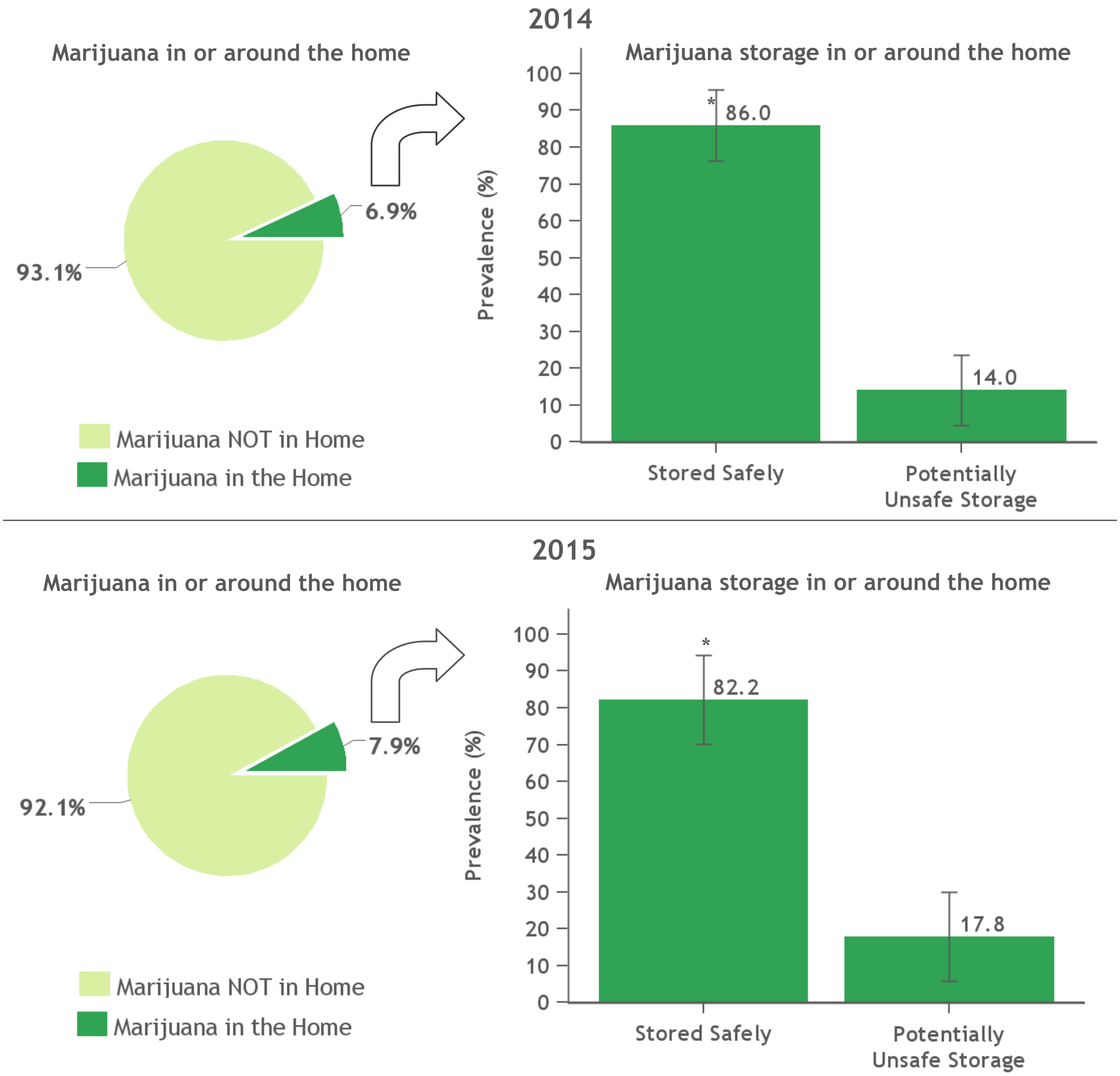
- The prevalence of marijuana or marijuana products in or around homes where children live was not statistically different between 2014 and 2015.[a]
- The prevalence of marijuana being used inside homes where children live was not statistically different between 2014 and 2015.[b]

[a] Marijuana or marijuana products in or around the home: 2014 6.9% (95% CI 4.9-8.9%), 2015 7.9% (95% CI 4.9-10.9%)

[b] Marijuana used inside the home: 2014 3.9% (95% CI 2.4-5.4%), 2015 2.6% (95% CI 0.8-4.4%)

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix C. For data, see Appendix C, Table C.1.

Figure 2. Percent of adults with children and marijuana in or around the home who store their marijuana in a safe place, 2014-2015.



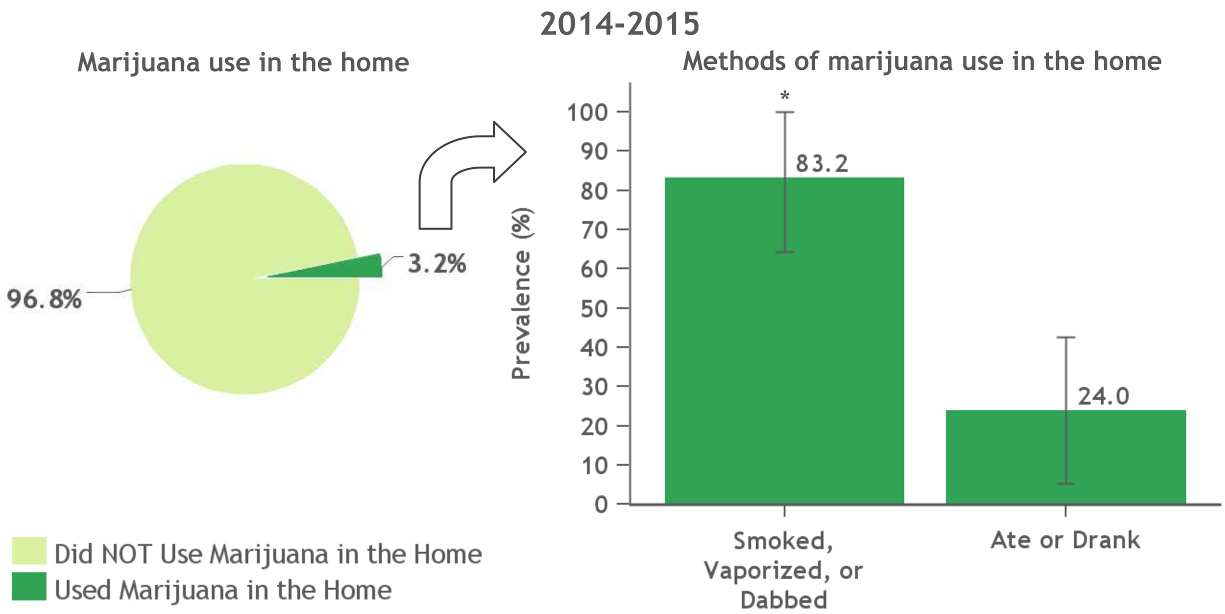
Produced by: EEOHT, CDPHE 2016
*Statistically different due to non overlapping 95% confidence intervals (95% CI).
†Black bars indicate margins of error (95% Confidence Intervals)
‡Data Source: Colorado Child Health Survey 2014-2015 a call-back survey from BRFSS for adults with children 14 years or younger in the home.
§Safe storage included a childproof container, a locked container, or a location a child cannot access.

Major findings:

- The prevalence of marijuana being stored safely in homes where children live was not statistically different between 2014 and 2015.[c]

Marijuana safe storage: 2014 86.0% (95% CI 76.4-95.6%), 2015 82.2% (95% CI 70.1-94.2%)

Figure 3. Methods of marijuana use among adults with children in the home, 2014-2015 (years combined).



Produced by: EEOHT, CDPHE 2016
*Statistically different due to non overlapping 95% confidence intervals (95% CI).
†Black bars indicate margins of error (95% CI)
‡Dabbing was added as a response in 2015.
§ Data Source: Colorado Child Health Survey 2014-2015 a call-back survey from BRFSS for adults with children 14 years or younger in the home.

Major findings

- Among adults who use marijuana in a home where children live, the prevalence of ‘smoked, vaporized or dabbed’ was statistically higher than ‘ate or drank’.[d]

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix C. For data, see Appendix C, Table C.2.
[d] For 2014-2015 combined years: smoked, vaporized or dabbed 83.2% (95% CI 64.3-100.0%), ate or drank 24.0% (95% CI 5.2-42.7%)
For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix C. For data, see Appendix C, Table C.3.

References

1. Colorado Department of Public Health and Environment. Maternal and Child Health Data, Colorado Child Health Survey Data. 2016; http://www.chd.dphe.state.co.us/topics.aspx?q=Maternal_Child_Health_Data. Accessed January 1, 2017.

Section 1

Monitoring Changes in Marijuana Use Patterns

Chapter 3

Healthy Kids Colorado Survey (HKCS) 2005-2015 Survey Results

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Katelyn E. Hall, MPH
Statistical Analyst
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Amy Anderson Mellies, MPH
Health Data Analyst
Health Surveys and Evaluation, Colorado Department of Public Health and Environment

Leonardo Kattari, MSW
Healthy Kids Colorado Survey Coordinator
Prevention Services, Colorado Department of Public Health and Environment

Kevin Berg, MA
GIS Epidemiologist
Environmental Epidemiology, Colorado Department of Public Health and Environment

Rickey Tolliver, MPH
Chief
Health Surveys and Evaluation, Colorado Department of Public Health and Environment

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health, and Toxicology, Colorado Department of Public Health and Environment

Reviewer

Ashley Brooks-Russell, PhD, MPH
Assistant Professor
Injury Prevention, Education and Research Program, Colorado School of Public Health

The HKCS survey and marijuana use in Colorado

The Healthy Kids Colorado Survey (HKCS) collects health information in the fall of odd years from public high school and middle school students. It is a voluntary, anonymous survey, and parents are notified ahead of time. HKCS is a collaboration of the Colorado Department of Public Health and Environment (CDPHE), the Colorado Department of Education, and the Colorado Department of Human Services, who recognized the need to gather critical data while minimizing the student survey requests to Colorado schools. Both state and regional data are available to provide schools and communities with information to support effective strategies to protect the health and promote academic achievement of Colorado youth. This survey also fulfills Colorado's reporting requirement for the CDC-sponsored Youth Risk Behavioral Surveillance Survey (YRBS)[1] and ensures Colorado data can be compared to both national data and data from other states. HKCS provides data on a wide range of health issues and risk factors affecting children and youth including: nutrition, physical activity, safety behaviors, mental health, alcohol, tobacco and other substance use, and sexual behaviors (high school only). The survey has included questions on marijuana since 1999.[2] This report includes results from 2005-2015 for high school and 2011-2015 for middle school.

For additional survey details and information about analysis methods, see Appendix D.

Survey questions

Table 1. Healthy Kids Colorado Survey questions asked of middle school and high school students about whether they use marijuana, when they use it and how they use it, 2005-2015.

Not all questions were included in all years and not all questions were asked of both middle school and high school students.

1. During your life, how many times have you used marijuana?

- 0 times
- 1 or 2 times
- 3 to 9 times
- 10 to 19 times
- 20 to 39 times
- 40 to 99 times
- 100 or more times

2. How old were you when you tried marijuana for the first time?

- I have never tried marijuana
- 8 years old or younger
- 9 or 10 years old
- 11 or 12 years old
- 13 or 14 years old
- 15 or 16 years old
- 17 years old or older

3. During the past 30 days, how many times did you use marijuana?

- 0 times
- 1 or 2 times
- 3 to 9 times
- 10 to 19 times
- 20 to 39 times
- 40 or more times

4. During the past 30 days, how did you use marijuana? (Select all that apply.)

- I did not use marijuana during the past 30 days
- I smoked it
- I ate it (in an edible, candy, tincture or other food)
- I used a vaporizer
- I dabbed it*
- I used it in some other way

5. During the past 30 days, how did you usually use marijuana? (Select only one response.)

- I did not use marijuana during the past 30 days
- I smoked it I ate it (in an edible, candy, tincture or other food)
- I used a vaporizer
- I dabbed it*
- I used it in some other way

*The response option of "I dabbed it" was added in 2015

The National Survey on Drug Use and Health

The Substance Abuse and Mental Health Services Administration (SAMHSA) tracks national and state level data on tobacco, alcohol, marijuana, and illicit drugs including non-medical use of prescription drugs through the National Survey on Drug Use and Health (NSDUH).[3] Colorado past 30 day marijuana use estimates from the NSDUH survey were compared with the Colorado HKCS past 30 day marijuana use estimates (Figure 2).

Definitions

Current use – Having used marijuana at least once in the past 30 days (any answer other than '0 times' on question 3) (Table 1)

Dabbing – a method of marijuana use where a "dab" (small amount) of marijuana concentrate is placed on a pre-heated surface, creating concentrated marijuana vapor to be inhaled.

Ever use – having used marijuana at least once in their lifetime (any answer other than '0 times' on question 1) (Table 1)

Tried marijuana before age 13 – answered '11 or 12 years old', '9 or 10 years old', or '8 years old or younger' on question 2 (Table 1)

Vaping (vaporization of marijuana) - a method of marijuana use in which marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

How to interpret survey results

Respondents to the Healthy Kids Colorado Survey are a sample of Colorado high school and middle school students. The percent of survey respondents selecting a specific answer might not be exactly the same as if every student in Colorado were surveyed. Therefore, the survey results are estimates, and each has a range of possible values (also called margin of error, confidence interval, or 95% CI). These ranges are very important when comparing two estimates, and the following terms are used throughout this report:

'Not statistically different'- Typically, if the ranges of possible values *overlap* for two different survey results (like two different years, or male vs. female), we cannot be confident that there is a true difference between the two (also called 'not statistically significant.') In some cases, an additional statistical test is done to confirm.

'Statistically higher' or 'statistically lower'- If the ranges of possible values *do not overlap* for two different results, we CAN be confident that there is a true difference between the two (also called 'statistically significant.')

On the figures in this report, these ranges of possible values are indicated by black bars. In footnotes, they are referred to by the statistical term '95% CI.'

Results

Results are displayed in Figures 1-13 and Maps 1-2 below.

Trends in marijuana use in Colorado

Survey results from 2015 indicate that approximately 38% of Colorado high school students report having ever used marijuana and 21% report use in the past 30 days (Figures 1 & 3). These estimates are similar to national estimates of ever and current marijuana use among high school students (Figure 1). From 2005-2015, estimates of current marijuana use among Colorado high school students have fluctuated between approximately 20% and 25% (Figures 1 & 3). From 2005 to 2013, the HKCS estimates of current marijuana use among high school students in Colorado were higher than the NSDUH estimates for current marijuana use among high school aged adolescents. However, the difference became smaller in 2013, at 19.7% on HKCS and 17.4% on NSDUH (Figure 2). Among Colorado middle school students in 2015, an estimated 7.6% had ever used marijuana and an estimated 4.4% reported currently using marijuana (Figure 3). Current marijuana use among high school students in Colorado has remained below current alcohol use from 2005 to 2015 and above current tobacco smoking from 2011 to 2015. Current alcohol use and tobacco smoking among high school students in Colorado has trended downward since 2005, while current marijuana use has remained stable (Figure 4). In both 2013 and 2015, current marijuana use among Colorado 9th graders (13.7%, 12.4%) was statistically lower than among 10th graders (19.0%, 18.8%), which was statistically lower than among 11th graders (22.1%, 26.3%) (Figure 5).

Marijuana use among Colorado high school students by gender, race & ethnicity, and sexual orientation

Current marijuana use among male high school students in 2013 (21.5%) was statistically higher than among female students (17.7%), but current use for both genders was nearly identical in 2015 (21.4%, 21.0%) (Figure 6). Current marijuana use among middle school students was not statistically different between males and females in 2013 (5.3%, 4.8%) or 2015 (3.8%, 5.2%) (Figure 7). Prevalence of current marijuana use and age of first use varied among students of different races and ethnicities (Figures 8 & 11). The percent of white non-Hispanic students who tried marijuana before age 13 was statistically lower than among black, Hispanic, or multiple or other race students (Figure 11). Prevalence of marijuana use also varied among students with different sexual orientation. In both 2013 and 2015, estimated current use of marijuana among students identifying as gay, lesbian, or bisexual (39.7%, 34.9%) was statistically higher than the estimated current use among students identifying as heterosexual (17.7%, 19.5%) (Figure 9). In 2015, a large portion of high seniors reported first trying marijuana at ages 13-14 years old (27.0%) and 15-16 years old (43.1%) compared to younger ages and 17 and older (Figure 10).

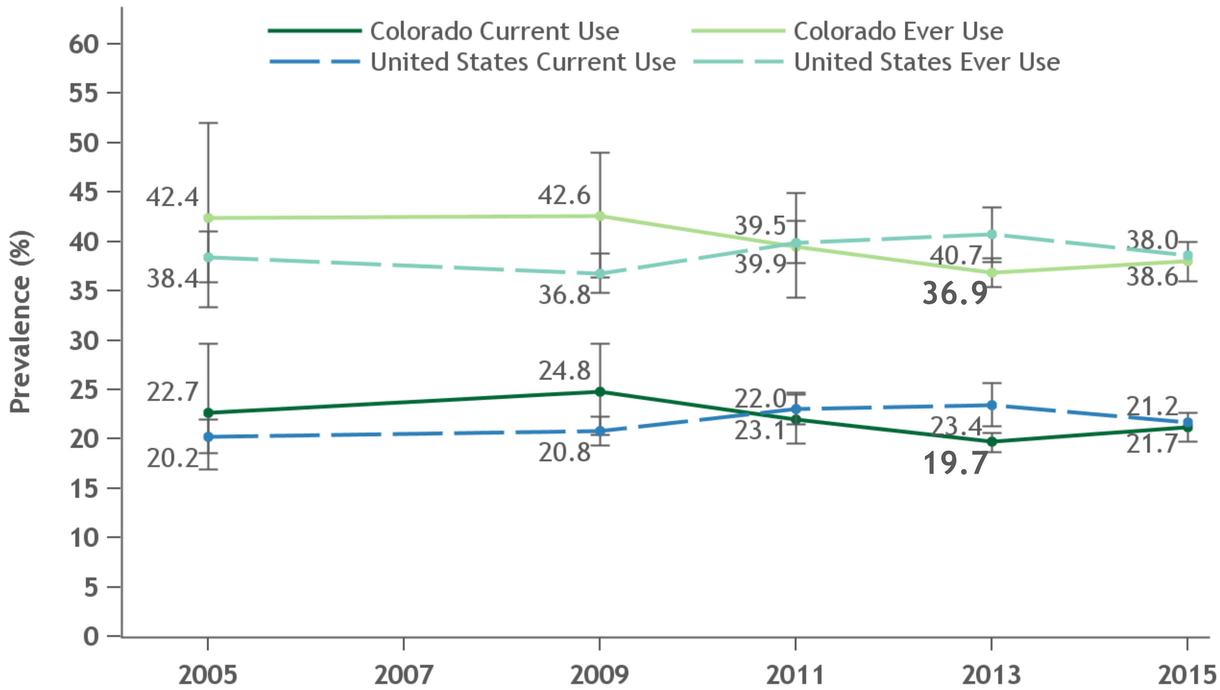
Methods and frequency of marijuana use in Colorado

In 2015, 87% of high school students who currently used marijuana reported that smoking was their usual method of use – much higher than edibles (2%), vaping (5%), or other methods of use (6%) (Figure 12). More than one-third of high school or middle school students who reported current marijuana use in 2015 had used once or twice in the past 30 days, while approximately 27% of high school students and 20% of middle school students had used 20 or more times in the past 30 days (Figure 13). The estimates of marijuana use at each frequency level fluctuated from 2005 to 2015, with no notable trends (Figure 14).

Marijuana use in Colorado by region

Marijuana use also varies greatly by Health Statistics Region (HSR). Some of Colorado's larger counties represent a single HSR, but for smaller or less populated areas, several counties may be represented by a single HSR (Maps 1 & 2). In both 2013 and 2015, health statistics regions 7 (Pueblo County 32.0%, 30.1%) and 9 (Dolores, San Juan, Montezuma, La Plata, and Archuleta Counties 24.6%, 26.2%) were statistically higher than the state prevalence (19.7%, 21.2%) for current marijuana use among high school students. For all but one HSR, current marijuana use among high school students in 2015 was not statistically different from 2013. Health statistics region 10 (Montrose, Delta, Gunnison, Ouray, Hinsdale, and San Miguel Counties) did have statistically lower current marijuana use among high school students in 2015 (17.5%) than in 2013 (26.7%) (Map 2).

Figure 1. Prevalence of ever and current marijuana use for high school students in Colorado (HKCS) compared to the national prevalence (YRBS), 2005-2015.



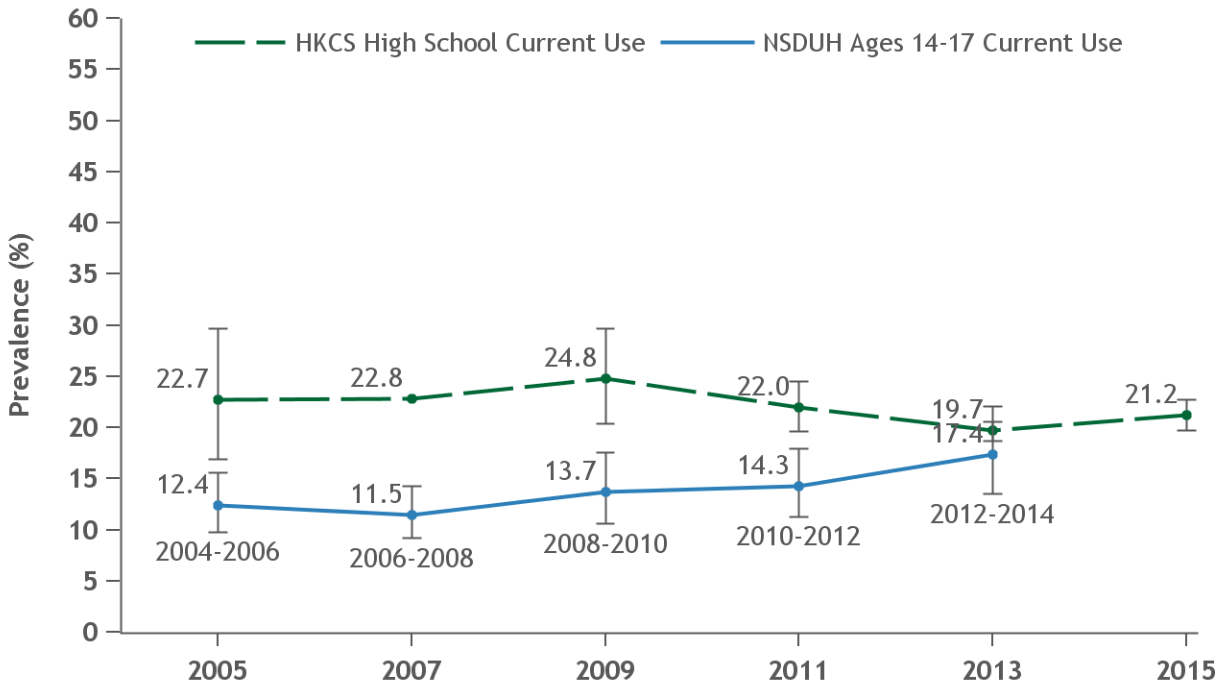
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Ever Use is defined as marijuana use at least one time during a student's lifetime and Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Colorado estimates are from the Healthy Kids Colorado Survey (HKCS) and United States estimates are from the Youth Risk Behavioral Surveillance System survey. Note: Data for the year 2007 was not included due to low sample size.

Major findings

- HKCS estimates for both ever and current marijuana use in Colorado have had no statistical difference from the YRBS national estimates from 2005 through 2015, except for current use in 2013.
- In 2013, the HKCS estimate of current marijuana use among high school students in Colorado was statistically lower than the YRBS national estimate.[a]
- Comparing 2015 HKCS estimates with 2013, there was no statistical difference in current use or ever use among Colorado high school students.[b]
- The 2015 HKCS estimates for both ever and current marijuana use among high school students in Colorado were nearly identical to the 2015 YRBS national estimates.

[a] In 2013: HKCS estimate for Colorado 19.7%, (95% CI 18.7-20.6%), YRBS national estimate 23.4% (95% CI 21.3-25.7%).
[b] Current marijuana use in Colorado (HKCS): 2013 19.7% (95% CI 18.7-20.6%), 2015 21.2% (95% CI 19.7-22.7%). Ever marijuana use in Colorado (HKCS): 2013 36.8% (95% CI 35.4-38.3%), 2015 38.0% (95% CI 36.0-40.0%)
For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix D. For data, see Appendix D, Table D.1.

Figure 2. Prevalence of current marijuana use for high school aged adolescents in Colorado, 2005-2015.



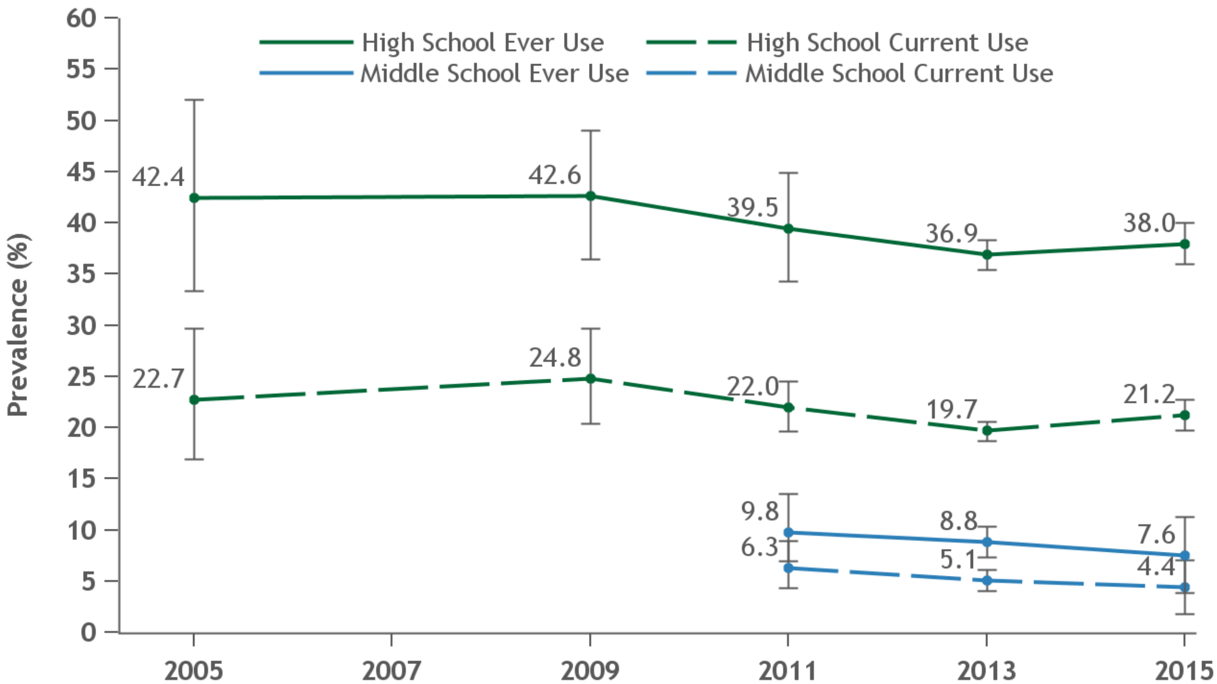
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2005-2015 and National Survey on Drug Use and Health (NSDUH) for 2004-2014 ages 14-17. Both are for Colorado only.

Major findings

- From 2005 to 2013, the HKCS estimates of current marijuana use among high school students in Colorado were higher than the NSDUH estimates for current marijuana use among high school aged adolescents in Colorado. However, the difference became smaller in 2013.[c]

[c] NSDUH data was a 3-year aggregate 2012-2014. For data, see Appendix D, Table D.2.
For statistical methods, see Appendix D.

Figure 3. Prevalence of ever and current marijuana use for high school and middle school students in Colorado, 2005-2015.



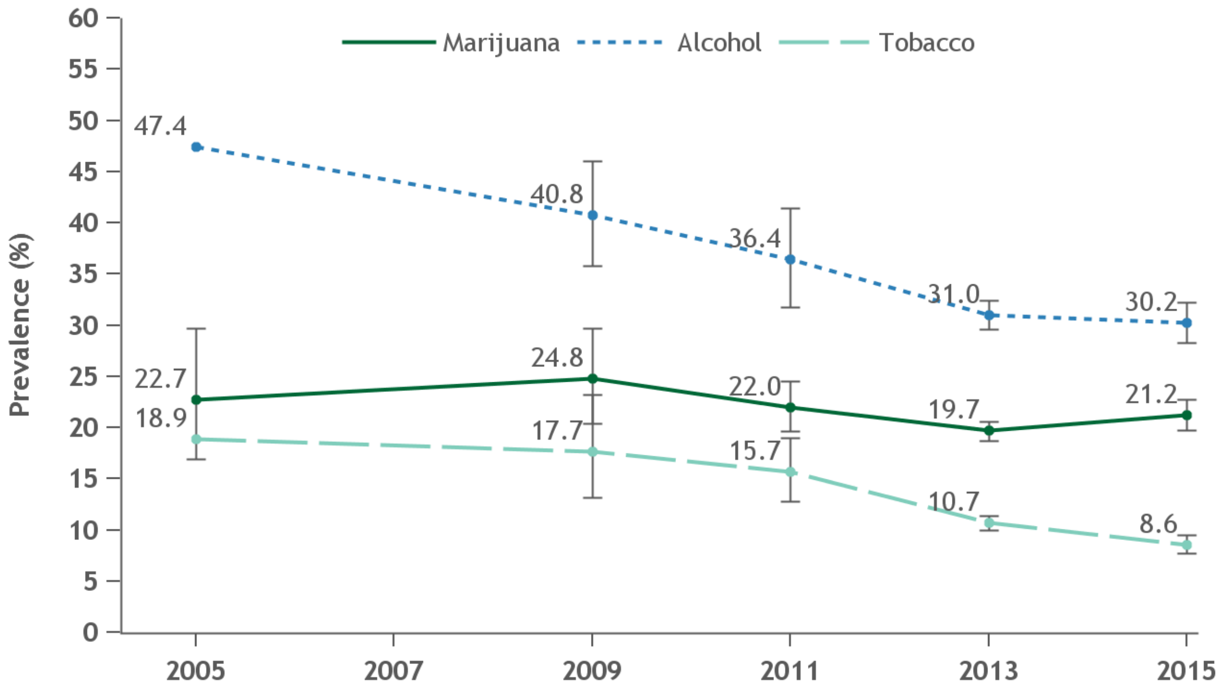
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Ever Use is defined as marijuana use at least one time during a student's lifetime and Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2005-2015. Data for the year 2007 was not included due to low sample size. Data for middle school marijuana use was not collected before 2011.

Major findings

- Among Colorado high school students, over the years 2005 to 2015, estimates of current marijuana use have fluctuated between 19.7% and 24.8%. None of these estimates were statistically different from each other.[d]
- Among Colorado high school students, over the years 2005 to 2015, estimates of having ever used marijuana have fluctuated between 36.9% and 42.6%. None of these estimates were statistically different from each other.[d]
- Among Colorado middle school students in 2015, an estimated 4.4% were currently using marijuana and an estimated 7.6% had ever used marijuana. Between 2011 and 2015, none of the estimates were statistically different.[d]

[d] For data, see Appendix D, Table D.3.
For statistical methods, see Appendix D.

Figure 4. Prevalence of current marijuana use for high school students in Colorado compared to current alcohol use and tobacco smoking in Colorado, 2009-2015.



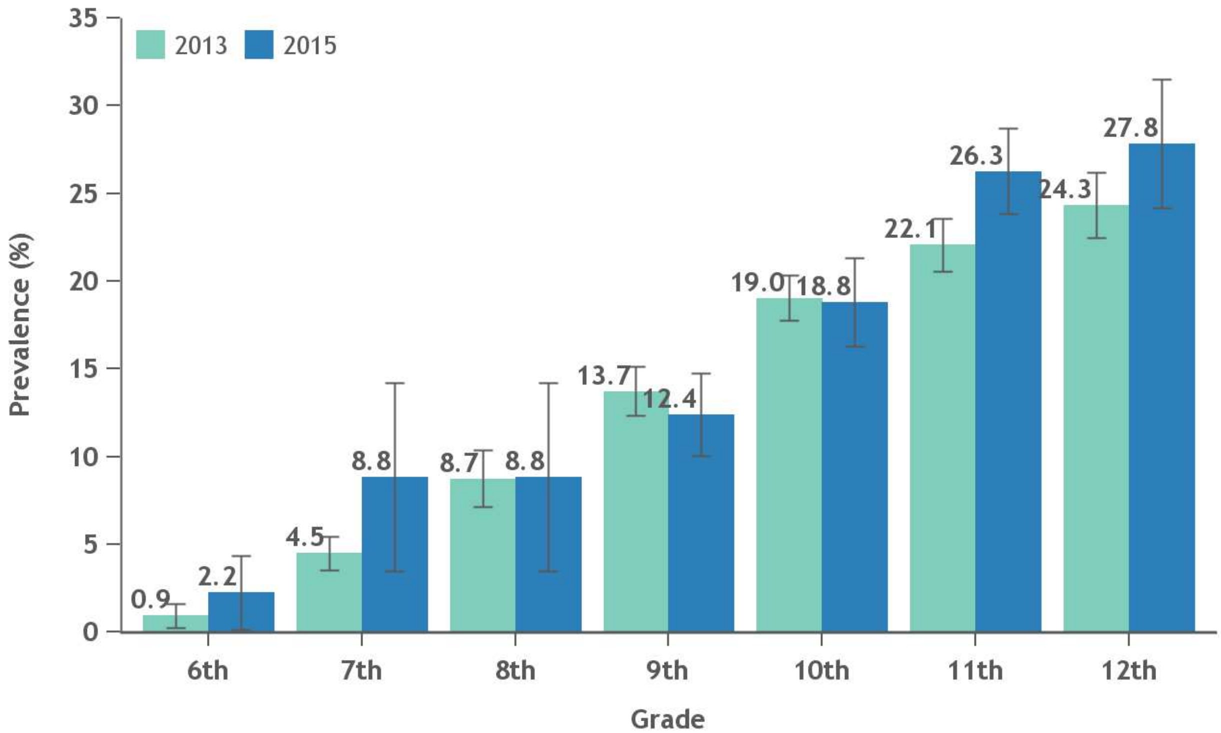
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2005-2015. Note: Data for the year 2007 was not included due to low sample size.

Major findings

- The prevalence of current marijuana use among high school students in Colorado has remained statistically higher than current tobacco smoking from 2011 through 2015 and has remained statistically lower than current alcohol use from 2009 through 2015.
- Current alcohol use was statistically lower in 2015 compared to 2009.[e]
- Current tobacco smoking was statistically lower in 2015 compared to 2013 and in 2013 compared to 2011.[f]
- Current marijuana use has remained stable from 2009 through 2015 with the prevalence of current marijuana use among high school students ranging from 19.7%-24.8%.

[e] Current alcohol use: 2015 30.2% (95% CI 28.3-32.2%), 2009 40.8% (95% CI 35.8-46.0%)
[f] Current tobacco use: 2015 8.6% (95% CI 7.7-9.5%), 2013 10.7% (95% CI 10.0-11.4%), 2011 15.7% (95% CI 12.8-19.0%)
For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix D. For data, see Appendix D, Table D.4.

Figure 5. Prevalence of current marijuana use for high school and middle school students in Colorado by grade, 2013-2015.



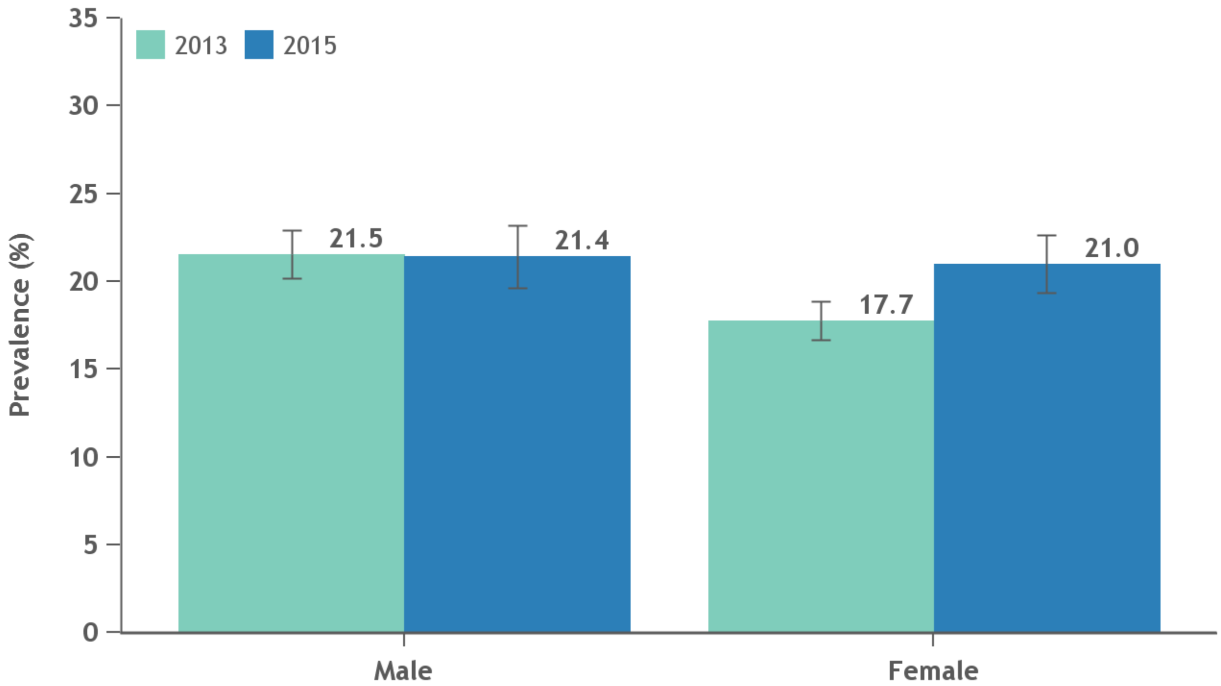
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2013-2015.

Major findings

- In both 2013 and 2015, estimates of current marijuana use among Colorado students in each grade level trended upward from 6th through 12th grade, with current use higher in older grades than younger grades.
- In both 2013 and 2015, estimated current use among Colorado 9th graders was statistically lower than among 10th graders, and current use among 10th graders was statistically lower than among 11th graders. [g]
- Estimated current use among Colorado 11th graders was statistically higher in 2015 than it was in 2013. There was not a statistical difference in current use among all other grades between 2013 and 2015. [h]

[g] In 2013: 9th graders 13.7% (95% CI 12.3-15.1%), 10th graders 19.0% (95% CI 17.7-20.3%), 11th graders 22.1% (95% CI 20.6-23.5%); In 2015: 9th graders 12.4% (95% CI 10.0-14.7%), 10th graders 18.8% (95% CI 16.3-21.3%), 11th graders 26.3% (95% CI 23.8-28.7%)
[h] Current use among Colorado 11th graders: 2015 26.3% (95% CI 23.8-28.7%), 2013 (22.1%, 95% CI: 20.6%-23.5%).
For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix D. For data, see Appendix D, Table D.5.

Figure 6. Prevalence of current marijuana use for high school students in Colorado by gender, 2013-2015.



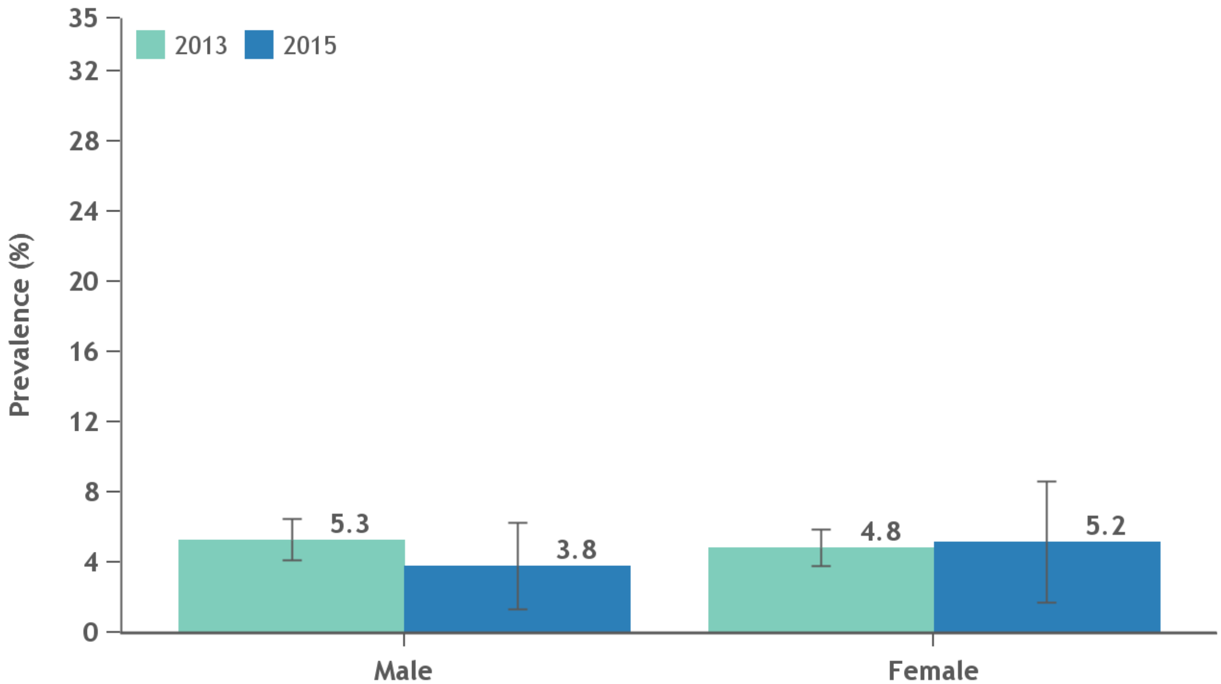
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2013-2015.

Major findings

- The estimate of female high school students in Colorado who reported current marijuana use in 2015 was statistically higher than in 2013.[i]
- Estimates for current marijuana use among male high school students in Colorado were nearly identical in 2013 and 2015.

[i]Colorado female high school students current marijuana use: 2013 17.7% (95% CI 16.6-18.8%), 2015 21.0% (95% CI 19.3-22.6%) For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix D. For data, see Appendix D, Table D.6.

Figure 7. Prevalence of current marijuana use for middle school students in Colorado by gender, 2013-2015.



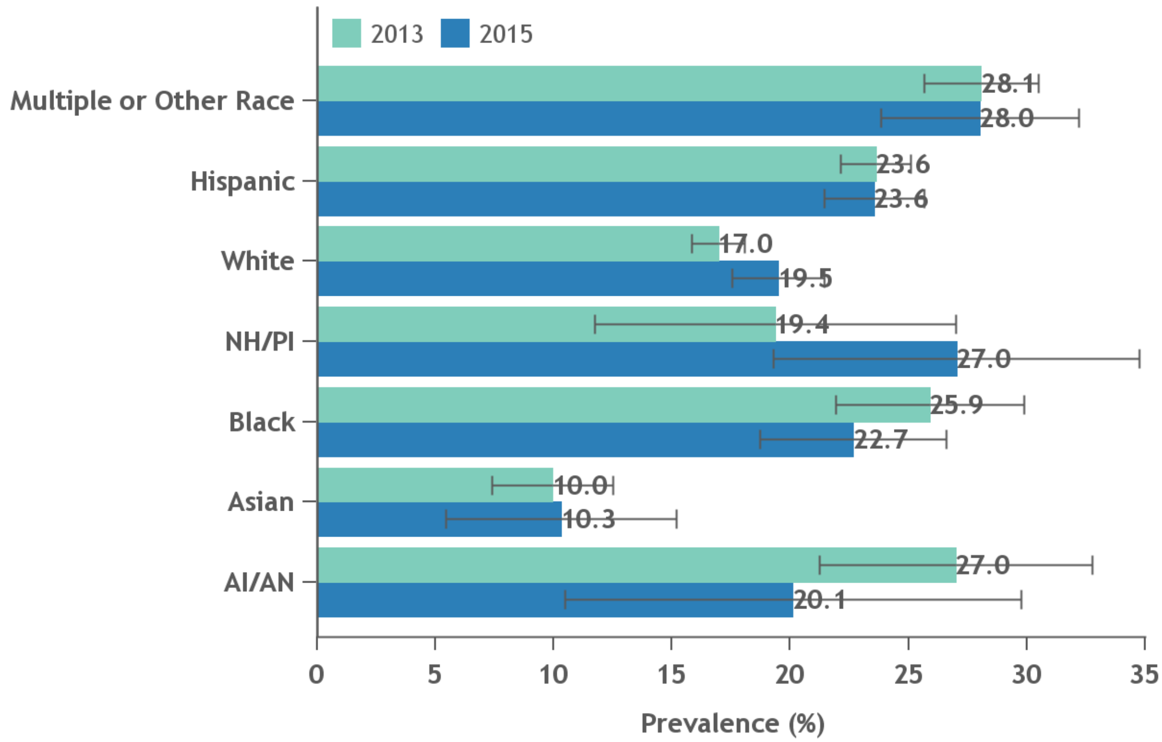
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2013-2015.

Major findings

- Current marijuana use was not statistically different between 2013 and 2015 for either male or female middle school students in Colorado. [j]

[j] Males: 2013 5.3% (95% CI 4.1-6.5%), 2015 3.8% (95% CI 1.3-6.2%); Females: 2013 4.8% (95% CI 3.8-5.9%), 2015 5.2% (95% CI 1.7-8.6%)
For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix D. For data, see Appendix D, Table D.7.

Figure 8. Prevalence of current marijuana use for high school students in Colorado by race/ethnicity, 2013-2015.



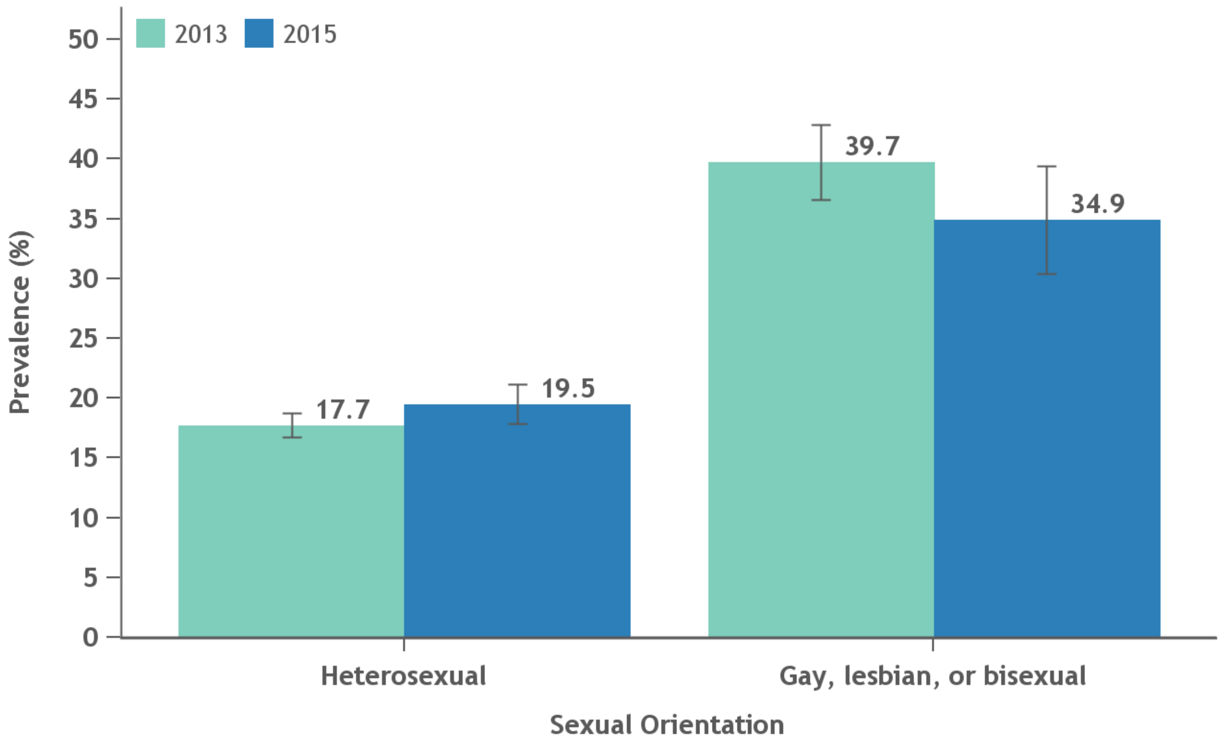
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Hispanic includes respondents who selected “Hispanic” for ethnicity and “white” for race. Those who selected “Hispanic” for ethnicity and a non-white race are included under “multiple or other race”.
AI: American Indian, AN: Alaska Native, NH: Native Hawaiian, PI: Pacific Islander.
§Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2013-2015.

Major findings

- In both 2013 and 2015, current marijuana use was statistically lower among Asian high school students than among white, Hispanic, black, and multiple or other race students.[k]
- In both 2013 and 2015, current marijuana use was statistically higher among multiple or other race high school students than among white students.[k]
- In 2013, current marijuana use was also statistically higher among Hispanic, black and American Indian/Alaskan Native high school students than among white students.[k]

[k] For data, see Appendix D, Table D.8.
For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix D.

Figure 9. Prevalence of current marijuana use among high school students in Colorado by sexual orientation, 2013-2015.



Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2013-2015.

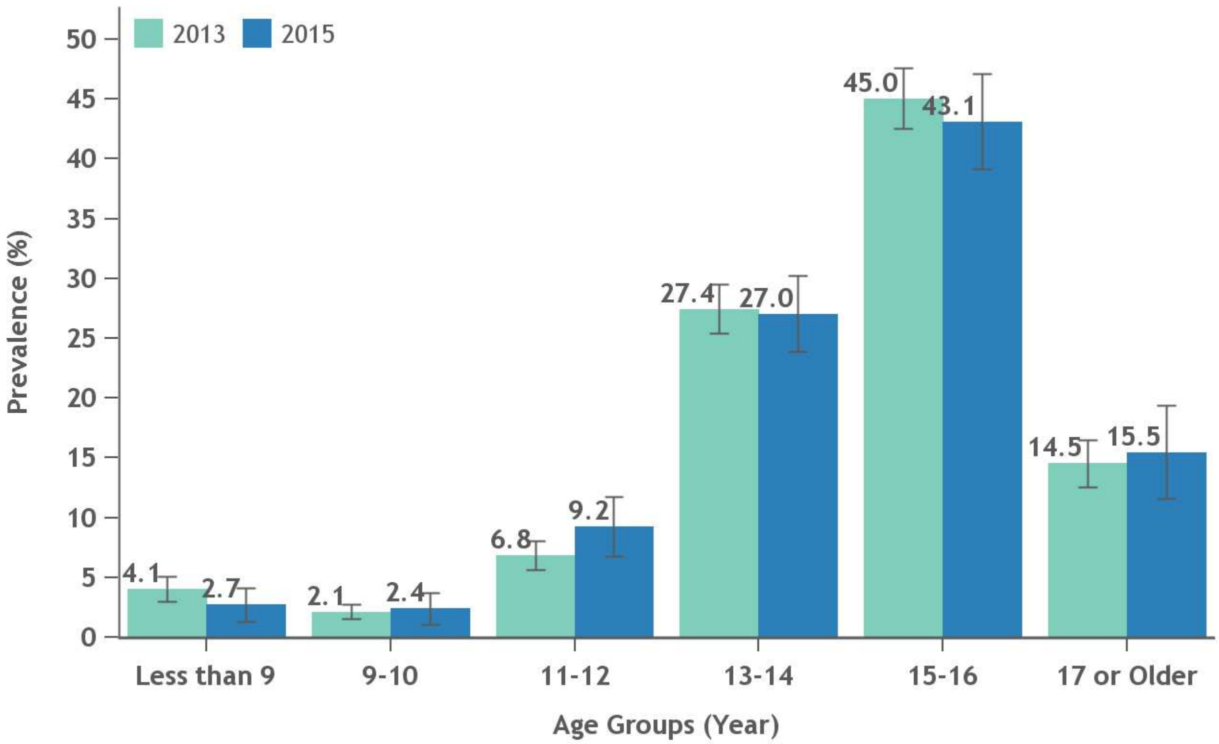
Major findings

- In 2013 and 2015, current use of marijuana among students identifying as gay, lesbian or bisexual, was statistically higher than estimated current use among students identifying as heterosexual. [l]

[l] In 2013: gay, lesbian, or bisexual students 39.7% (95% CI 36.5-42.9%), heterosexual students 17.7% (95% CI 16.7-18.7%). In 2015: gay, lesbian, or bisexual students 34.9% (95% CI 30.4-39.4%), heterosexual students 19.5% (95% CI 17.8-21.1%).

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix D. For data, see Appendix D, Table D.9.

Figure 10. Age of first marijuana use among high school seniors in Colorado who reported ever using marijuana, 2013-2015.



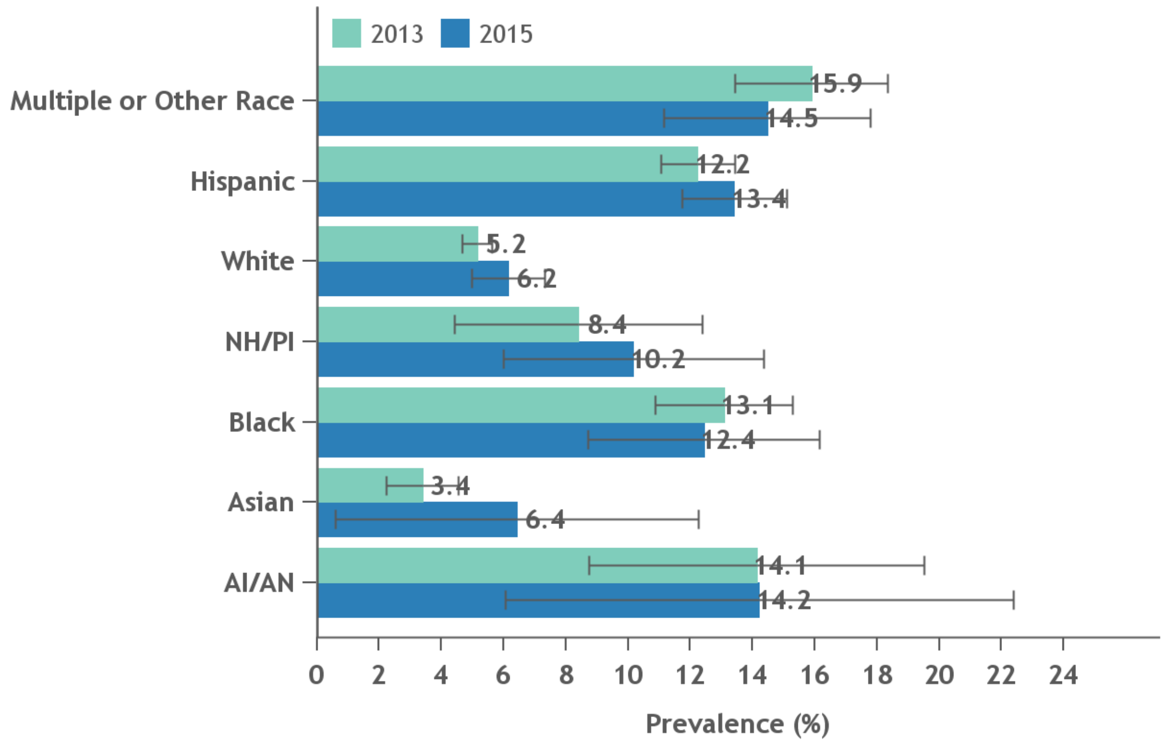
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2013-2015.

Major findings

- In 2015, among high school seniors who had used marijuana at least once in the past, an estimated 84.4% of them first used by age 16 or before, 41.3% first used by age 14 or before, and 14.3% first used by age 12 or before.[m]
- Age of first marijuana use followed a similar pattern among high school seniors surveyed in 2013 who reported ever using marijuana.

[m] First used by age 12 includes the “Less than 9” (2.7%), “9-10” (2.4%) and “11-12” (9.2%), totaling 14.3%; first used by age 14 includes those plus “13-14” (27.0%), totaling 41.3%; first used by age 16 includes those plus “15-16” (43.1%), totaling 84.4%
For data, see Appendix D, Table D.10.

Figure 11. Prevalence of high school students in Colorado who tried marijuana before age 13 by race/ethnicity, 2013-2015.



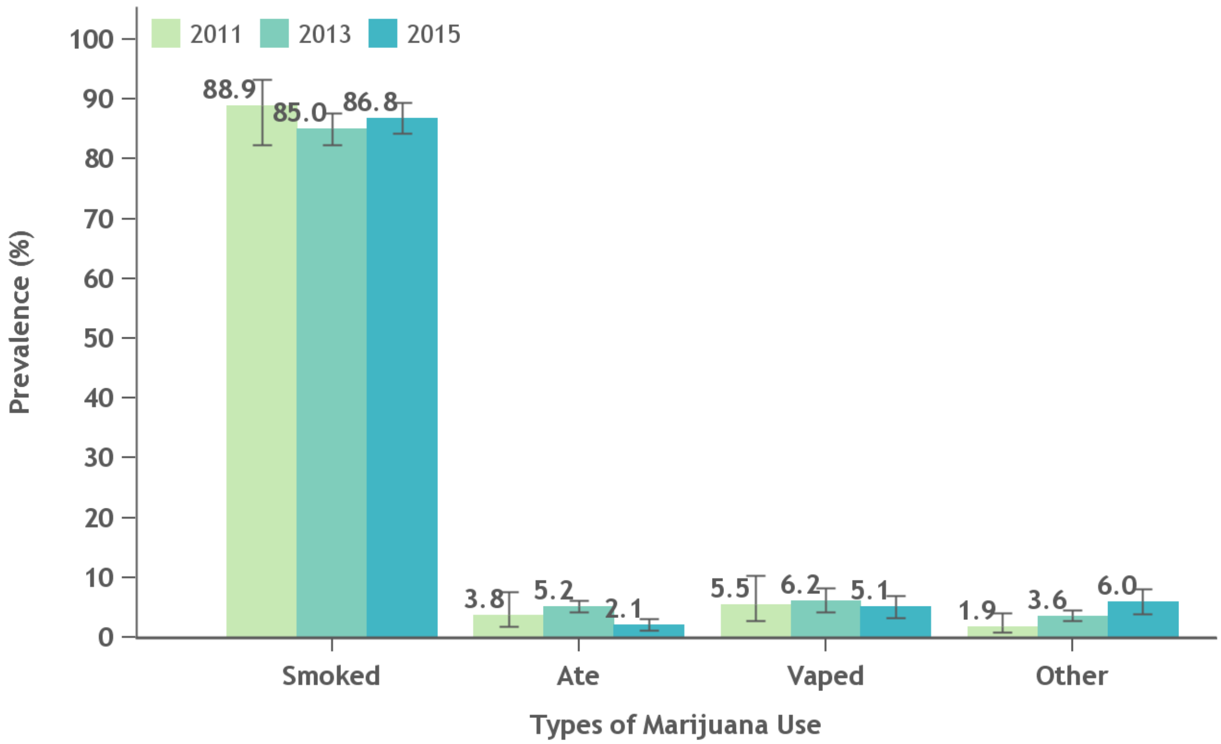
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Hispanic includes respondents who selected "Hispanic" for ethnicity and "white" for race. Those who selected "Hispanic" for ethnicity and a non-white race are included under "multiple or other race".
AI: American Indian, AN: Alaska Native, NH: Native Hawaiian, PI: Pacific Islander.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2013-2015.

Major findings

- In both 2013 and 2015, the estimated percent of white students who first tried marijuana before age 13 was statistically lower than among black, Hispanic, and multiple or other race students. [n]
- In 2013, the estimated percent of Asian students who first tried marijuana before age 13 was statistically lower than among black, Hispanic, American Indian/Alaskan Native and multiple or other race students.[n]

[n] For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix D. For data, see Appendix D, Table D.11.

Figure 12. Usual methods of marijuana use among high school students in Colorado who reported current marijuana use, 2011-2015.



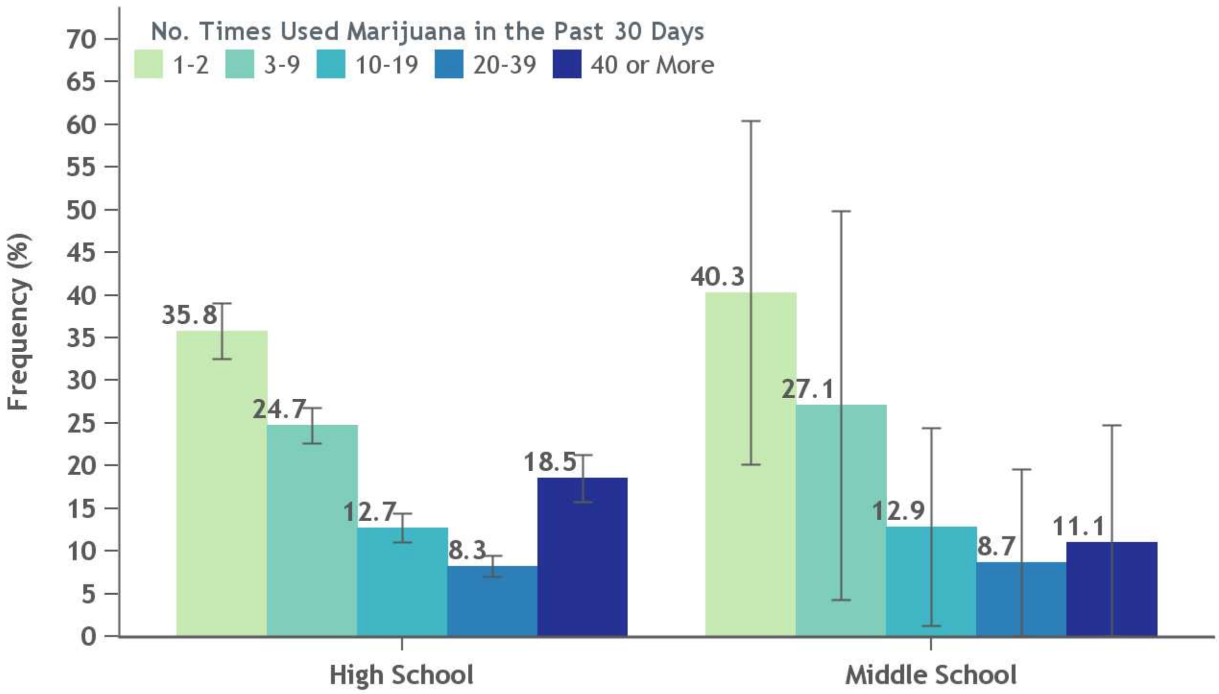
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡In 2015 the 'Other' category included 'Other' and 'Dabbing.'
§Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2011-2015.

Major findings

- A large majority of high school students who currently use marijuana report that smoking is their usual method of use, as compared to edibles, vaping or other methods of use.
- The percentage of high school students who reported usually using edibles was statistically lower in 2015 compared to 2013.[o]

[o] Usually use edibles: 2013 5.2% (95% CI 4.2-6.1%), 2015 2.1% (95% CI 1.2-3.0%)
For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix D. For data, see Appendix D, Table D.12.

Figure 13. Frequency of marijuana use among high school and middle school students in Colorado who reported current marijuana use, 2015.



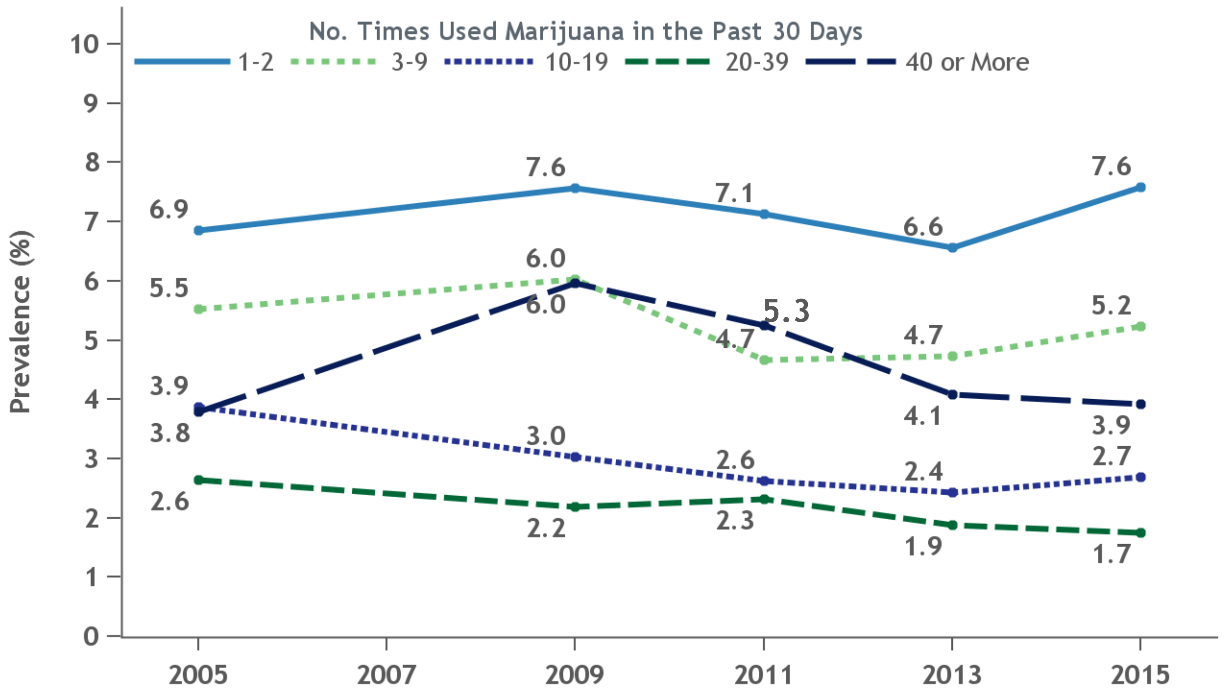
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2013-2015.

Major findings

- In 2015, among high school students currently using marijuana, an estimated 35.8% used it once or twice in the past 30 days, while 26.8% used it 20 or more times.[p]
- Among middle school students currently using marijuana, an estimated 40.3 % used once or twice in the past 30 days and 19.8% used 20 or more times. [q]

[p] 20 or more times includes “20-39” (8.3%) and “40 or more” (18.5%), totaling 26.8%
[q] 20 or more times includes “20-39” (8.7%) and “40 or more” (11.1%), totaling 19.8%
For statistical methods, see Appendix D. For data, see Appendix D, Table D.13.

Figure 14. Frequency of marijuana use among high school students in Colorado, 2005-2015.



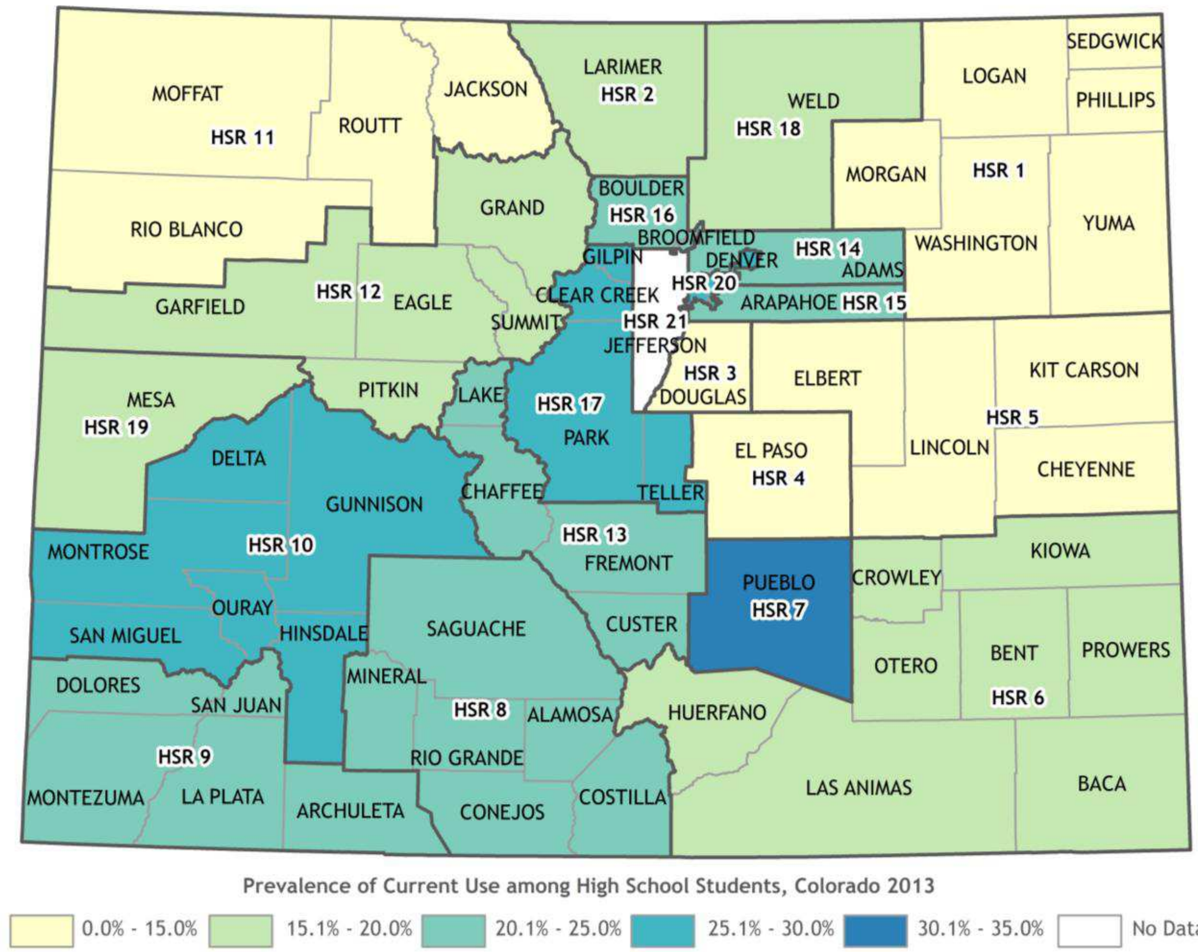
Produced by: EEOHT, CDPHE 2016
*Black bars indicate margins of error (95% Confidence Intervals).
†Current Use is defined as marijuana use at least once in the past 30 days.
‡Data Source: Healthy Kids Colorado Survey (HKCS) prevalence estimates for 2005-2015. Note: Data for the year 2007 was not included due to low sample size.

Major findings

- The estimated percent of Colorado high school students using marijuana at each frequency level fluctuated for surveys from 2005 to 2015, with no notable trends.[r]

[r] For data, see Appendix D, Table D.14.
For statistical methods, see Appendix D.

Map 1. Prevalence of current marijuana use among high school students in Colorado, 2013

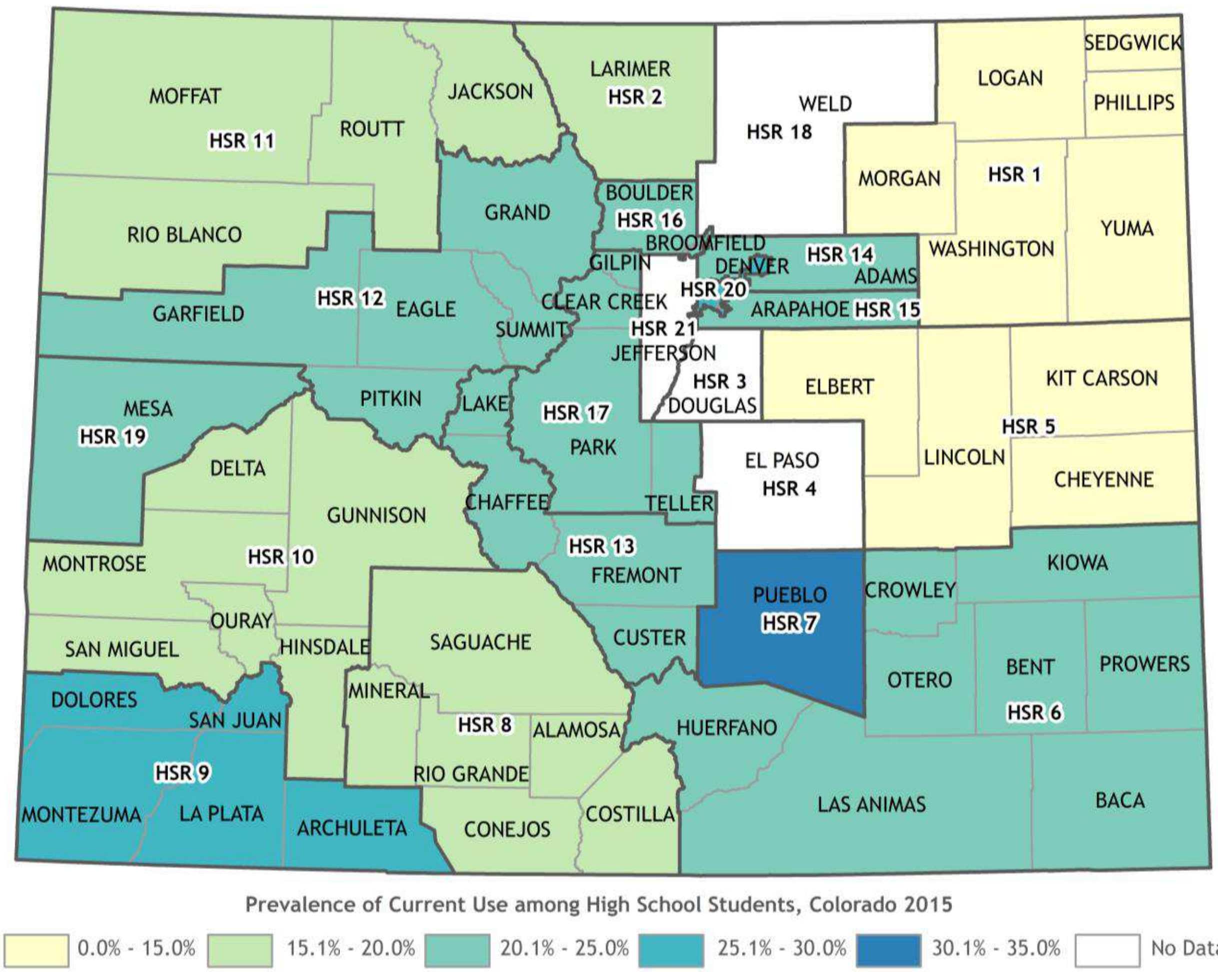


Major findings

- In 2013, health statistic regions 7 (Pueblo County, 32.0%), 10 (Montrose, Delta, Gunnison, Ouray, Hinsdale, and San Miguel Counties, 26.7%), 20 (Denver County, 26.6%), 17 (Gilpin, Clear Creek, Park, and Teller Counties, 25.1%), 9 (Dolores, San Juan, Montezuma, La Plata, and Archuleta Counties, 24.6%), and 13 (Lake, Chaffee, Fremont, and Custer Counties, 22.9%), were statistically higher than the 2013 Colorado state estimate of current use among high school students of 19.7%.[s]

[s] In 2013: HSR 7 - 32.0% (95% CI 25.7-38.4%), HSR 10 - 26.7% (95% CI 22.3-31.0%), HSR 20 - 26.6% (95% CI 22.5-30.8%), HSR 17 - 25.1% (95% CI 21.9-28.3%), HSR 9 - 24.6% (95% CI 20.9-28.3%), HSR 13 – 22.9% (95% CI 21.2-24.7%), all of Colorado - 19.7% (95% CI 18.7-20.6%)
For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix D.

Map 2. Prevalence of Current Marijuana Use among High School Students in Colorado, 2015



Major findings

- In 2015, health statistics regions 7 (Pueblo County, 30.1%) and 9 (Dolores, San Juan, Montezuma, La Plata, and Archuleta Counties, 26.2%) were statistically higher than the 2015 Colorado state estimate of current use among high school students of 21.2%.[t]
- Current marijuana use in health statistics region 10 (Montrose, Delta, Gunnison, Ouray, Hinsdale, and San Miguel Counties) was statistically lower in 2015 (17.5%) than it was in 2013 (26.7%).[u]
- For all other health statistics regions, current use in 2015 was not statistically different from current use in 2013.

[t] In 2015: HSR 7 - 30.1% (95% CI 27.1-33.2%), HSR 9 - 26.2% (95% CI 24.7-37.7%), all of Colorado - 21.2% (95% CI 19.7-22.7%)
[u] HSR 10: 2013 - 26.7% (95% CI 22.3-31.0%), 2015 - 17.5% (95% CI12.7-22.3%)
For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix D.

References

1. Centers for Disease Control and Prevention. Youth Risk Behavioral Surveillance System. *Adolescent and School Health* http://www.cdc.gov/healthyyouth/data/yrbs/.
2. Colorado Department of Public Health and Environment. Adolescent Health Data, Healthy Kids Colorado Survey. *Colorado Health and Environmental Data* 2015; http://www.chd.dphe.state.co.us/topics.aspx?q=Adolescent_Health_Data, 2016.
3. Substance Abuse and Mental Health Services Administration. Population Data / NSDUH. https://www.samhsa.gov/data/population-data-nsduh/2015.

Section 1

Monitoring Changes in Marijuana Use Patterns

Chapter 4

Pregnancy Risk Assessment Monitoring System (PRAMS) 2014 Survey Results

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Katelyn E. Hall, MPH
Statistical Analyst
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Ashley Juhl, MSPH
Maternal and Child Health Epidemiologist
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Anne Schiffmacher, MPH
Maternal and Child Health Epidemiologist
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Allison Grace Bui, MPH
Epidemiologist
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Rickey Tolliver, MPH
Chief
Health Surveys and Evaluation Branch, Colorado Department of Public Health and Environment

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health, and Toxicology Branch, Colorado Department of Public Health and Environment

Reviewer

Laura Borgelt, PharmD
Associate Dean and Professor
Departments of Clinical Pharmacy and Family Medicine, University of Colorado Anschutz Medical Campus

The PRAMS survey and marijuana use in Colorado

The Pregnancy Risk Assessment Monitoring System (PRAMS) is a survey sponsored by the Centers for Disease Control and Prevention (CDC). The survey asks new mothers questions about their pregnancy and their new baby. It provides data not available from other sources about pregnancy and the first few months after delivery, and allows CDC and the states to monitor changes in maternal and child health indicators, such as unintended pregnancy, prenatal care, breastfeeding, infant health, smoking and alcohol use. These data can be used to identify groups of women and infants at high risk for health problems, to monitor changes in health status, and to measure progress toward goals in improving the health of mothers and infants.[1] In 2014, PRAMS in Colorado asked about marijuana use before, during and after pregnancy (Table 1).[2]

For additional survey details and information about analysis methods, see Appendix E.

Survey questions

Table 1. Pregnancy Risk Assessment Monitoring System question about marijuana use, 2014.

1. During any of the following time periods, did you use marijuana or hashish (hash)? For each time period, say No if you did not use then or say Yes if you did.

   a. During the 3 months before I got pregnant.
   b. During the first 3 months of my pregnancy.
   c. During the last 3 months of my pregnancy.
   d. At any time during my most recent pregnancy.
   e. Since my baby was born.
   f. Don't know/don't remember

Definitions

Using marijuana during pregnancy was defined by combining three responses: *during the first 3 months of my pregnancy; during the last 3 months of my pregnancy;* and *at any time during my most recent pregnancy.*

Using marijuana and breastfeeding after delivery was defined as answering 'Yes' to using marijuana *since my baby was born* AND answering 'Yes' to one of two breastfeeding questions: *Did you ever breastfeed or pump breastmilk to feed your new baby*; or *Are you currently breastfeeding or feeding pumped milk to your new baby.*

How to interpret survey results

Respondents to the PRAMS survey are a sample of Colorado women who recently gave birth. The percent of survey respondents selecting a specific answer might not be exactly the same as if all Colorado women who recently gave birth were surveyed. Therefore, the survey results are estimates, and each has a range of possible values (also called margin of error, confidence interval, or 95% CI). These ranges are very important when comparing two estimates, and the following terms are used throughout this report:

'Not statistically different'- Typically, if the ranges of possible values *overlap* for two different survey results (like two different years, or male vs. female), we cannot be confident that there is a true difference between the two (also called 'not statistically significant.') In some cases, an additional statistical test is done to confirm.

'Statistically higher' or 'statistically lower'- If the ranges of possible values *do not overlap* for two different results, we CAN be confident that there is a true difference between the two (also called 'statistically significant.')

On the figures in this report, these ranges of possible values are indicated by black bars. In footnotes, they are referred to by the statistical term '95% CI.'

Results

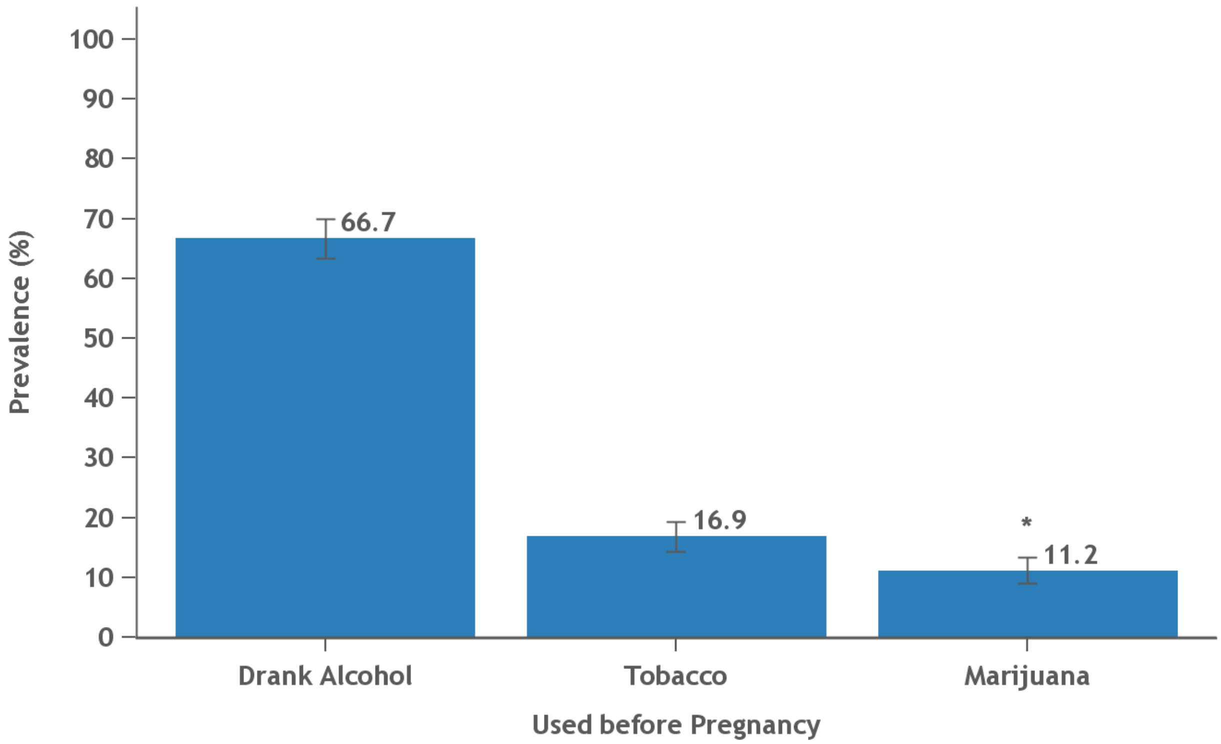
Results are displayed in Figures 1-5 below.

In 2014, among new mothers in Colorado, marijuana use before pregnancy (11.2%) was statistically lower than use of tobacco (16.9%) or alcohol (66.7%) before pregnancy (Figure 1). During pregnancy, alcohol use (12.8%) was statistically higher than use of tobacco (6.4%) or marijuana (5.7%) (Figure 2). A 2016 article estimated that 3.9% of pregnant women in the United States overall used marijuana during pregnancy (data not shown).[3] This was not statistically different from the PRAMS estimate of 5.7% for Colorado.

Marijuana use before pregnancy (11.2%) was statistically higher than use during pregnancy (5.7%) or use by breastfeeding mothers after delivery (4.5%) (Figure 3). There was no statistical difference between use during pregnancy and use by breastfeeding mothers after delivery. Marijuana use during pregnancy was statistically higher among women with an unintended pregnancy (9.1%) than among women who intended to become pregnant (4.0%) (Figure 4).

When marijuana use during pregnancy was compared among different demographics, both education and age showed statistical differences, while race/ethnicity did not. Use during pregnancy was statistically higher among women with less than a 12th grade education (15.7%) than among women with some college (4.1%) (Figure 5). It was also statistically higher among women 20-24 years old (12.6%) than among women 25-34 years old (4.3%) or women 35 years old or older (2.7%) (Figure 5). There were no statistical differences in marijuana use during pregnancy by race/ethnicity (Figure 5).

Figure 1. Colorado women who reported using substances before pregnancy, 2014.



Produced by: EEOHT, CDPHE 2016
*95% confidence intervals do not overlap.
†Black bars indicate margins of error (95% Confidence Intervals).
‡Data Source: Colorado Pregnancy Risk Assessment Monitoring System 2014.

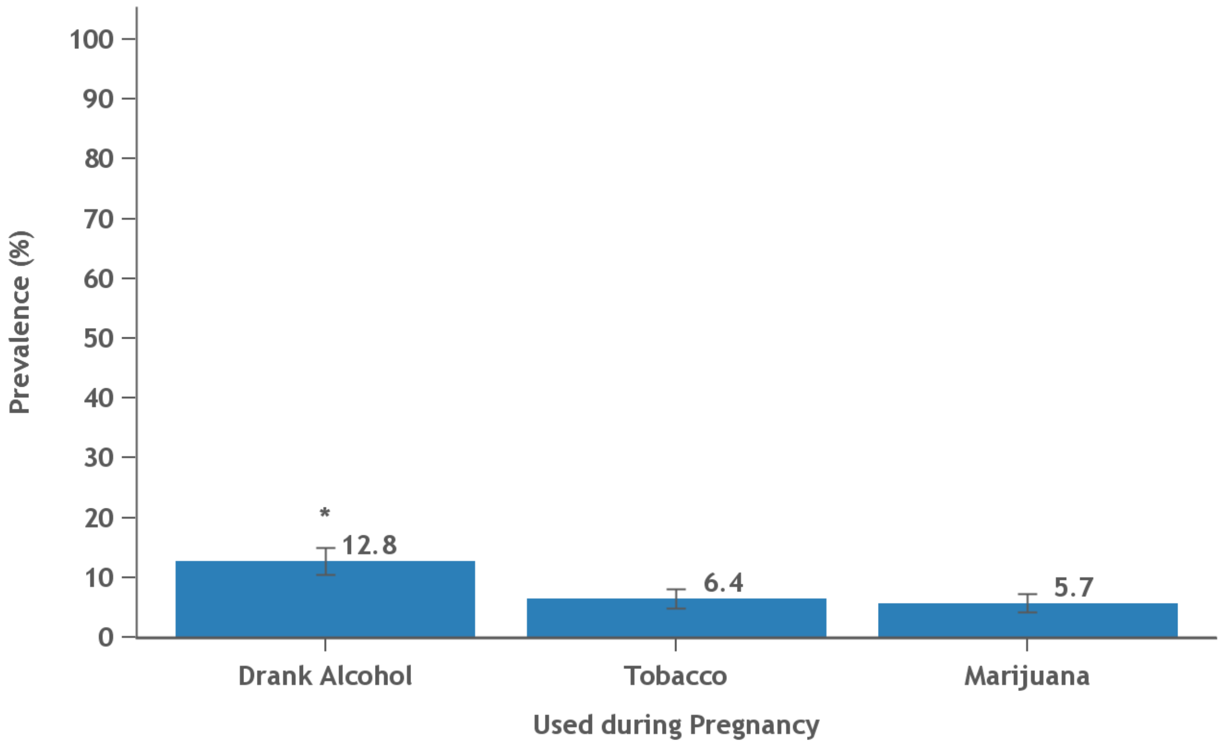
Major findings

- The prevalence of marijuana use before pregnancy among women who recently gave birth was statistically lower than use of tobacco or alcohol before pregnancy.[a]

[a] 2014 substance use before pregnancy: alcohol 66.7% (95% CI 63.4-69.9%), tobacco 14.4% (95% CI 14.4-19.4%), marijuana 11.2% (95% CI 9.0-13.3%)

For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix E. For data, see Appendix E, Table E.1.

Figure 2. Colorado women who reported using substances during pregnancy, 2014.



Produced by: EEOHT, CDPHE 2016
*95% confidence intervals do not overlap.
†Black bars indicate margins of error (95% Confidence Intervals).
‡Tobacco and alcohol use was during the last 3 months of pregnancy.
§Data Source: Colorado Pregnancy Risk Assessment Monitoring System 2014.

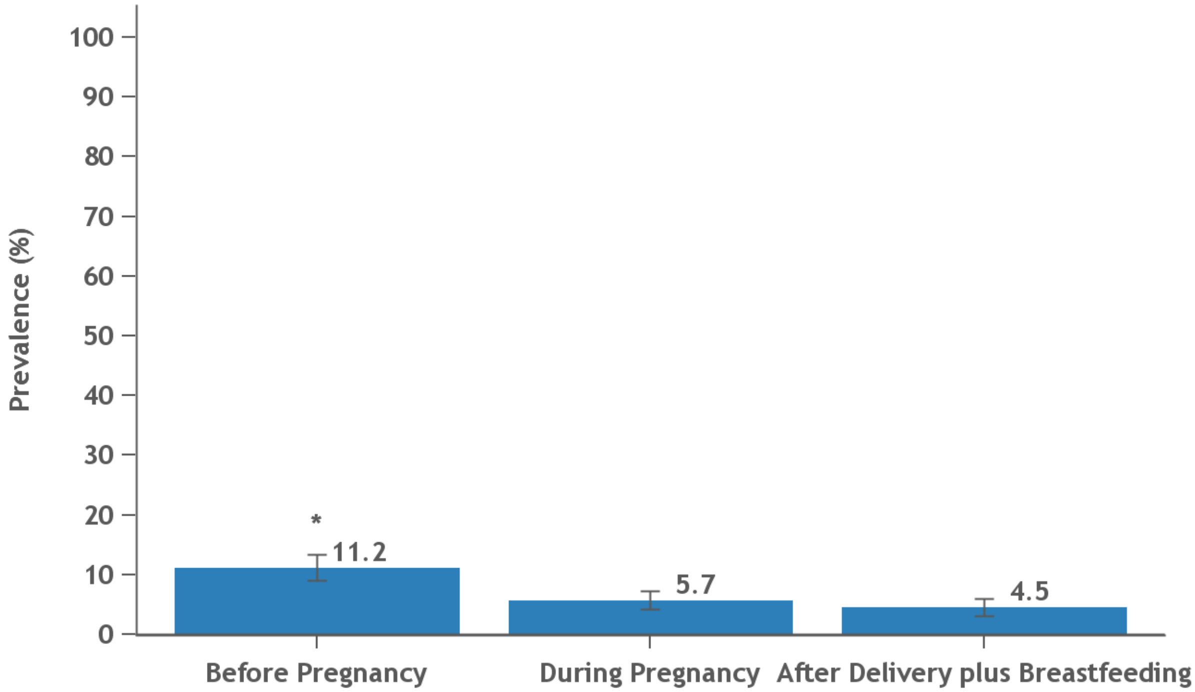
Major findings

- The prevalence of alcohol use during pregnancy was statistically higher than use of tobacco or marijuana during pregnancy. The use of marijuana was not statistically different from use of tobacco.[b]

[b] 2014 substance use during pregnancy: alcohol 12.8% (95% CI 10.5-15.0%), tobacco 6.4% (95% CI 4.8-8.1%), marijuana 5.7% (95% CI 4.2-7.2%)

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix E. For data, see Appendix E, Table E.2.

Figure 3. Colorado women who reported using marijuana before, during, and after pregnancy, 2014.



Produced by: EEOHT, CDPHE 2016
*95% confidence intervals do not overlap.
†Black bars indicate margins of error (95% Confidence Intervals).
‡Data Source: Colorado Pregnancy Risk Assessment Monitoring System 2014.

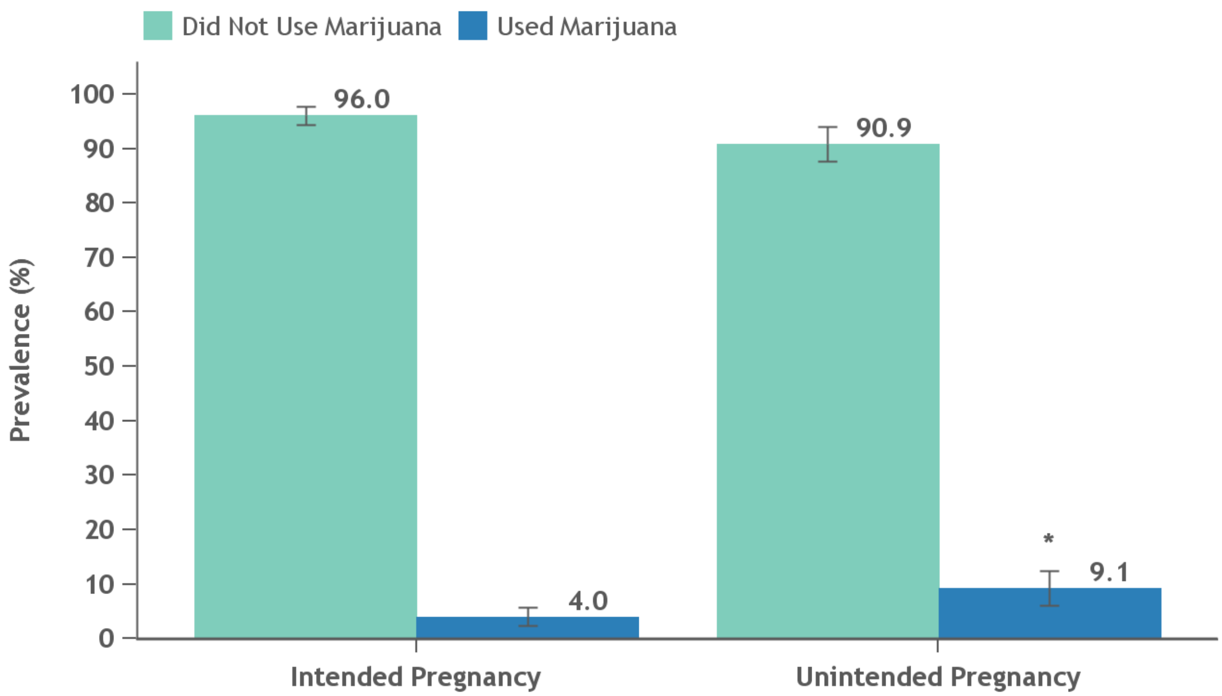
Major findings

- The prevalence of marijuana use before pregnancy was statistically higher than use during pregnancy or use by breastfeeding mothers after delivery. There was no statistical difference between use during pregnancy and use by breastfeeding mothers after delivery.[c]

[c] 2014 marijuana use: before pregnancy 11.2% (95% CI 9.0-13.3%), during pregnancy 5.7% (95% CI 4.2-7.2%), by breastfeeding mothers after delivery 4.5% (95% CI 3.1-5.9%)

For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix E. For data, see Appendix E, Table E.3.

Figure 4. Colorado women who reported using marijuana during pregnancy by intention to become pregnant, 2014.



Produced by: EEOHT, CDPHE 2016
*95% confidence intervals do not overlap.
†Black bars indicate margins of error (95% Confidence Intervals).
‡Data Source: Colorado Pregnancy Risk Assessment Monitoring System 2014.

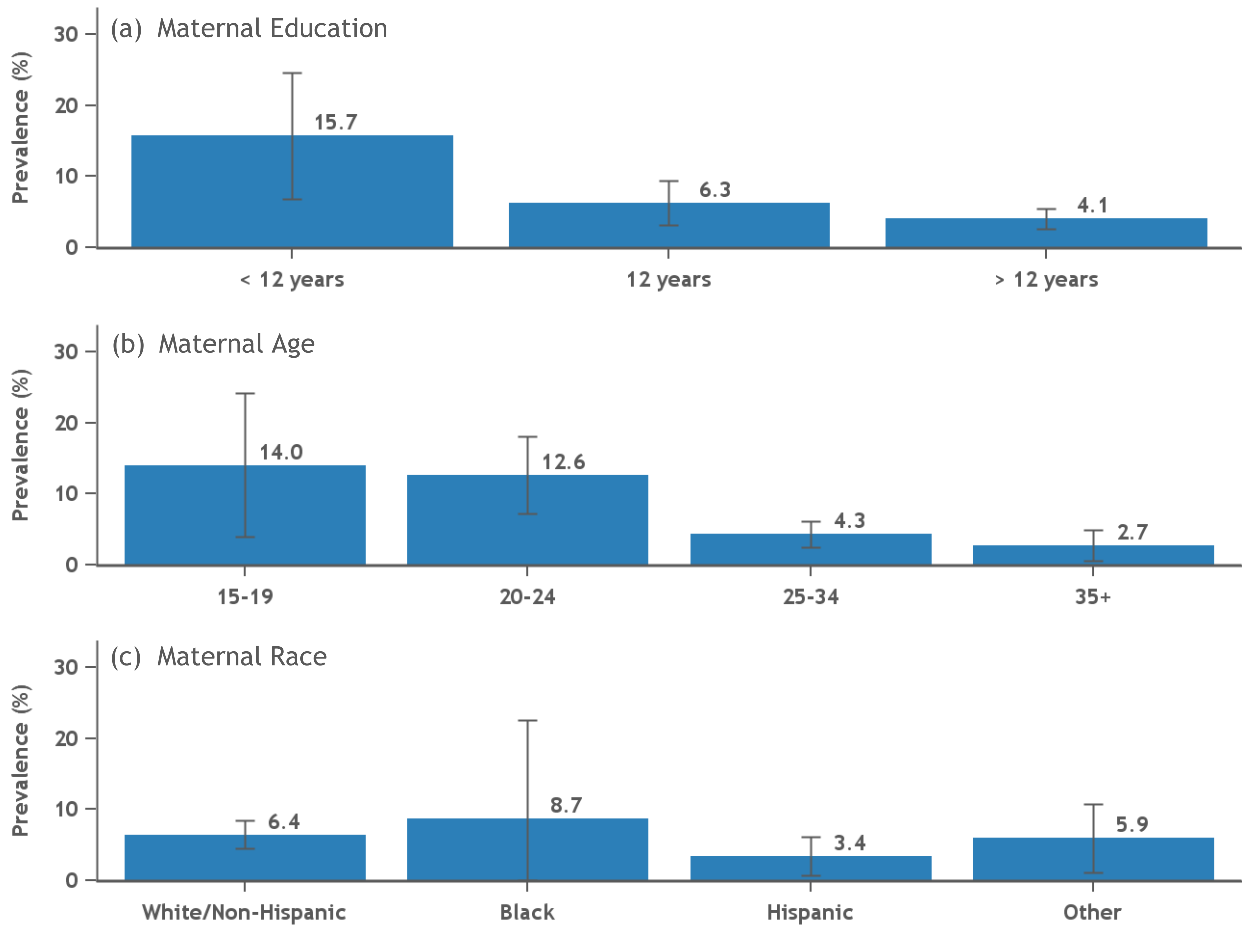
Major findings

- The prevalence of marijuana use during pregnancy was statistically higher among women with an unintended pregnancy than among women who intended to become pregnant.[d]

[d] 2014 marijuana use during pregnancy, by intention to become pregnant: intended pregnancy 4.0% (95% CI 2.3-5.7%), unintended pregnancy 9.1% (95% CI 6.0-12.3%)

For an explanation of terms, see "How to interpret survey results" above. For statistical methods, see Appendix E. For data, see Appendix E, Table E.4.

Figure 5. Colorado women who reported using marijuana during pregnancy by maternal education (a), age (b), and race (c), 2014.



Produced by: EEOHT, CDPHE 2016
†Black bars indicate margins of error (95% Confidence Intervals).
‡Data Source: Colorado Pregnancy Risk Assessment Monitoring System 2014.

Major Findings

- The prevalence of marijuana use during pregnancy was statistically higher among women with less than a 12th grade education than among women with some college.[e]
- The prevalence of marijuana use during pregnancy was statistically higher among women 20-24 years old than among women 25-34 years old or women 35 years old or older.[f]
- There were no statistical differences in marijuana use during pregnancy by race/ethnicity.[g]

[e] 2014 marijuana use during pregnancy, by education: <12 years 15.7% (95% CI 6.9-24.5%), 12 years 6.3% (95% CI 3.2-9.5%), >12 years 4.1% (95% CI 2.6-5.5%)

[f] 2014 marijuana use during pregnancy, by maternal age: 15-19 years old 14.0% (95% CI 3.9-24.1%), 20-24 years old 12.6% (95% CI 7.2-18.0%), 25-34 years old 4.3% (95% CI 2.5-6.1%), 35 years or older 2.7% (95% CI 0.6-4.9%)

[g] 2014 marijuana use during pregnancy, by race/ethnicity: White/non-Hispanic 6.4% (95% CI 4.4-8.4%), Black 8.7% (95% CI 0.0-22.5%), Hispanic 3.4% (95% CI 0.7-6.2%), Other 5.9% (95% CI 1.1-10.8%)

For an explanation of terms, see “How to interpret survey results” above. For statistical methods, see Appendix E. For data, see Appendix E, Table E.5.

References

1. Centers for Disease Control and Prevention. PRAMS. 2016; https://www.cdc.gov/prams/, https://www.cdc.gov/prams/.
2. Colorado Department of Public Health and Environment. Pregnancy Risk Assessment Monitoring System. https://www.colorado.gov/pacific/cdphe/pregnancysurvey.
3. Volkow ND, Compton WM, Wargo EM. The Risks of Marijuana Use During Pregnancy. *JAMA*. 2017;317(2):129-130.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Background

The Colorado Department of Public Health and Environment (CDPHE) was given statutory (25-1.5-110, C.R.S.) responsibility to:

- "…monitor changes in drug use patterns, broken down by county and race and ethnicity, and the emerging science and medical information relevant to the health effects associated with marijuana use."

- "…appoint a panel of health care professionals with expertise in cannabinoid physiology to monitor the relevant information."

Based on this charge, CDPHE appointed a 14-member committee, the Retail Marijuana Public Health Advisory Committee, to review scientific literature on the health effects of marijuana. Members of this committee (see Appendix, Retail Marijuana Public Health Advisory Committee Membership Roster) are individuals in the fields of public health, medicine, epidemiology, and medical toxicology who demonstrate expertise related to marijuana through their work, training or research. This committee was charged with the duties as outlined in 25-1.5-110 C.R.S. to "...establish criteria for studies to be reviewed, review studies and other data, and make recommendations, as appropriate, for policies intended to protect consumers of marijuana or marijuana products and the general public."

The committee has met since May 2014 to complete these duties. The overall goal was to implement an unbiased and transparent process for evaluating scientific literature and data on marijuana use and health outcomes. The committee was particularly interested in ensuring quality information is shared about the known physical and mental health effects associated with marijuana use – and also about what is unknown at present. The official bylaws of this committee are included in Appendix A, Retail Marijuana Public Health Advisory Committee By-laws.

The committee used a standardized systematic literature review process to search and grade the existing scientific literature on health effects of marijuana. Findings were synthesized into evidence statements that summarize the quantity and quality of scientific evidence supporting an association between marijuana use and a health outcome. These evidence statements were classified as follows:

- **Substantial evidence** - indicates robust scientific findings that support an association between marijuana use and the outcome.
- **Moderate evidence** - indicates scientific findings support an association between marijuana use and the outcome, but these findings have some limitations.
- **Limited evidence** - indicates modest scientific findings that support an association between marijuana use and the outcome, but these findings have significant limitations.
- **Mixed evidence** - indicates both supporting and non-supporting scientific findings for an association between marijuana use and the outcome, with neither direction dominating.
- **Body of research failing to show an association -** indicates the topic has been researched without evidence of an association; is further classified as a **limited**, **moderate** or **substantial** body of research.
- **Insufficient evidence -** indicates the outcome has not been sufficiently studied to conclude whether or not there is an association between marijuana use and the outcome.

The committee also translated these evidence statements into plain language so they are understandable to the general public for future use in public health messaging. In addition, the committee was asked to develop public health recommendations based on potential concerns identified through the review process and to articulate research gaps based on common limitations of existing research. All these were presented to the full committee during open public meetings with opportunities for stakeholder input. Final statements, recommendations and research gaps were formally approved by a majority vote of the committee.

The topics for review were originally chosen in 2014 based on recently published peer-reviewed publications outlining the potential health effects of marijuana use, and public health priorities identified from key informant interviews of local public health officials across Colorado, including in urban, rural, and resort communities. Additional topics added in 2015 and 2016 were based on committee and stakeholder suggestions. Key findings for each topic are presented below. More detailed findings including literature citations are included in each of the individual chapters.

An important note for all key findings is the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. Another limitation of the available research data is that most studies did not or could not measure the THC level (potency) of marijuana used by subjects, nor which other cannabinoids were present. There are diverse products now available in Colorado, many of which are likely higher in potency than the marijuana used by study subjects for much of the literature reviewed.

The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Summary of key findings

Marijuana use among adolescents and young adults

The committee reviewed the relationships between adolescent and young adult marijuana use and cognitive abilities, academic performance, mental health and future substance use. Weekly marijuana use by adolescents is associated with impaired learning, memory, math and reading, even 28 days after last use. Weekly use is also associated with failure to graduate from high school. Adolescents and young adults who use marijuana are more likely to experience psychotic symptoms as adults, such as hallucinations, paranoia, delusional beliefs and feeling emotionally unresponsive. Evidence shows marijuana users can become addicted to marijuana and treatment for marijuana addiction can decrease use and dependence. Additionally, marijuana users who quit have lower risks of cognitive and mental health outcomes than those who continue to use.

Marijuana use and cancer

The committee reviewed different forms of cancer relative to marijuana use, as well as the chemicals released in marijuana smoke and vapor. Strong evidence shows marijuana smoke contains many of the same cancer-causing chemicals found in tobacco smoke. However, there is conflicting research for whether or not a higher cumulative level of marijuana smoking is associated with lung cancer. Limited evidence suggests an association between marijuana use and both testicular and prostate cancers. On the other hand, the limited evidence available concerning cancers of the bladder, head and neck suggests that they might not have any association with marijuana use.

Marijuana use and cardiovascular effects

The committee reviewed myocardial infarction, stroke and death from cardiovascular causes, relative to marijuana use. There is a moderate level of scientific evidence that marijuana use increases risk for some forms of stroke in individuals younger than 55, and more limited evidence that marijuana use may increase risk for heart attack. Research is lacking concerning other cardiovascular events and conditions, including death.

Marijuana dose and drug interactions

The committee reviewed THC (tetrahydrocannabinol, the main psychoactive component of marijuana) levels relative to marijuana dose and method of use, the effects of secondhand marijuana smoke, drug-drug interactions involving marijuana, and relationships between marijuana and opioid use. One important finding is that it can take up to four hours after consuming an edible marijuana product to reach the peak THC blood concentration and feel the full effects. There is credible evidence of clinically important drug-drug interactions between marijuana and multiple medications, including some anti-seizure medications and a common blood-thinner. Data about potential interactions are lacking for many drugs at this time and likely to evolve substantially over coming years. Finally, there is some evidence that opioid pain medication overdose deaths are lower in states with legal medical marijuana than would be expected based on trends in states without legal medical marijuana. There is conflicting evidence for whether or not marijuana use is associated with a decrease in opioid use among chronic pain patients or individuals with a history of problem drug use.

Marijuana use and driving

The committee reviewed driving impairment and motor vehicle crash risk relative to marijuana use, as well as evidence indicating how long it takes for impairment to resolve after marijuana use. It found the risk of a motor vehicle crash increases among drivers with recent marijuana use. Furthermore, the higher the blood THC level, the higher the motor vehicle crash risk. In addition, using alcohol and marijuana together increases impairment and the risk of a motor vehicle crash more than using either substance alone. For less-than-weekly marijuana users, using marijuana containing 10 milligrams or more of THC is likely to impair the ability to safely drive, bike or perform other safety-sensitive activities. Less-than-weekly users should wait at least six hours after smoking or eight hours after eating or drinking marijuana to allow time for impairment to resolve.

Marijuana use and gastrointestinal or reproductive effects

The committee reviewed gastrointestinal diseases, particularly cyclic vomiting, and infertility or abnormal reproductive function. Evidence shows that long-time, daily or near daily marijuana use is associated with cyclic vomiting. This condition has been called cannabinoid hyperemesis syndrome. In such cases, stopping marijuana use may relieve the vomiting. There is conflicting research for whether or not marijuana use is associated with male infertility or abnormal reproductive function, and research is lacking on female reproductive function related to marijuana use.

Marijuana use and injury

The committee reviewed workplace, recreational and other non-driving injuries, burns from hash-oil extraction or failed electronic smoking devices, and physical dating violence. Evidence shows marijuana use may increase the risk of workplace injury while impaired, but is unclear for other types of non-driving related injury. There have been many reports of severe burns resulting from home-extraction of butane hash oil leading to explosions, and cases of electronic smoking devices exploding, leading to trauma and burns. Concerning dating violence, adolescent girls who use marijuana may be more likely to commit physical violence against their dating partners, and adolescent boys who use marijuana may be more likely to be victims of physical dating violence.

Marijuana use and neurological, cognitive and mental health effects

The committee reviewed the potential relationships between marijuana use and cognitive impairment, mental health disorders and substance abuse. Strong evidence shows that daily or near daily marijuana users are more likely to have impaired memory lasting a week or more after quitting. An important acute effect of THC is psychotic symptoms, such as hallucinations, paranoia and delusional beliefs during intoxication. These symptoms are worse with higher doses. Daily or near daily marijuana use is associated with developing a psychotic disorder such as schizophrenia. Finally, evidence shows marijuana users can become addicted to marijuana and treatment for marijuana addiction can decrease use and dependence.

Marijuana use during pregnancy and breastfeeding

The committee reviewed adverse birth outcomes, effects of prenatal marijuana use on exposed offspring later in childhood or adolescence and effects of marijuana use by a breastfeeding mother. Biological evidence shows THC passes through the placenta to the fetus, so the unborn child is exposed to THC if the mother uses marijuana, and THC passes through breast milk to a breastfeeding child. Marijuana use during pregnancy may be associated with an increased risk of heart defects or stillbirth. Stronger evidence was found for effects that are seen months or years after birth if a child's mother used marijuana while pregnant with the child. These include decreased growth and impaired cognitive function and attention. Decreased academic ability or increased depression symptoms may also occur.

Marijuana use and respiratory effects

The committee reviewed respiratory diseases such as chronic obstructive pulmonary disorder (COPD), chronic bronchitis and asthma, respiratory infections and lung function relative to smoked marijuana. It also reviewed potential health effects of vaporized marijuana. Strong evidence shows an association between daily or near-daily marijuana use and chronic bronchitis. Additionally, daily or near daily marijuana use may be associated with bullous lung disease and pneumothorax in individuals younger than 40 years of age. Research is lacking concerning any possible association between marijuana use and COPD, emphysema or respiratory infections. Smokers who switch from marijuana smoking to marijuana vaporizing may have fewer respiratory symptoms and improved pulmonary function. Finally, a notable effect of acute use is a short-term improvement in lung airflow.

Unintentional marijuana exposures in children

The committee reviewed unintentional marijuana exposure relative to marijuana legalization and child-resistant packaging. They found strong evidence that more unintentional marijuana exposures of children occur in states with increased legal access to marijuana, and that the exposures can lead to significant clinical effects requiring hospitalization. Additionally, evidence shows child resistant packaging prevents exposure to children from potentially harmful substances, such as THC.

The following table includes the committee's most prominent findings from reviews of scientific literature on marijuana use and potential health effects.

Table 1. Substantial and moderate findings from systematic literature review

Marijuana use among adolescents and young adults (p.97)		
	Substantial	**Moderate**
Cognitive and academic	Less high school graduation	Impaired cognitive abilities and academic performance after 28 days abstinence
Mental health	Psychotic symptoms in adulthood	Psychotic disorder in adulthood (daily or near-daily users)
Substance use, abuse and addiction	Can develop marijuana addiction‡	Increased marijuana use and addiction‡ after adolescence
	Other illicit drug use and addiction‡ after adolescence	Alcohol or tobacco use and addiction‡ after adolescence
Benefits of quitting	Treatment for marijuana addiction‡ can reduce use and dependence	Quitting marijuana lowers risk of cognitive and mental health effects
Marijuana use and cancer (p.113)		
	Substantial	**Moderate**
Chemicals in MJ smoke or vapor	Marijuana smoke contains same cancer-causing chemicals as tobacco smoke	
Cancer and pre-cancerous lesions	Pre-cancerous lesions with daily or near-daily use	Failure to show association with lung cancer for less than 10 joint-years cumulative use
Marijuana use and cardiovascular effects (p.123)		
	Substantial	**Moderate**
		Increased risk of ischemic stroke in individuals younger than 55

‡ In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

Table 1. (continued) Substantial and moderate findings from systematic literature review

Marijuana dose and drug interaction (p.131) → = results in/produces.		
	Substantial	**Moderate**
THC levels	Smoking >10 mg THC produces blood THC level near or > 5 ng/mL within 10 minutes	Ingesting ≥15 mg THC may → blood THC level > 5 ng/mL
	Time to peak blood THC level is up to four hours post ingestion	Inhaling vaporized THC→ blood THC level similar to smoking the same dose
Secondhand exposure	Typical secondhand exposure → NO positive drug screen by urine or blood	

Marijuana use and driving (p.149) * = applies only to less-than-weekly users. → = results in/produces.		
	Substantial	**Moderate**
Impairment and crash risk	Increased motor vehicle crash risk with recent use	THC blood level and motor vehicle crash risk
	Increased risk of driving impairment at blood THC of 2-5 ng/mL*	Higher blood THC in impaired drivers now than in the past
	Smoking >10 mg THC leads to driving impairment*	
	Orally ingesting >10 mg THC leads to driving impairment*	
	Combined use with alcohol increases crash risk	
Time to wait before driving	Waiting ≥ 6 hrs after smoking < 18 mg → driving impairment resolves/nearly resolves*	Waiting ≥ 6 hrs after smoking about 35 mg → driving impairment resolves/nearly resolves*
	Waiting ≥ 8 hrs after orally ingesting < 18 mg → driving impairment resolves/nearly resolves*	

*** = applies only to less-than-weekly users.**
→ = results in/produces.
There were no substantial or moderate findings for Marijuana Use and Injury

Table 1. (continued) Substantial and moderate findings from systematic literature review

Marijuana use and gastrointestinal and reproductive effects (p.161)		
	Substantial	**Moderate**
		Cyclic vomiting with long-time, daily or near-daily use (cannabinoid hyperemesis syndrome)

Marijuana use and neurological, cognitive, mental health effects (p.183)		
	Substantial	**Moderate**
Cognitive effects	Impaired memory for at least 7 days (daily or near-daily users)	
Mental health effects	Acute psychotic symptoms during intoxication	Psychotic disorder in adulthood (daily or near-daily users)
Substance use and addiction	Can develop marijuana addiction‡	
	Daily or near-daily users may experience withdrawal symptoms	
	Treatment of marijuana addiction‡ can reduce use and dependence	

Marijuana use during pregnancy and breastfeeding (p.197)		
	Substantial	**Moderate**
Effects on exposed offspring		Attention problems
		Decreased IQ scores in young children
		Decreased cognitive function
		Decreased growth

There were no substantial or moderate findings for Marijuana Use and Injury

Table 1. (continued) Substantial and moderate findings from systematic literature review

Marijuana use and respiratory effects (p.213)		
	Substantial	**Moderate**
Smoked marijuana	Chronic bronchitis with cough/wheeze/ sputum	
	Acute use improves airflow	
Unintentional marijuana exposures in children (p.225)		
	Substantial	**Moderate**
	Legal marijuana access increases unintentional marijuana exposures in children	Child-resistant packaging reduces unintentional pediatric poisonings

Public Health Recommendations

It is important to continue improving data quality by systematically collecting information on the frequency, amount, potency and method of marijuana use in both public health surveillance and medical care settings. During hospitalizations and emergency department visits, marijuana use should be a standard question, and follow-up questions should clarify timing and amount of last use. Improved testing methods and documentation are needed in relation to motor vehicle crashes and driving under the influence of drugs (DUID).

Questions regarding marijuana use should be continued on population-based surveys such as the Behavioral Risk Factors Surveillance System (BRFSS), the Healthy Kids Colorado Survey (HKCS) and Pregnancy Risk Assessment Monitoring System (PRAMS). Surveillance methods should continue to be expanded to collect more detailed information, such as quantity and methods of use, perceptions of risk, reasons for using and adverse effects experienced. To better assess potential health impacts, data on hospitalizations and emergency department visits related to marijuana should be further explored.

Public education on potential health effects of marijuana is important, particularly related to the effects of use during pregnancy, adolescent use, driving after using and unsafe storage around children. Dispensaries and industry should continue to partner with public health in disseminating education about these topics of highest concern. Education for health care providers on the known health effects of marijuana use may encourage more open dialog between providers and patients.

Research Gaps

Important research gaps related to the population-based health effects of marijuana use were identified during the literature and data review process. These research gaps were based on common limitations of existing research, exposures or outcomes not sufficiently studied, or issues important to public education or policymaking. These research gaps provide an important framework for continuing to prioritize research related to marijuana use and public health. The committee strongly recommends Colorado support research to fill these important gaps in public health knowledge. While outside the scope of this committee's duties, the committee also recognizes more research is needed on the potential therapeutic benefits of marijuana.

A common theme among the research gaps was the need for studies with better defined marijuana-use histories and practices. This should include frequency, amount, potency, and method of marijuana use; length of abstinence; and a standardized method for documenting cumulative lifetime marijuana exposure. A particularly important need is the evaluation of effects separately for less frequent users versus daily or near-daily users. Researchers should consider evaluating separately by age group, gender or other characteristics when the health effect being studied could differ among groups - for example, by age for cardiovascular effects or by gender for mental health effects.

Research gaps particularly important to public health and safety include the need for: 1) additional research using marijuana with THC levels consistent with currently available products; 2) research on impairment in marijuana users who use more than weekly and may have developed tolerance; 3) research to identify improved testing methods for impairment either through alternate biological testing methods or physical tests of impairment; and 4) research to better characterize the pharmacokinetics/pharmacodynamics, potential drug interactions, health effects, and impairment related to newer methods of marijuana use such as edibles and vaporizing as well as other cannabinoids such as cannabidiol (CBD).

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 1

Systematic Literature Review Process

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health, and Toxicology Branch, Colorado Department of Public Health and Environment

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment

Reviewer

Andrew Monte, MD
Emergency Medicine Physician and Medical Toxicologist
University of Colorado and Rocky Mountain Poison and Drug Center

Committee objectives

The RMPHAC was appointed in April 2014, had its first organizational meeting in May 2014, and began the scientific review process in June 2014. The committee established these objectives:

- Develop well-designed, systematic, unbiased criteria for selecting and evaluating studies
- Systematically review the scientific literature currently available on health effects of marijuana use
- Judge and openly discuss the science using expert scientific and medical opinion.
- Establish committee consensus on population health effects of marijuana use based on current science
- Establish committee consensus on translation of the science into public health messages
- Recommend public health-related policies based on the current science and expert medical discussion
- Recommend public health surveillance activities to address any gaps in knowledge discovered
- Identify and prioritize gaps in science important to public health
- Create a framework to add emerging evidence and update committee findings

The committee also selected and prioritized review topics based on recently published peer-reviewed publications outlining the potential health effects of marijuana use, and public health priorities identified from key informant interviews of Colorado public health officials. These topics included:

- Marijuana Use During Pregnancy and Breastfeeding
- Neurological and Mental Health Effects
- Effects on Youth and Unintentional Poisonings
- Marijuana Dose and Drug Interactions
- Extrapulmonary Effects and Injuries
- Respiratory Effects and Lung Cancer

Within each of these topics, Colorado Department of Public Health and Environment (CDPHE) staff established specific research questions to ensure that the relevant public health issues were covered in the literature review process.

The overall goal of the committee was to implement an unbiased and transparent process for evaluating scientific literature. The official committee bylaws included procedures for disclosing potential conflicts of interest, including financial relationships with companies in the marijuana industry; financial relationships with companies engaged in the treatment of patients for marijuana-related health effects; funding support from the National Institute on Drug Abuse; and personal or political beliefs that may prevent an unbiased recommendation.

Outside technical experts were recruited from CDPHE staff, the University of Colorado School of Medicine, and the Colorado School of Public Health to search the scientific literature and summarize and present findings to the full committee. All committee members were provided access to the summary findings and the full-text literature for review before each committee meeting.

Overview of systematic review process

The committee utilized a PRISMA framework to ensure an unbiased and complete systematic literature review.[1] The following are the general steps that were followed for each review topic:

1. Search: Conduct a broad search of peer-reviewed publications (Medline).
2. Review: Download articles from search and relevant cited articles.
3. Rate the findings: Each finding in the articles is rated as a high, medium, or low quality finding based on the strengths and limitations of the methods. Evaluation of the strengths and limitations was based on criteria in the GRADE system, which is a well-accepted method for evaluating the quality of scientific evidence.
4. Group related findings: Each finding is categorized based on population, exposure, and outcome (health effect).
5. Weigh the evidence: Draft evidence statements that summarize the quantity and quality of evidence.
6. Translate the evidence: Draft public health statements that translate the evidence statements into lay language understandable by the general public.
7. Synthesize the evidence: Draft public health recommendations based on potential concerns identified through the review process.
8. Identify research gaps: Draft statements to articulate the research gaps identified during the review process.
9. Present to committee: Findings, evidence statements, public health statements, public health recommendations, and research gaps are formally presented to committee for review and revision during open public meetings.
10. Public comment: During the open public meetings, interested stakeholders and members of the general public are invited to provide comments relevant to the topic presented.
11. Reach consensus: Committee members come to consensus on findings, evidence statements, public health statements, public health recommendations, and research gaps.
12. Officially adopt summary statements: Committee votes to officially accept findings, evidence statements, public health statements, public health recommendations, and research gaps.

Searching the literature

Literature review methods were approved by the full committee. Medline was the priority research database used to obtain articles for the review, though the Embase biomedical database and gray literature were secondarily reviewed when references in included articles were not included in the initial Medline search. Relevant articles cited in reviews or other primary studies also were included. Studies of marijuana use in humans were the primary focus of the review. Review of animal studies was reserved for specific topics with limited human research. In general, highly specialized research, such as brain imaging studies not directly associated with measurable clinical outcomes, was not evaluated in-depth unless an appropriately experienced reviewer was available. Research databases other than Medline were searched primarily when time allowed though very little additional data was found via these additional searches. All available peer-reviewed literature on a given topic identified through these methods was reviewed, regardless of positive or negative findings.

For Medline searches, the appropriate Medical Subject Heading (MeSH) terms were chosen for each topic and used for the search. To find newer articles relevant to the topic (those without MeSH yet applied), a list of specific terms was established for each topic area. For example, the general search string used for marijuana was: "Cannabis [mesh] OR Cannabis OR Marijuana OR Marihuana OR Ganja OR Hashish OR Hemp OR Bhang OR Tetrahydrocannabinol."

Rating the findings

Findings were rated as a high, medium, or low quality based on the strengths and limitations of the methods. Evaluation of the strengths and limitations was based on criteria in the "GRADE approach to evaluating the quality of evidence."[2] The GRADE system is a well-established method for systematic literature review and has been used by the Cochrane Collaboration, British Medical Journal, American College of Physicians, World Health Organization, and many others.[2]

High quality

The official definition is: "We are very confident that the true effect lies close to that of the estimate of the effect outlined in the study." High quality findings originate from well-designed and well-controlled studies with few limitations. In the context of observational epidemiology studies, which was the most common study type in this systematic review, high quality does not necessarily imply causation. High quality implies that an observed association persists between an exposure and effect in an appropriately-sized study population after adjusting for the appropriate confounders.

Medium quality

The official definition is: "We are moderately confident in the effect estimate outlined in the study. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different." Moderate quality findings originate from studies that may be well designed, but have limitations that affect the interpretation of the results. In the context of observational epidemiology studies, moderate quality implies the finding of an observed association with an interpretation that may be limited by a small study population or insufficient adjustment for important confounders.

Low quality

The official definition is: "Our confidence in the effect estimate outlined in the study is limited. The true effect may be substantially different from the estimate of the effect." Low quality findings originate from studies with significant methodological limitations that affect the interpretation of the results. In the context of observational epidemiology studies, low quality implies the finding of an observed association with an interpretation that is significantly restricted by major study limitations.

When critically reviewing the literature, all findings were initially considered medium quality and subsequently adjusted up or down in quality based on the strengths and limitations of the methodology. Quality ratings were applied to individual outcomes; therefore, it was possible for a single study to have multiple findings of differing quality. Criteria for evaluating strengths and limitations for this literature review included:

- Methods of selecting exposed and comparison groups
- Relevance of study population to the population of interest
- Method for describing extent of exposure or marijuana use (e.g., ever vs. never, frequency measured by days used, measured by number of times used, etc.)
- Method for measuring exposure (self-report or other methods)
- Adequacy of exposure and outcome group sizes

- Methods for measurement of outcome (validated tools, blinded if subjective, etc.)
- Adequacy of adjustment for confounders (e.g., tobacco smoking, other drug use, education level, etc.) for both positive effects and lack of positive effect
- Full vs. selective outcome reporting
- Effect size and width of confidence intervals
- Temporal relationship between exposure and effect
- Completeness of follow-up
- Adequacy of sample size for assessing lack of positive effect

Grouping the findings and weighing the evidence

Findings from individual studies were grouped together to facilitate weighing the overall scientific evidence. Findings were usually grouped based on outcome (health effect). However, in specific situations, findings could be further subdivided based on factors such as: age group of the exposed population, special subject circumstances such as pregnancy or breastfeeding, level or method of marijuana use, and time period since last use of marijuana. Standardized definitions of level of use and age groups were established to help facilitate the grouping of findings:

Levels of marijuana use

- Daily or near daily use: 5-7 days/week.
- Weekly use: 1-4 days/week.
- Less-than-weekly use: less than 1 day/week.
- Acute use: Used within the last few hours, such that the short-term effects or symptoms are still being experienced.

Age groups

- Child: up to 9 years of age.
- Adolescent: 9 through 17 years of age.
- Young Adult: 18 through 24 years of age.
- Adult: 25 through 64 years of age.
- Older Adult: 65 years of age and older.

Once findings were appropriately grouped, evidence statements (e.g., “We found moderate evidence that adolescents who regularly use marijuana are less likely than non-users to graduate high school.”) were drafted based on the following criteria which were approved by the committee:

Substantial evidence refers to:

1. Robust scientific findings that support the outcome with no credible opposing scientific evidence. This was defined as any of the following:
    - At least one high quality positive finding, plus supporting findings at least one of which is medium quality, with no opposing findings (must include studies of at least two cohorts)
    - At least three medium quality positive findings from studies of at least two cohorts, with no opposing findings
    - Many high and medium quality positive findings from studies of at least two cohorts that heavily outweigh opposing findings
    - At least two high quality positive findings from systematic reviews or meta-analyses published within the past 10 years
2. A robust body of scientific literature that has examined the outcome and failed to demonstrate a positive finding. This was defined as any of the following:
    - At least one high quality study lacking a positive finding, plus at least one medium quality supporting study, and no opposing findings (must include studies of at least two cohorts)
    - At least three medium quality studies lacking a positive finding from studies of at least two cohorts, and no opposing findings
    - Many high and medium quality studies lacking a positive finding that heavily outweigh opposing findings
    - At least two high quality systematic reviews or meta-analyses published within the past 10 years lacking positive findings

Moderate evidence refers to:

1. Strong scientific findings that support the outcome, but these findings have some limitations. This was defined as any of the following:
    - A single high quality positive finding , with no opposing findings
    - At least one medium quality positive finding, plus supporting findings with no opposing findings; supporting findings can include animal studies
    - Many medium and low quality positive findings from studies of at least two cohorts that heavily outweigh opposing findings
    - A single high quality positive finding from a systematic review or meta-analysis published within the past 10 years
2. A strong body of scientific literature that has examined the outcome and failed to demonstrate a positive finding. This was defined as any of the following:
    - A single high quality study lacking a positive finding, and no opposing findings
    - At least one medium quality study lacking a positive finding, plus supporting findings, and no opposing findings
    - Many medium and low quality studies lacking positive findings from studies of at least two cohorts that heavily outweigh opposing findings
    - A single high quality systematic review or meta-analysis published within the past 10 years lacking positive findings

Limited evidence refers to:

1. Modest scientific findings that support the outcome, but these findings have significant limitations. This was defined as any of the following:
    - A single medium quality positive finding
    - Two or more low quality positive findings from studies of at least two cohorts
    - One low quality positive finding supported by animal studies
    - Many low quality positive findings from studies of at least two cohorts that outweigh opposing findings
2. Modest scientific finding that have examined the outcome and failed to demonstrate a positive finding. This was defined as any of the following:
    - A single medium quality study lacking a positive finding
    - Two or more low quality studies lacking positive findings from studies of at least two cohorts
    - One low quality study lacking a positive finding supported by animal studies
    - Many low quality studies lacking positive findings from studies of at least two cohorts that outweigh opposing findings

Mixed evidence refers to:

Both supporting and non-supporting scientific findings for the outcome with neither direction dominating. This was defined as the following:

- Mixed findings, with neither direction dominating

Insufficient evidence refers to:

The outcome has not been sufficiently studied. This was defined as any of the following:

- A single low quality positive finding with no supporting findings
- There are no studies examining the outcome or relevant parameters

These criteria were translated into evidence statements using the following guidelines:

- Substantial positive evidence becomes: "We found substantial evidence…"
- Substantial lack of positive evidence becomes: "We found a substantial body of research that failed to show an association…"
- Moderate positive evidence becomes: "We found moderate evidence…"
- Moderate lack of positive evidence becomes: "We found a moderate body of research that failed to show an association…"
- Limited evidence becomes: "We found limited evidence…"
- Limited lack of positive evidence becomes: "We found a limited body of research that failed to show an association…"
- Mixed evidence becomes: "We found mixed evidence for whether or not…"
- Insufficient evidence becomes: "There is insufficient evidence to determine…"

Evidence statements were drafted by CDPHE technical staff, revised based on committee review and feedback from technical advisors and public stakeholders, and finally approved by a vote of the committee.

Translating the evidence statements into public health statements

Evidence Statements were translated into Public Health Statements using a standardized convention to ensure traceability back to the scientific literature. Public Health Statements were designed to accurately reflect the evidence statements using language that could be understood by the general public. The goals of the committee were to ensure that the Public Health Statements: 1) conveyed the volume and quality of research related to the outcome; 2) provided a generalized framework to allow consistent language for all findings regardless of topic; and 3) allowed the statement to stand on its own without context. These statements were drafted by CDPHE technical staff, revised based on comments from the committee, technical advisors and public stakeholders, and finally approved by a vote of the committee. The standardized convention used for the translation is shown below:

Standardized convention: <level of> marijuana use <by specific group> <strength of relationship> associated with <outcome>, <specific circumstances>.

A specific example: “Regular marijuana use by adolescents and young adults is strongly associated with impaired learning, memory, math and reading achievement, even after 28 days or more since last use.”

Standard language was chosen for the “strength of relationship,” corresponding to the level of evidence from the Evidence Statements:

- Substantial positive evidence becomes “is strongly associated”
- Substantial research lacking positive evidence becomes “an association is unlikely”
- Moderate positive evidence becomes “is associated”
- Moderate research lacking positive evidence becomes “an association appears unlikely”
- Limited evidence becomes “may be associated”
- Limited research lacking positive evidence becomes “might not be associated"
- Mixed evidence becomes “There is conflicting evidence for whether or not ___ is associated”

The wording “associated with” was specifically chosen to represent epidemiologic (i.e., statistical) associations, and NOT to imply causality.

Synthesizing the evidence: public health recommendations and research gaps

Based on the literature review, public health recommendations were drafted. The committee recommendations were separated into data quality issues, surveillance, and education recommendations. Data quality issues were defined as recommendations to improve current data collection deficiencies at the clinical or governmental level that prevent full analysis of public health outcomes related to marijuana use. Public health surveillance recommendations were based on improving capacity to detect an acute public health danger (e.g., real-time emergency department surveillance for detection of poisonings from contaminated products); the ability to characterize chronic public health dangers to support policy and other intervention decisions (e.g., surveillance of marijuana-related traffic fatalities or skiing injuries); or the ability to generate epidemiologic data (e.g. BRFSS survey questions), to contribute to planning and evaluating population level interventions. Education recommendations were included to ensure health-based information on marijuana use is provided to the appropriate target audiences.

In addition to public health recommendations, important research gaps related to the population-based health effects of marijuana use were identified during the literature review process. These research gaps were based on common limitations of existing research (e.g., not enough focus on occasional marijuana use, distinct from regular or heavy use); exposures not sufficiently studied (e.g., dabbing or edibles); outcomes not sufficiently studied; or issues important to public education or policymaking (e.g., impairment in frequent users). These research gaps provide an important framework for prioritizing research related to marijuana use and public health. Statements articulating the public health recommendations and research gaps were initially drafted by CDPHE technical staff, revised based on comments from the committee, technical advisors and public stakeholders, and finally approved by a vote of the committee.

Consensus and approval by the committee

CDPHE technical staff formally presented findings, evidence statements, public health statements, public health recommendations and research gaps to the committee for review and revision during open public meetings. During these open public meetings, interested stakeholders and members of the general public were invited to provide comments relevant to the topic presented. The committee chair facilitated a consensus process to ensure all committee members could agree on the scientific evaluation and wording. Once consensus was achieved, the committee voted to officially accept these statements and recommendations.

Procedures for reviewing and updating documents

The Retail Marijuana Public Health Advisory Committee will continue to meet quarterly throughout 2017 and 2018. All approved evidence statements, public health statements, public health recommendations, and research gaps will be reviewed and updated if needed on a two-year cycle. The committee also will expand the reviewed literature to include new topics as new research becomes available or new public health concerns arise.

References

1. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol*. 2009;62(10):1006-1012.
2. GRADE guidelines - best practices using the GRADE framework. *GRADE working group* http://training.cochrane.org/path/grade-approach-evaluating-quality-evidence-pathway, 2014.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 2

Marijuana Use Among Adolescents and Young Adults

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2016)

Kristina Phillips, PhD
Clinical Psychologist, Professor
School of Psychological Sciences, University of Northern Colorado
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2014, 2016)

Reviewer

George Sam Wang, MD
Assistant Professor, University of Colorado Anschutz Medical Campus
Emergency Medicine Physician and Medical Toxicologist, Children's Hospital Colorado
Volunteer Faculty, Rocky Mountain Poison and Drug Center
(2014, 2016)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of potential health effects among adolescents and young adults who use marijuana. In particular, the relationships between marijuana use and cognitive abilities, academic performance, mental health and future substance use were reviewed.

Adolescence through young adulthood is a critical window for social and emotional development and for neurocognitive functioning. It also is a time that has an increased risk of developing mental health disorders, including depression and anxiety. In Colorado, almost 23 percent of students who started high school in 2011 did not graduate by 2015.[1] Almost 30 percent of Colorado high school students in 2015 felt sad or hopeless almost every day for two weeks or more, an indicator for depression, and 6 percent attempted suicide.[2]

A growing body of literature suggests parts of the brain continue to develop well into a person's twenties.[3] Alcohol use is known to affect this development and have negative cognitive, mental health and social consequences.[4,5] This raises concern that marijuana use may do the same. The impact of marijuana use on brain development, and on future cognitive abilities and mental health, has been the subject of much public debate. A recent example is the claim that marijuana use lowers IQ[6] and the counterclaim that it does not.[7] While most health effects of interest are long-term, there is also concern that marijuana's acute health effects, which include fragmented thinking and anxiety,[8] might lead to rash decisions or abnormal behavior. One prominent case in Colorado was a 19-year-old college student who behaved strangely and fell to his death after using marijuana.[9]

Analyses of 2015 Behavioral Risk Factor Surveillance System data, completed for this report, estimated that 26 percent of young adults in Colorado ages 18-25 have used marijuana within the last month. About half of them use daily or near-daily. 2015 Healthy Kids Colorado Survey data, also analyzed for this report, estimate that 21 percent of Colorado high school students used marijuana within the last month. With that many adolescents and young adults using marijuana at least monthly, the potential adverse health effects are a significant public health concern. It is of critical importance to evaluate what the scientific literature says about the health effects of marijuana use among adolescents and young adults.

Definitions

Age groups

- Adolescents: 9 to 17 years of age.
- Young adults: 18 to 24 years of age.

Levels of marijuana use

- Daily or near-daily use: 5-7 days/week.
- Weekly use: 1-4 days/week.
- Less-than-weekly use: less than 1 day/week.

Cannabis use disorder – a formal diagnosis indicating two or more of these factors: hazardous use, social/interpersonal problems related to use, neglects major roles in order to use, legal problems, withdrawal, tolerance, uses more or longer than planned, repeated attempts to quit or reduce use, much time is spent using, physical or psychological problems related to use, and/or gives up activities in order to use;[10] commonly called addiction.

Cognitive abilities - brain-based skills we need to carry out any task from the simplest to the most complex, which include retrieving information from memory, using logic to solve problems, communicating through language, mentally visualizing a concept, and focusing attention when distractions are present.

Illicit drugs – fall into two categories: 1) Those drugs that are illegal to process, sell, and consume; includes cocaine, methamphetamine, ecstasy and heroin. 2) Those drugs that are legal to process, sell, and consume when prescribed by a physician, but are then misused or used without a prescription; includes prescription pain medication and prescription sedatives.

Intelligence quotient (IQ) - a number used to express the apparent relative intelligence of a person, determined by one's performance on a standardized intelligence test relative to the average performance of others of the same age.

Marijuana addiction - an informal term which is more commonly used than cannabis use disorder, but the two are considered equivalent by the committee and many mental health professionals.

Psychotic disorders – these include schizophrenia, schizoaffective, schizophreniform, schizotypal, and delusional disorders. These formal diagnoses are made when a combination of psychotic symptoms are present (possibly combined with other mental health symptoms), the symptoms cause significant problems with work, relationships or self-care and they have been present for six months or longer.[10]

Psychotic symptoms - these include auditory or visual hallucinations, difficulty separating real from imagined, perception that self or others can read minds, perceived ability to predict the future, feeling that an outside force is controlling thoughts or actions, fear that someone intends to harm them, belief they have supernatural gifts, apathy, social withdrawal, absent or blunted emotions, occurrences of unclear speech or inability to speak or difficulty organizing thoughts to complete activities.[10]

Key findings

The committee's strongest findings are related to reduced cognitive abilities and academic achievement, problem use or addiction[‡] to marijuana or other substances after adolescence and experiencing psychotic symptoms or diagnoses. Weekly marijuana use by adolescents is associated with impaired learning, memory, math and reading, even 28 days after last use. Weekly use is also associated with failure to graduate from high school and may be associated with failure to attain a college degree. Adolescents and young adults who use marijuana are more likely to experience psychotic symptoms as adults, such as hallucinations, paranoia, delusional beliefs and feeling emotionally unresponsive. Daily or near-daily use is associated with developing a psychotic disorder such as schizophrenia in adulthood.

Concerning future substance use, marijuana use among adolescents and young adults is associated with future tobacco and illicit drug use and high-risk use of alcohol. In addition, marijuana users can develop addiction[‡] to marijuana. Strong evidence shows that treatment for marijuana addiction[‡] can decrease use and dependence. Additionally, marijuana users who quit have lower risks of cognitive and mental health outcomes than those who continue to use. Finally, the committee found conflicting evidence regarding the potential effect of adolescent marijuana use on future IQ.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

[‡] In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

Recommendations

A number of important public health recommendations were identified. There were significant limitations in the reviewed literature regarding the characterization of marijuana use. To facilitate future study of the effects of marijuana, it is important to improve data quality by systematically collecting information on the frequency, amount, potency, and method of marijuana use in both public health surveillance and clinical settings.

It also is important to better characterize the prevalence of marijuana use among Colorado adolescents and young adults. Questions regarding marijuana use should be added (or continued) on population-based surveys such as the Behavioral Risk Factors Surveillance System (BRFSS), the Healthy Kids Colorado Survey (HKCS) and the National College Health Assessment (NCHS). In order to better assess potential adverse outcomes, adolescent and young adult hospitalizations and emergency department visits related to marijuana should be monitored using de-identified data available from the Colorado Hospital Association. Addiction[‡] treatment admissions should be monitored using data from the Colorado Office of Behavioral Health, and the prevalence of addiction[‡] among different groups should be obtained.

Public education on the potential effects of marijuana use also is important and should be designed for adolescents and young adults themselves as well as parents and caregivers. Educational materials for schools and colleges should be accurate and could be combined with other behavioral education. Education should include information on what addiction looks like. Finally, availability and access to treatment should be promoted.

The committee also identified a number of important research gaps. A common theme among the research gaps was the need for studies with better defined marijuana-use histories, including frequency, amount, potency, and method of marijuana use and length of abstinence. A particular need was identified for evaluation of effects separately for less-than-weekly users versus daily or near-daily users. Studies of psychological outcomes suggest a possible difference between males and females, and future studies should evaluate them separately. Finally, more studies are needed that examine marijuana use as a predictor of risk behaviors, especially among adolescents, college attending young adults and non-college attending young adults.

[‡] In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

Table 1 Findings summary: Marijuana use among adolescents and young adults

For information on the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
Cognitive and academic	Less high school graduation	Impaired cognitive abilities and academic performance after 28 days abstinence	Less likely to earn college degree	Lower IQ after brief abstinence	Lower future IQ scores
Mental health	Psychotic symptoms in adulthood	Psychotic disorder in adulthood (daily or near-daily users)			Depression or anxiety after adolescence
					Suicidal thoughts or attempts
Substance use, abuse and addiction	Can develop marijuana addiction‡	Increased marijuana use and addiction‡ after adolescence			
		Alcohol or tobacco use and addiction‡ after adolescence			
	Other illicit drug use and addiction‡ after adolescence				
Benefits of quitting	Treatment for marijuana addiction‡ can reduce use and dependence	Quitting marijuana lowers risk of cognitive and mental health effects			

‡ In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix F.

Cognitive and academic

1. We found **MODERATE** evidence that adolescents and young adults who use marijuana weekly or more frequently are more likely than non-users to have ongoing impairment of cognitive and academic abilities for at least 28 days after last use.[11-14]
2. We found **INSUFFICIENT** evidence to determine whether or not adolescents who use marijuana are more likely than non-users to score lower on IQ tests after brief abstinence.[15,16] (Revised*)
3. We found **MIXED** evidence for whether or not adolescent marijuana use affects future IQ scores.[17-19] (Added*)
4. We found **SUBSTANTIAL** evidence that adolescents who use marijuana weekly or more frequently are less likely than non-users to graduate from high school.[20-24] (Revised[*])
5. We found **LIMITED** evidence that adolescents and young adults who use marijuana weekly or more frequently are less likely than non-users to attain a college degree.[23,25-27]

Mental health

6. We found **SUBSTANTIAL** evidence that adolescents and young adults who use marijuana are more likely than non-users to develop psychotic symptoms in adulthood, and this likelihood increases with more frequent use.[28-32] (Revised*)
7. We found **MODERATE** evidence that adolescents and young adults who use marijuana daily or near-daily are more likely than non-users to develop psychotic disorders like schizophrenia in adulthood.[28,33-35] (Revised*)
8. We found **MIXED** evidence for whether or not adolescent and young adult marijuana users are more likely than non-users to have symptoms or a diagnosis of anxiety in adulthood.[33,36-39]
9. We found **MIXED** evidence for whether or not adolescent and young adult marijuana users are more likely than non-users to have symptoms or a diagnosis of depression in adulthood.[32,33,36-42]
10. We found **MIXED** evidence for whether or not adolescent and young adult marijuana users are more likely than non-users to have suicidal thoughts or attempt suicide.[42-46]

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix F for dates of most recent literature review.

Substance use, abuse and addiction[‡]

11. We found SUBSTANTIAL evidence that marijuana users can develop cannabis use disorder, including adolescent and young adult users.[47,48] (Added*)
12. We found MODERATE evidence that adolescent and young adult marijuana users are more likely than non-users to increase their use and to develop cannabis use disorder in adulthood.[21,22,49]
13. We found MODERATE evidence that adolescent and young adult marijuana users are more likely than non-users to use and be addicted[‡] to alcohol or tobacco in adulthood.[21,22,50,51]
14. We found SUBSTANTIAL evidence that adolescent and young adult marijuana users are more likely than non-users to use and be addicted[‡] to illicit drugs in adulthood.[21,26,38,50,52-56]

Benefits of quitting

15. We found MODERATE evidence that adolescent and young adult marijuana users who quit have lower risks of cognitive and mental health outcomes than those who continue to use.[15,16,41,50]
16. We found SUBSTANTIAL evidence that some adolescent and young adult marijuana users who receive treatment for cannabis use disorder (including cognitive behavioral therapy, motivational enhancement/interviewing, multidimensional family therapy and/or abstinence-based contingency management) can decrease their marijuana use and dependence.[57-61] (Added[*])

[‡] In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix F for dates of most recent literature review.

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

Cognitive and academic

1. Weekly or more frequent marijuana use by adolescents and young adults is associated with impaired learning, memory, math and reading achievement, even 28 days after last use.
    a. These impairments increase with more frequent marijuana use.
2. There is conflicting evidence on whether or not adolescent marijuana use is associated with changes in future IQ scores. (Added*)
3. Weekly or more frequent marijuana use by adolescents is strongly associated with failure to graduate from high school. (Revised*)
4. Weekly or more frequent marijuana use by adolescents and young adults may be associated with not attaining a college degree.

Mental health

5. Marijuana use by adolescents and young adults is strongly associated with developing psychotic symptoms in adulthood, such as hallucinations, paranoia and delusional beliefs. (Revised*)
    a. This risk is higher with more frequent marijuana use.
    b. This risk may be higher among those who start using marijuana at a younger age.
6. Daily or near-daily marijuana use by adolescents and young adults is associated with developing a psychotic disorder such as schizophrenia in adulthood. (Revised*)

Substance use, abuse and addiction‡

7. Some marijuana users become addicted‡ to marijuana. Starting marijuana use during adolescence or young adulthood is associated with future marijuana addiction‡. (Revised*)
8. Marijuana use by adolescents and young adults - even less-than-weekly use - is associated with future high-risk use of alcohol, tobacco, and other drugs like cocaine, ecstasy, opioids and methamphetamine.

Benefits of quitting

9. Adolescents and young adults who quit marijuana use have a lower risk of developing cognitive impairment or mental health disorders than those who continue to use.
10. There are treatments for marijuana addiction‡ that can reduce use and dependence. (Added*)

‡ In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

* Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix F for dates of most recent literature review.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub-populations.

Data quality

- Standardization of data collection on frequency, amount, potency, and method of marijuana use in medical records and other surveillance data sources.
- Specify marijuana use as separate from other drug use in medical records and other surveillance data sources.

Surveillance

- Monitor adolescent use and the factors associated with adolescents initiating use, through surveys such as the Healthy Kids Colorado Survey (HKCS).
- Monitor young adult use and the factors associated with initiation of use, through surveys such as the Behavioral Risk Factor Surveillance Survey (BRFSS).
- Monitor National College Health Assessment data, Colorado and national, for comparisons related to college students.
- Monitor adolescent and young adult marijuana-related hospitalizations (both psychiatric and non-psychiatric) and emergency department visits.
- Monitor adolescent and young adult cannabis use disorder treatment rates.
- Evaluate prevalence of cannabis use disorder among adolescents and young adults and monitor trends.

Education

- Public education for adolescents, young adults, parents and caregivers, using optimal methods including social media.
- Develop accurate educational materials for schools and colleges, either stand-alone or integrated with other behavioral education.
- Promote accurate information about cannabis use disorder.
- Promote availability and access to treatment for cannabis use disorder.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Research studies on all outcomes should evaluate different levels of use separately, such as daily or near-daily, weekly and less-than-weekly use.
- Research studies on all outcomes should include former users and continuing users with comparable prior use frequency and age of onset to help separate long-term effects from the effects of current use.
- Additional studies with more varied time periods of abstinence are needed to assess the duration of cognitive impact of marijuana use.
- Studies evaluating the potential psychological outcomes of marijuana use should have separate evaluations of males and females.
- Increase the number of studies that examine marijuana use as a predictor of risk behaviors, especially among adolescents, college attending young adults and non-college attending young adults.
- More studies are needed to assess the risk of increasing use or developing cannabis use disorder among groups with different levels of use, especially for less-than-weekly use. These should also assess this risk based on different ages of initiating use.
- Studies are needed to compare the factors associated with adolescents initiating use between states with different legal status. These studies should include specific factors such as parental influences, marijuana marketing and marijuana merchandising.
- Better studies are needed to assess causality rather than only association, which may be confounded by other factors.

References

1. Colorado Department of Education. Graduation Statistics. 2016; https://www.cde.state.co.us/cdereval/gradcurrent,.
2. Colorado Department of Public Health and Environment. Adolescent Health Data, Healthy Kids Colorado Survey. *Colorado Health and Environmental Data* 2015; http://www.chd.dphe.state.co.us/topics.aspx?q=Adolescent_Health_Data, 2016.
3. Johnson SB, Blum RW, Giedd JN. Adolescent maturity and the brain: the promise and pitfalls of neuroscience research in adolescent health policy. *J Adolesc Health*. 2009;45(3):216-221.
4. Skala K, Walter H. Adolescence and Alcohol: a review of the literature. *Neuropsychiatr*. 2013;27(4):202-211.
5. White A, Hingson R. The burden of alcohol use: excessive alcohol consumption and related consequences among college students. *Alcohol Res*. 2013;35(2):201-218.
6. Bradberry T. Study Shows Heavy Adolescent Pot Use Permanently Lowers IQ. *Forbes*, http://www.forbes.com/sites/travisbradberry/2015/02/10/new-study-shows-smoking-pot-permanently-lowers-iq/#7d2d0562185c2015.
7. Ingraham C. No, marijuana use doesn't lower your IQ. *The Washington Post*. October 22, 2014, 2014.
8. Grotenhermen F. Pharmacokinetics and pharmacodynamics of cannabinoids. *Clin Pharmacokinet*. 2003;42(4):327-360.
9. Nicholson K. Man who plunged from Denver balcony ate 6x recommended amount of pot cookie. *The Denver Post*. April 17, 2014, 2014.
10. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. Washington , DC2013.
11. Pope HG, Jr., Gruber AJ, Hudson JI, Cohane G, Huestis MA, Yurgelun-Todd D. Early-onset cannabis use and cognitive deficits: what is the nature of the association? *Drug Alcohol Depend*. 2003;69(3):303-310.
12. Bolla KI, Brown K, Eldreth D, Tate K, Cadet JL. Dose-related neurocognitive effects of marijuana use. *Neurology*. 2002;59(9):1337-1343.
13. Medina KL, Hanson KL, Schweinsburg AD, Cohen-Zion M, Nagel BJ, Tapert SF. Neuropsychological functioning in adolescent marijuana users: subtle deficits detectable after a month of abstinence. *J Int Neuropsychol Soc*. 2007;13(5):807-820.
14. Hooper SR, Woolley D, De Bellis MD. Intellectual, neurocognitive, and academic achievement in abstinent adolescents with cannabis use disorder. *Psychopharmacology (Berl)*. 2014;231(8):1467-1477.
15. Fried PA, Watkinson B, Gray R. Neurocognitive consequences of marihuana--a comparison with pre-drug performance. *Neurotoxicol Teratol*. 2005;27(2):231-239.
16. Fried P, Watkinson B, James D, Gray R. Current and former marijuana use: preliminary findings of a longitudinal study of effects on IQ in young adults. *CMAJ*. 2002;166(7):887-891.
17. Jackson NJ, Isen JD, Khoddam R, et al. Impact of adolescent marijuana use on intelligence: Results from two longitudinal twin studies. *Proc Natl Acad Sci U S A*. 2016;113(5):E500-508.
18. Meier MH, Caspi A, Ambler A, et al. Persistent cannabis users show neuropsychological decline from childhood to midlife. *Proc Natl Acad Sci U S A*. 2012;109(40):E2657-2664.

19. Mokrysz C, Landy R, Gage SH, Munafo MR, Roiser JP, Curran HV. Are IQ and educational outcomes in teenagers related to their cannabis use? A prospective cohort study. *J Psychopharmacol*. 2016;30(2):159-168.
20. Fergusson DM, Horwood LJ, Beautrais AL. Cannabis and educational achievement. *Addiction*. 2003;98(12):1681-1692.
21. Lynne-Landsman SD, Bradshaw CP, Ialongo NS. Testing a developmental cascade model of adolescent substance use trajectories and young adult adjustment. *Dev Psychopathol*. 2010;22(4):933-948.
22. Brook JS, Balka EB, Whiteman M. The risks for late adolescence of early adolescent marijuana use. *Am J Public Health*. 1999;89(10):1549-1554.
23. Horwood LJ, Fergusson DM, Hayatbakhsh MR, et al. Cannabis use and educational achievement: findings from three Australasian cohort studies. *Drug Alcohol Depend*. 2010;110(3):247-253.
24. Stiby AI, Hickman M, Munafo MR, Heron J, Yip VL, Macleod J. Adolescent cannabis and tobacco use and educational outcomes at age 16: birth cohort study. *Addiction*. 2015;110(4):658-668.
25. Fergusson DM, Boden JM. Cannabis use and later life outcomes. *Addiction*. 2008;103(6):969-976; discussion 977-968.
26. Fergusson DM, Horwood LJ. Does cannabis use encourage other forms of illicit drug use? *Addiction*. 2000;95(4):505-520.
27. Baggio S, Iglesias K, Deline S, et al. Not in Education, Employment, or Training status among young Swiss men. Longitudinal associations with mental health and substance use. *J Adolesc Health*. 2015;56(2):238-243.
28. van Os J, Bak M, Hanssen M, Bijl RV, de Graaf R, Verdoux H. Cannabis use and psychosis: a longitudinal population-based study. *Am J Epidemiol*. 2002;156(4):319-327.
29. Kuepper R, van Os J, Lieb R, Wittchen HU, Hofler M, Henquet C. Continued cannabis use and risk of incidence and persistence of psychotic symptoms: 10 year follow-up cohort study. *Bmj*. 2011;342:d738.
30. Henquet C, Krabbendam L, Spauwen J, et al. Prospective cohort study of cannabis use, predisposition for psychosis, and psychotic symptoms in young people. *Bmj*. 2005;330(7481):11.
31. Fergusson DM, Horwood LJ, Ridder EM. Tests of causal linkages between cannabis use and psychotic symptoms. *Addiction*. 2005;100(3):354-366.
32. Arseneault L, Cannon M, Witton J, Murray RM. Causal association between cannabis and psychosis: examination of the evidence. *Br J Psychiatry*. 2004;184:110-117.
33. Bechtold J, Simpson T, White HR, Pardini D. Chronic Adolescent Marijuana Use as a Risk Factor for Physical and Mental Health Problems in Young Adult Men. *Psychol Addict Behav*. 2015;10.1037/adb0000103.
34. Di Forti M, Marconi A, Carra E, et al. Proportion of patients in south London with first-episode psychosis attributable to use of high potency cannabis: a case-control study. *Lancet Psychiatry*. 2015;2(3):233-238.
35. Zammit S, Allebeck P, Andreasson S, Lundberg I, Lewis G. Self reported cannabis use as a risk factor for schizophrenia in Swedish conscripts of 1969: historical cohort study. *Bmj*. 2002;325(7374):1199.
36. Miettunen J, Murray GK, Jones PB, et al. Longitudinal associations between childhood and adulthood externalizing and internalizing psychopathology and adolescent substance use. *Psychol Med*. 2013;10.1017/S0033291713002328:1-12.
37. Degenhardt L, Coffey C, Romaniuk H, et al. The persistence of the association between adolescent cannabis use and common mental disorders into young adulthood. *Addiction*. 2013;108(1):124-133.

38. Zaman T, Malowney M, Knight J, Boyd JW. Co-Occurrence of Substance-Related and Other Mental Health Disorders Among Adolescent Cannabis Users. *J Addict Med*. 2015;10.1097/adm.0000000000000138.

39. Gage SH, Hickman M, Heron J, et al. Associations of cannabis and cigarette use with depression and anxiety at age 18: findings from the Avon Longitudinal Study of Parents and Children. *PLoS One*. 2015;10(4):e0122896.

40. Horwood LJ, Fergusson DM, Coffey C, et al. Cannabis and depression: an integrative data analysis of four Australasian cohorts. *Drug Alcohol Depend*. 2012;126(3):369-378.

41. Pahl K, Brook JS, Koppel J. Trajectories of marijuana use and psychological adjustment among urban African American and Puerto Rican women. *Psychol Med*. 2011;41(8):1775-1783.

42. Rasic D, Weerasinghe S, Asbridge M, Langille DB. Longitudinal associations of cannabis and illicit drug use with depression, suicidal ideation and suicidal attempts among Nova Scotia high school students. *Drug Alcohol Depend*. 2013;129(1-2):49-53.

43. Kokkevi A, Richardson C, Olszewski D, Matias J, Monshouwer K, Bjarnason T. Multiple substance use and self-reported suicide attempts by adolescents in 16 European countries. *Eur Child Adolesc Psychiatry*. 2012;21(8):443-450.

44. Consoli A, Peyre H, Speranza M, et al. Suicidal behaviors in depressed adolescents: role of perceived relationships in the family. *Child Adolesc Psychiatry Ment Health*. 2013;7(1):8.

45. Spears M, Montgomery AA, Gunnell D, Araya R. Factors associated with the development of self-harm amongst a socio-economically deprived cohort of adolescents in Santiago, Chile. *Soc Psychiatry Psychiatr Epidemiol*. 2014;49(4):629-637.

46. Zhang X, Wu LT. Suicidal ideation and substance use among adolescents and young adults: a bidirectional relation? *Drug Alcohol Depend*. 2014;142:63-73.

47. 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.

48. Hasin DS, Saha TD, Kerridge BT, et al. Prevalence of Marijuana Use Disorders in the United States Between 2001-2002 and 2012-2013. *JAMA Psychiatry*. 2015;72(12):1235-1242.

49. Swift W, Coffey C, Carlin JB, Degenhardt L, Patton GC. Adolescent cannabis users at 24 years: trajectories to regular weekly use and dependence in young adulthood. *Addiction*. 2008;103(8):1361-1370.

50. Swift W, Coffey C, Degenhardt L, Carlin JB, Romaniuk H, Patton GC. Cannabis and progression to other substance use in young adults: findings from a 13-year prospective population-based study. *J Epidemiol Community Health*. 2012;66(7):e26.

51. Rubinstein ML, Rait MA, Prochaska JJ. Frequent marijuana use is associated with greater nicotine addiction in adolescent smokers. *Drug Alcohol Depend*. 2014;141:159-162.

52. Fergusson DM, Boden JM, Horwood LJ. Cannabis use and other illicit drug use: testing the cannabis gateway hypothesis. *Addiction*. 2006;101(4):556-569.

53. Schepis TS, Krishnan-Sarin S. Characterizing adolescent prescription misusers: a population-based study. *J Am Acad Child Adolesc Psychiatry*. 2008;47(7):745-754.

54. Fiellin LE, Tetrault JM, Becker WC, Fiellin DA, Hoff RA. Previous use of alcohol, cigarettes, and marijuana and subsequent abuse of prescription opioids in young adults. *J Adolesc Health*. 2013;52(2):158-163.

55. Nakawaki B, Crano WD. Predicting adolescents' persistence, non-persistence, and recent onset of nonmedical use of opioids and stimulants. *Addict Behav*. 2012;37(6):716-721.

56. Moss HB, Chen CM, Yi HY. 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;136:51-62.

57. Stanger C, Ryan SR, Scherer EA, Norton GE, Budney AJ. Clinic- and home-based contingency management plus parent training for adolescent cannabis use disorders. *J Am Acad Child Adolesc Psychiatry*. 2015;54(6):445-453 e442.

58. Stanger C, Budney AJ, Kamon JL, Thostensen J. A randomized trial of contingency management for adolescent marijuana abuse and dependence. *Drug Alcohol Depend*. 2009;105(3):240-247.

59. Rigter H, Henderson CE, Pelc I, et al. Multidimensional family therapy lowers the rate of cannabis dependence in adolescents: a randomised controlled trial in Western European outpatient settings. *Drug Alcohol Depend*. 2013;130(1-3):85-93.

60. Hendriks V, van der Schee E, Blanken P. Treatment of adolescents with a cannabis use disorder: main findings of a randomized controlled trial comparing multidimensional family therapy and cognitive behavioral therapy in The Netherlands. *Drug Alcohol Depend*. 2011;119(1-2):64-71.

61. Dennis M, Godley SH, Diamond G, et al. The Cannabis Youth Treatment (CYT) Study: main findings from two randomized trials. *J Subst Abuse Treat*. 2004;27(3):197-213.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 3

Marijuana Use and Cancer

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Ken Gershman, MD, MPH
Manager
Medical Marijuana Research Grants Program, Colorado Department of Public Health and Environment
(2016)

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2014)

Madeline Morris, BS
Graduate Student, Colorado School of Public Health
(2014)

Todd Carlson, MD
Internal Medicine Resident, University of Colorado
(2014)

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health, and Toxicology, Colorado Department of Public Health and Environment
(2014)

David Goff Jr., MD, PhD, FACP, FAHA
Dean and Professor, Colorado School of Public Health
(2014)

Reviewers

Russell Bowler, MD, PhD
Professor of Medicine, National Jewish Health and University of Colorado
(2016)

Ken Gershman, MD, MPH
Manager
Medical Marijuana Research Grants Program, Colorado Department of Public Health and Environment
(2014)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana use and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of different forms of cancer relative to marijuana use, as well as the chemicals released in marijuana smoke and vapor.

Cancer is a disease that affects all ages and demographics. More than 20,000 Coloradoans are diagnosed with cancer each year,[1] with nearly one-third eventually dying from it.[2] Many behavioral factors are known to increase cancer risk, including tobacco smoking,[3] alcohol use,[4] and poor diet.[5] This raises concern that marijuana use may also increase cancer risk. It is important to identify any cancer-causing chemicals that marijuana users are exposed to and to investigate possible connections between marijuana use and various forms of cancer.

Definitions

Cancer-causing chemicals – chemicals known to cause cancer in humans, including polycyclic aromatic hydrocarbons

Combustion by-products – chemicals produced when a material is burned. These chemicals including carbon monoxide and polycyclic aromatic hydrocarbons.

Marijuana combustion - the heating of marijuana flower or concentrate by applying a direct heat source of 230 degrees Celsius or above in order to produce smoke for inhalation. Combustion methods include burning a joint, blunt, pipe, or bong bowl.

Mainstream smoke – also known as firsthand smoke, it is the smoke that a smoker inhales from a lit cigarette, pipe, or joint and then exhales.

Polycyclic aromatic hydrocarbons - a group of more than 100 different chemicals released from burning coal, oil, gasoline, trash, tobacco, wood, or other organic substances.

Sidestream smoke – the smoke that wafts off the end of a lit cigarette, pipe or joint into the surrounding air.

Secondhand smoke – the smoke that is inhaled by non-smokers when near to a person smoking, also known as passive exposure.

Vaporization of marijuana (vaping) - a method of marijuana use in which marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

Water pipe - a pipe for smoking tobacco, marijuana, etc., that draws the smoke through water to cool it. Examples are a hookah and a bong.

Key findings

Strong evidence shows that marijuana smoke contains many of the same cancer-causing chemicals found in tobacco smoke. Marijuana smoke from water pipes or bongs may contain more cancer-causing chemicals than smoke from a marijuana joint. On the other hand, marijuana vapor may contain fewer cancer-causing chemicals than smoke from a marijuana joint.

Most lung cancer studies have used the concept of “joint-years” as a measure of total cumulative marijuana smoking. A “joint-year” is the equivalent of smoking one joint per day for a year. Levels of cumulative use in these studies tended to divide into people who have smoked more than 10 joint-years and people who have smoked fewer than 10 joint years. There is conflicting research for whether or not smoking *more* than 10 joint-years is associated with lung cancer. For those who have smoked *fewer* than 10 joint-years, an association appears unlikely.

Limited evidence suggests an association between marijuana use and both testicular (nonseminoma) and prostate cancers. On the other hand, the limited evidence available concerning cancers of the bladder, head and neck suggests that they might not have any association with marijuana use.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

The committee recommends improved documentation of cumulative lifetime marijuana use history for individuals diagnosed with cancer, including methods of use. Public health should monitor the prevalence of relevant cancers through the Colorado Central Cancer Registry, and educate the public on the potential for additive risks to lung health related to smoking both tobacco and marijuana.

Additional study is needed about the possible associations between marijuana use and various types of cancer. These should include improved methods to assess cumulative marijuana exposure to facilitate comparisons between studies and relevance to the clinical setting. They should include older age groups separately, due to the increased risk of cancer. Finally, they should include adequate numbers of non-tobacco smokers, to eliminate the confounding introduced by tobacco smoking.

Table 1 Findings summary: Marijuana use and cancer

For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
Chemicals in MJ smoke or vapor	Marijuana smoke contains same cancer-causing chemicals as tobacco smoke		Water-pipe smoke has more cancer-causing chemicals than smoke from joints		
			Vaporized marijuana has fewer cancer-causing chemicals than smoke from joints		
Cancer and pre-cancerous lesions	Pre-cancerous lesions with daily or near-daily use	Failure to show association with lung cancer for less than 10 joint-years cumulative use	Increased risk of nonseminoma testicular cancer		Association with lung cancer for more than 10 joint-years cumulative use
			Increased risk of prostate cancer		
			Failure to show association with bladder cancer		
			Failure to show association with head and neck cancer		

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix G.

Chemical content of marijuana smoke or vapor

1. We found **SUBSTANTIAL** evidence that marijuana smoke, both mainstream and sidestream, contains many of the same cancer-causing chemicals as tobacco smoke.[6-10]
2. We found **LIMITED** evidence from simulated smoking studies that smoke from water pipes or bongs contains more cancer-causing chemicals per milligram of THC compared to smoke from unfiltered joints.[6,11]
3. We found **LIMITED** evidence that marijuana vaporizers produce fewer combustion by-products, including carbon monoxide and polycyclic aromatic hydrocarbons, compared with smoking marijuana.[10,12,13] (Added*)

Cancer and pre-cancerous lesions

4. We found **SUBSTANTIAL** evidence that daily or near-daily marijuana smoking is associated with pre-malignant lesions in the airway.[14-16]
5. We found **MIXED** evidence for whether or not cumulative levels of marijuana smoking greater than the equivalent of one joint per day for 10 years are associated with lung cancer.[17-21] (Revised*)
6. We found a **MODERATE** body of research that failed to show an association between cumulative levels of marijuana smoking less than the equivalent of one joint per day for 10 years and lung cancer.[17-22] (Revised*)
7. We found **LIMITED** evidence that marijuana use among adult males increases risk of nonseminoma testicular cancer.[23-25]
8. We found **LIMITED** evidence [1]that marijuana use among adult males increases risk of prostate cancer.[22]
9. We found a **LIMITED** body of research that failed to show an association between marijuana use by adults and transitional cell carcinoma of the bladder.[22,26,27] (Revised*)
10. We found a **LIMITED** body of research that failed to show an association between marijuana use by adults and head and neck cancer.[28] (Added*)

*Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix G for dates of most recent literature review.

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

1. Marijuana smoke, both firsthand and secondhand, contains many of the same cancer-causing chemicals as tobacco smoke.
2. Marijuana smoke from water pipes or bongs may contain more cancer-causing chemicals than smoke from a joint.
3. Vaporized marijuana may contain fewer cancer-causing chemicals than smoke from a joint. (Added*)
4. Daily or near-daily marijuana smoking is strongly associated with pre-malignant lesions that may lead to cancer in the airways of your lungs.
5. There is conflicting research on whether or not smoking marijuana more than a joint per day for 10 years is associated with lung cancer. (Revised*)
6. An association appears unlikely between marijuana smoking and lung cancer when used less than a joint per day for 10 years. (Revised*)
7. Marijuana use may be associated with prostate cancer or nonseminoma testicular cancer.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality

- Improved documentation of cumulative lifetime marijuana use history for individuals diagnosed with cancer, including methods of use.

Surveillance

- Monitor the prevalence of relevant cancers through the Colorado Central Cancer Registry.

Education

- Educate the public on the [2]potential for additive risks to lung health related to smoking both tobacco and marijuana.

*Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix G for dates of most recent literature review.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Improved studies assessing the risk of lung and oropharyngeal cancers related to marijuana use, especially including adequate numbers of non-tobacco smokers, assessment of cumulative marijuana exposure, and older age groups.
- Additional, high quality studies assessing the risk of relevant non-respiratory-tract cancers related to marijuana use, using good methods to assess cumulative marijuana exposure.

References

1. Colorado Department of Public Health and Environment. *Cancer in Colorado 2003-2012, Statistical Tables and Highlights All Cancers Combined Number of Diagnosed Cancers and Average Annual Age-Adjusted Incidence Rates per 100,000 by Sex, County/Region, Time Period, Colorado 2003-2009 and 2010-2012*. 2015.
2. Colorado Department of Public Health and Environment. *Cancer in Colorado 2003-2012, Statistical Tables and Highlights All Cancers Combined Number of Cancers Deaths and Average Annual Age-Adjusted Mortality Rates per 100,000 by Sex, County/Region, Time Period, Colorado 2003-2009 and 2010-2012*. 2015.
3. American Cancer Society. Health Risks of Smoking Tobacco. 2015; http://www.cancer.org/cancer/cancercauses/tobaccocancer/health-risks-of-smoking-tobacco. Accessed December 28, 2016, http://www.cancer.org/cancer/cancercauses/tobaccocancer/health-risks-of-smoking-tobacco.
4. National Cancer Institute. Alcohol and Cancer Risk. 2013; https://www.cancer.gov/about-cancer/causes-prevention/risk/alcohol/alcohol-fact-sheet#q2. Accessed December 28, 2016.
5. Cancer Research UK. Diet Facts and Evidence. 2016; http://www.cancerresearchuk.org/about-cancer/causes-of-cancer/diet-and-cancer/diet-facts-and-evidence. Accessed December 28, 2016.
6. Gieringer D. Waterpipe Study. *Multidisciplinary Assocation for Psycheldelic Studies (MAPS)*. 1996;6(3).
7. Lee ML, Novotny M, Bartle KD. Gas chromatography/mass spectrometric and nuclear magnetic resonance spectrometric studies of carcinogenic polynuclear aromatic hydrocarbons in tobacco and marijuana smoke condensates. *Anal Chem*. 1976;48(2):405-416.
8. Moir D, Rickert WS, Levasseur G, et al. A comparison of mainstream and sidestream marijuana and tobacco cigarette smoke produced under two machine smoking conditions. *Chem Res Toxicol*. 2008;21(2):494-502.
9. Sparacino CM, Hyldburg PA, Hughes TJ. Chemical and Biological Analysis of Marijuana Smoke Condensate. In: Services USDoHaH, ed, 1990.
10. Gieringer D, St. Laurent J, Goodrich S. Cannabis Vaporizer Combines Efficient Delivery of THC with Effective Suppression of Pyrolytic Compounds. *Journal of Cannabis Therapeutics*. 2004;4(1).
11. Gowing LR, Ali RL, White JM. Respiratory harms of smoked cannabis. In: Australia DaASCS, ed. *DASC Monograph No. 8, Research Series*, 2000.
12. Abrams DI, Vizoso HP, Shade SB, Jay C, Kelly ME, Benowitz NL. Vaporization as a smokeless cannabis delivery system: a pilot study. *Clin Pharmacol Ther*. 2007;82(5):572-578.
13. Pomahacova B, Van der Kooy F, Verpoorte R. Cannabis smoke condensate III: the cannabinoid content of vaporised Cannabis sativa. *Inhal Toxicol*. 2009;21(13):1108-1112.
14. Barsky SH, Roth MD, Kleerup EC, Simmons M, Tashkin DP. Histopathologic and molecular alterations in bronchial epithelium in habitual smokers of marijuana, cocaine, and/or tobacco. *J Natl Cancer Inst*. 1998;90(16):1198-1205.
15. Fligiel SE, Roth MD, Kleerup EC, Barsky SH, Simmons MS, Tashkin DP. Tracheobronchial histopathology in habitual smokers of cocaine, marijuana, and/or tobacco. *Chest*. 1997;112(2):319-326.
16. Gong H, Jr., Fligiel S, Tashkin DP, Barbers RG. Tracheobronchial changes in habitual, heavy smokers of marijuana with and without tobacco. *Am Rev Respir Dis*. 1987;136(1):142-149.

17. Aldington S, Harwood M, Cox B, et al. Cannabis use and risk of lung cancer: a case-control study. *Eur Respir J*. 2008;31(2):280-286.

18. Callaghan RC, Allecbeck P, Sidorchuk A. Marijuana use and risk of lung cancer: a 40-year cohort study. *Cancer Causes Control*. 2013;24:1811-1820.

19. Han B, Gfroerer JC, Colliver JD. Associations between duration of illicit drug use and health conditions: results from the 2005-2007 national surveys on drug use and health. *Ann Epidemiol*. 2010;20(4):289-297.

20. Hashibe M, Morgenstern H, Cui Y, et al. Marijuana use and the risk of lung and upper aerodigestive tract cancers: results of a population-based case-control study. *Cancer Epidemiol Biomarkers Prev*. 2006;15(10):1829-1834.

21. Zhang LR, Morgenstern H, Greenland S, et al. Cannabis smoking and lung cancer risk: Pooled analysis in the International Lung Cancer Consortium. *Int J Cancer*. 2014;10.1002/ijc.29036.

22. Sidney S, Jr CPQ, Friedman GD, Tekawa IS. Marijuana use and cancer incidence (California, United States). *Cancer Causes & Control*. 1997;8(5):722-728.

23. Trabert B, Sigurdson AJ, Sweeney AM, Strom SS, McGlynn KA. Marijuana use and testicular germ cell tumors. *Cancer*. 2011;117(4):848-853.

24. Daling JR, Doody DR, Sun X, et al. Association of marijuana use and the incidence of testicular germ cell tumors. *Cancer*. 2009;115(6):1215-1223.

25. Lacson JCA, Carroll JD, Tuazon E, Castelao EJ, Bernstein L, Cortessis VK. Population-based case-control study of recreational drug use and testis cancer risk confirms an association between marijuana use and nonseminoma risk. *Cancer*. 2012;118(21):5374-5383.

26. Chacko Ja, Heiner JG, Siu W, Macy M, Terris MK. Association between marijuana use and transitional cell carcinoma. *Urology*. 2006;67(1):100-104.

27. Thomas AA, Wallner LP, Quinn VP, et al. Association between cannabis use and the risk of bladder cancer: results from the California Men's Health Study. *Urology*. 2015;85(2):388-392.

28. de Carvalho MF, Dourado MR, Fernandes IB, Araujo CT, Mesquita AT, Ramos-Jorge ML. Head and neck cancer among marijuana users: a meta-analysis of matched case-control studies. *Arch Oral Biol*. 2015;60(12):1750-1755.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 4

Marijuana Use and Cardiovascular Effects

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2014)

Katelyn E. Hall, MPH
Retail Marijuana Health Monitoring Program, Colorado Department of Public Health and Environment
(2014)

David Goff Jr., MD, PhD, FACP, FAHA
Dean and Professor, Colorado School of Public Health
(2014)

Reviewers

Andrew Monte, MD
Emergency Medicine Physician, University of Colorado
Medical Toxicologist, Rocky Mountain Poison and Drug Center
(2016)

Ken Gershman, MD, MPH
Manager
Medical Marijuana Research Grants Program, Colorado Department of Public Health and Environment
(2016)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana use and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of myocardial infarction, stroke and death from cardiovascular causes, relative to marijuana use.

Cardiovascular disease is the leading cause of death for both men and women in the United States and is responsible for one in four deaths.[1] The financial cost in the United States is over $200 billion each year.[1] Tobacco smoking is a major risk factor and causes one of every three deaths from heart disease.[2] There is concern that marijuana smoking may contribute to heart disease in ways similar to tobacco smoking. Marijuana use often causes a faster heart rate, elevated blood pressure, and an increased need for oxygen[3] in the hours immediately after use, all of which are effects that can contribute to cardiovascular disease or be dangerous in a person who already has cardiovascular disease. With approximately 13 percent of Colorado adults using marijuana, it is important to identify any potential connections between marijuana use and the development or worsening of cardiovascular disease.

Definitions

Acute marijuana use – marijuana used within the past few hours, such that the short-term effects or symptoms are still being experienced.

Cardiovascular disease – a disease of the heart and/or blood vessels, including both heart disease and stroke.

Heart disease – encompasses several conditions that affect the heart, including coronary heart disease, myocardial infarction (heart attack), heart failure, arrhythmias and heart valve problems.

Myocardial infarction – the medical term for a “heart attack,” which occurs when blood flow to the heart is blocked, causing injury to part of the heart muscle. This can cause a life-threatening change in heart rhythm (arrhythmia).

Stroke – an event that blocks blood flow to part of the brain or causes bleeding into the brain, causing permanent damage.

Key findings

There is a moderate level of scientific evidence that marijuana use increases risk for some forms of stroke in individuals younger than age 55 years, and more limited evidence that marijuana use may increase risk for heart attack. Research is lacking for other cardiovascular events and conditions, including death.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

The committee recommends that health care systems and providers improve the documentation of marijuana use history during hospitalizations and emergency department visits, including timing, potency and amount of last marijuana use and measures of cumulative lifetime use. Public health should monitor and analyze this data for possible associations between marijuana use and cardiovascular events. Educational programs for adult users, their families, and health care providers who care for them should be developed to ensure more information is shared about the known health effects of marijuana use, as well as what is unknown at present.

Additional research on critical cardiovascular events is needed. This research should seek good data on timing, potency and amount of last marijuana use, in order to evaluate potential acute associations. Similarly, better data on cumulative lifetime use is important when evaluating potential long-term associations. Prospective studies enlisting groups of marijuana users and non-users should be done, and observed outcomes should include both the development of chronic cardiovascular disease and the occurrence of acute cardiovascular events.

Table 1 Findings summary: Marijuana use and cardiovascular effects
For an explanation of the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process.

Substantial	Moderate	Limited	Insufficient	Mixed
	Increased risk of ischemic stroke in individuals younger than 55	Increased risk of myocardial infarction (heart attack) with acute use	Death due to cardiovascular cause with acute or long-term use	

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix H.

1. We found **MODERATE** evidence that marijuana use increases risk of ischemic stroke in individuals younger than 55 years of age.[4-9] (Revised*)
2. We found **LIMITED** evidence that acute marijuana use increases risk of myocardial infarction.[10,11]
3. We found **INSUFFICIENT** evidence to determine whether or not marijuana use changes the risk of death related to a cardiovascular event, either acutely or over time. [12-14]

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

1. Marijuana use is associated with increased risk of stroke in individuals younger than 55 years of age. (Revised*)
2. Acute marijuana use may be associated with increased risk of heart attack among adults.

*Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix H for dates of most recent literature review.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality

- Improved documentation of marijuana use history during hospitalizations and emergency department visits, including timing, potency and amount of last marijuana use and measures of cumulative lifetime use.

Surveillance

- Monitor and analyze emergency department and hospitalization data for possible associations between marijuana use and cardiovascular events.

Education

- Public education about the potential cardiovascular risks of cannabis use.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Additional studies of critical cardiovascular events, with improved data on timing, potency and amount of last marijuana use (for potential acute associations) and cumulative lifetime use (for potential long-term associations).
- Prospective studies of cohorts of marijuana users and non-users for possible associations with the development of chronic cardiovascular disease or with acute cardiovascular events.

References

1. Mozaffarian D, Benjamin EJ, Go AS, et al. Heart Disease and Stroke Statistics-2016 Update: A Report From the American Heart Association. *Circulation*. 2016;133(4):e38-360.
2. U.S. Department of Health & Human Services. *The Health Consequences of Smoking - 50 Years of Progress, A Report of the Surgeon General*. 2014.
3. Grotenhermen F. Pharmacokinetics and pharmacodynamics of cannabinoids. *Clin Pharmacokinet*. 2003;42(4):327-360.
4. Geller T, Loftis L, Brink DS. Cerebellar infarction in adolescent males associated with acute marijuana use. *Pediatrics*. 2004;113(4):e365-370.
5. Barber PA, Pridmore HM, Krishnamurthy V, et al. Cannabis, ischemic stroke, and transient ischemic attack: a case-control study. *Stroke*. 2013;44(8):2327-2329.
6. Wolff V, Armspach J-P, Lauer V, et al. Cannabis-related stroke: myth or reality? *Stroke*. 2013;44(2):558-563.
7. Hackam DG. Cannabis and stroke: systematic appraisal of case reports. *Stroke*. 2015;46(3):852-856.
8. Rumalla K, Reddy AY, Mittal MK. Recreational marijuana use and acute ischemic stroke: A population-based analysis of hospitalized patients in the United States. *J Neurol Sci*. 2016;364:191-196.
9. Thanvi BR, Treadwell SD. Cannabis and stroke: is there a link? *Postgrad Med J*. 2009;85(1000):80-83.
10. Mittleman Ma, Lewis Ra, Maclure M, Sherwood JB, Muller JE. Triggering Myocardial Infarction by Marijuana. *Circulation*. 2001;103(23):2805-2809.
11. Jouanjus E, Lapeyre-Mestre M, Micallef J, French Association of the Regional A, Dependence Monitoring Centres Working Group on Cannabis C. Cannabis use: signal of increasing risk of serious cardiovascular disorders. *J Am Heart Assoc*. 2014;3(2):e000638.
12. Mukamal KJ, Maclure M, Muller JE, Mittleman Ma. An exploratory prospective study of marijuana use and mortality following acute myocardial infarction. *American Heart Journal*. 2008;155(3):465-470.
13. Frost L, Mostofsky E, Rosenbloom JI, Mukamal KJ, Mittleman Ma. Marijuana use and long-term mortality among survivors of acute myocardial infarction. *American Heart Journal*. 2013;165(2):170-175.
14. Sidney S, Beck JE, Tekawa IS, Quesenberry CP, Friedman GD. Marijuana use and mortality. *Am J Public Health*. 1997;87(4):585-590.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 5

Marijuana Dose and Drug Interactions

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Michael F. Wempe, PhD
Associate Research Professor
Department of Pharmaceutical Sciences, University of Colorado Anschutz Medical Campus
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2014, 2016)

Kim Siegel, MD, MPH
Occupational Medicine Resident, University of Colorado Denver
(2014)

Mike Kosnett, MD, MPH
Associate Clinical Professor, Division of Clinical Pharmacology and Toxicology, Department of Medicine, University of Colorado School of Medicine, Department of Environmental and Occupational Health, Colorado School of Public Health
(2014)

Reviewer

Laura Borgelt, PharmD
Associate Dean and Professor
Departments of Clinical Pharmacy and Family Medicine, University of Colorado Anschutz Medical Campus
(2014, 2016)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of THC levels relative to marijuana dose and method of use, the effects of secondhand marijuana smoke, drug-drug interactions involving marijuana, and relationships between marijuana and opioid use.

In an era of legalized marijuana, it is possible that more individuals will drive or work while under the influence of marijuana. Many employers are creating new marijuana policies and need accurate and easily interpretable marijuana testing. The Colorado State Patrol also is working to improve its marijuana testing.[1] As a result, it is important to have good information about marijuana testing methods and THC levels that can be expected relative to different types and amounts of use.

Another prominent public health question about marijuana is the health effects secondhand marijuana smoke may have, especially on children. Secondhand tobacco smoke is known to be associated with many diseases and health problems for both children and adults.[2] Many argue that marijuana smoke may be just as harmful. Analysis of 2014 and 2015 Colorado Child Health Survey data, completed for this report, estimated that approximately 16,000 homes in Colorado had children 1-14 years old with possible exposure to secondhand marijuana smoke or vapor in the home. While current public health education already advises against using marijuana around children, it is important to investigate the potential health effects of secondhand marijuana smoke.

About 1 percent of hospital admissions are due to drug-drug interactions, which occur when the effects of one medication are changed by the use of another medication or drug.[3] With an aging population, many of whom use multiple medications, these interactions are a growing concern.[4] Many medications have been found to have such interactions with alcohol or tobacco, raising reasonable concern for interactions with marijuana.[5,6] In 2014, about 3 percent of adults 65 years and older used marijuana.[7] Drug-drug interactions can be minimized if prescribers are aware of which medications and drugs affect each other, so they can adjust or change patients' medications appropriately. Therefore, it is important to identify any drug-drug interactions involving marijuana and inform the medical community.

Opioid abuse has increased dramatically in the United States over the past 15 years and has been declared an epidemic by the U.S. Department of Health & Human Services, causing more than 28,000 deaths in 2014.[8] In Colorado, 5 percent of people 12 years and older misused prescription pain relievers (primarily opioids) in 2013 and 2014.[9] The possibility that marijuana use can reduce opioid use and abuse is a prominent claim.[10] Others argue that marijuana use makes using opioids and other drugs more likely. It is important to clarify the relationships between marijuana use and opioid use.

Definitions

Levels of marijuana use

- Daily or near-daily use: 5-7 days/week
- Weekly use: 1-4 days/week
- Less-than-weekly use: less than 1 day/week

Analgesic – a medication used to relieve pain.

Dabbing - a method of marijuana use where a "dab" (small amount) of marijuana concentrate is placed on a pre-heated surface, creating concentrated marijuana vapor to be inhaled.

Drug-drug interaction – a potentially dangerous interaction that occurs when the effects of one medication are changed by the use of another medication or drug. An example is when a person taking a blood thinner starts a new medication or drug that causes an increase in the blood thinner, leading to bleeding. Similar interactions can occur with many medications.

Opioid - one of many medications or street drugs including heroin, opium and prescription pain medications such as morphine, hydrocodone (Vicodin, Norco, Lortab), oxycodone (Percocet, OxyContin), hydromorphone (Dilaudid), fentanyl and methadone.

Pharmacokinetic / pharmacodynamic - the absorption, distribution, metabolism and excretion of a drug and the effect the drug has on the body.

Secondhand marijuana smoke exposure - the smoke that is inhaled by non-smokers when near to a person smoking marijuana, also known as passive exposure.

- Typical conditions: exposure at or below the level of smoke present in a small ventilated room (such as with open windows or an exhaust fan) with multiple people smoking marijuana.
- Extreme conditions: exposure at or above the level of smoke present in a small room (or a vehicle) without ventilation and with multiple people smoking marijuana.

Tetrahydrocannabinol (THC) - the main psychoactive component of marijuana.

Thirdhand marijuana smoke exposure – residual contamination left in rooms and on clothes after marijuana smoking.

Vaporization of marijuana (vaping) – a method of marijuana use in which marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

Key findings

Multiple studies have measured blood THC levels following marijuana use. One important finding is that it can take up to four hours after consuming an edible marijuana product to reach the peak THC blood concentration and feel the full effects. This has important implications for the time to wait between doses or prior to safety-sensitive activities like driving. Smoking or vaporizing more than 10mg THC, or consuming an edible marijuana product with more than 15mg THC can lead to a blood THC level above 5ng/mL, which can be used to support a conviction for driving under the influence.

Regarding secondhand marijuana exposure, evidence shows that individuals passively exposed under usual conditions would not test above standard cutoffs for marijuana on a workplace urine test or driving impairment blood test. There is some evidence that secondhand exposure under extreme conditions can cause psychomotor impairment and increased heart rate.

Much has been said about the relationship between marijuana use and opioid use, but research remains limited. There is some evidence that opioid analgesic overdose deaths are lower in states with legal medical marijuana than would be expected based on trends in states without legal medical marijuana. There is conflicting evidence for whether or not marijuana use is associated with a decrease in opioid use among chronic pain patients or individuals with a history of problem drug use.

Clinical and pharmacokinetic data about potential drug-drug interactions with marijuana are currently lacking for many drugs and are likely to evolve substantially over coming years. There is credible evidence of clinically important drug-drug interactions with marijuana including the following: chlorpromazine, clobazam, clozapine, CNS depressants (e.g. barbiturates, benzodiazepines), disulfiram, hexobarbital, hydrocortisone, ketoconazole, MAO inhibitors, phenytoin, protease inhibitors (indinavir, nelfinavir), theophylline, tricyclic antidepressants and warfarin (see Table 2 for additional details). The lack of a cited interaction with other medications does not preclude the possibility that drug interactions exist; it simply means no studies have yet reported an interaction with that particular drug.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

The committee recommends continued data collection efforts to assess marijuana use patterns among Colorado users, including better characterization of method, amount, potency and frequency. Data on the THC content of Colorado products is also needed. Data collected in relation to impairment should include type, amount, potency and timing of marijuana used. The public should be educated on possible unwanted interactions between marijuana and medications and the potential effects of secondhand marijuana smoke.

Further research is needed to identify potential interactions between marijuana and medications. Secondhand and thirdhand marijuana smoke should be further studied, including identification of biomarkers of exposure and evaluation of health effects, especially in children. The relationship between marijuana use and opioid use remains unclear, and further research is needed, especially at the individual level. Research is also needed to better characterize the pharmacokinetics/pharmacodynamics of cannabinoids.

Table 1 Findings summary: Marijuana dose and drug interaction

All statements apply only to less-than-weekly users. → = results in/produces. For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
THC levels	Smoking >10 mg THC produces blood THC level near or > 5 ng/mL within 10 minutes	Ingesting ≥15 mg THC may → blood THC level > 5 ng/mL			
THC levels	Time to peak blood THC level is up to four hours post ingestion	Inhaling vaporized THC→ blood THC level similar to smoking the same dose			
Secondhand exposure	Typical secondhand exposure → NO positive drug screen by urine or blood		Extreme secondhand exposure →psychomotor impairment and increased heart rate	Secondhand exposure → positive drug screen by oral fluid	
Secondhand exposure				Health effects of secondhand exposure on children	
Secondhand exposure				Health effects of third-hand exposure	
Secondhand exposure				Health effects of secondhand vapor	

Table 1 (continued) Findings summary: marijuana dose and drug interaction

All statements apply only to less-than-weekly users. → = results in/produces. For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
Marijuana and opioids			Less opioid overdose deaths than expected in states with legal medical marijuana	Association between legal medical marijuana and opioid use	Marijuana use and reduction in opioid use by chronic pain patients
Marijuana and opioids					Marijuana use and reduction in opioid use by individuals with a history of problem drug use
Alternate methods				Dabbing and tolerance or withdrawal	

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix J.

THC levels resulting from different exposures

1. We found **SUBSTANTIAL** evidence that smoking more than about 10 mg THC (or part of a currently available marijuana cigarette) is likely to yield whole blood THC concentrations near or above 5 ng/mL within 10 minutes.[11-14]
2. We found **MODERATE** evidence that ingesting more than about 15 mg THC is capable of yielding a whole blood THC concentration above 5 ng/mL.[15-20]
3. We found **MODERATE** evidence that inhaling vaporized marijuana yields blood THC levels that are similar to those produced by smoking the same dose.[21,22]
4. We found **SUBSTANTIAL** evidence that it takes up to 4 hours after ingesting marijuana to reach peak blood THC concentrations.[15,16,18,19]

Secondhand (passive) exposure

5. We found **SUBSTANTIAL** evidence that an individual passively exposed to marijuana smoke (up to approximately 10% THC) under typical passive exposure conditions would NOT test above standard cutoffs for marijuana on a urine screening test or a blood test (given the current federal screening cutoff of 50 ng/mL for urine cannabinoid metabolites and the current Colorado limit for driving of 5 ng/mL whole blood THC).[23-35]
6. We found **INSUFFICIENT** evidence to determine whether individuals passively exposed to marijuana smoke would test above standard cutoffs by oral fluid testing because it has not yet been established which analyte or analytes to measure and which cutoff(s) to use.[23,24,36-39]
7. We found **LIMITED** evidence that individuals passively exposed to marijuana smoke under extreme passive exposure conditions (such as spending one hour in an unventilated space with individuals smoking marijuana of 11% potency) experience psychomotor impairment and increased heart rate in the hour immediately following exposure. [34,35] (Added*)
8. We found **INSUFFICIENT** evidence to determine the health effects of secondhand marijuana smoke in children. (Added*)
9. We found **INSUFFICIENT** evidence to determine the health effects of thirdhand marijuana smoke (the residual smoke that lingers in a room or on clothes). (Added*)
10. We found **INSUFFICIENT** evidence to determine whether or not secondhand marijuana vapor exposure is associated with adverse health effects. (Added*)

*Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix J for dates of most recent literature review.

Drug-drug interactions

11. There is credible evidence of clinically important drug-drug interactions between marijuana and the following medications: chlorpromazine, clobazam, clozapine, CNS depressants (e.g. barbiturates, benzodiazepines), disulfiram, hexobarbital, hydrocortisone, ketoconazole, MAO inhibitors, phenytoin, protease inhibitors (indinavir, nelfinavir), theophylline, tricyclic antidepressants and warfarin. The lack of a cited interaction does not preclude the possibility that drug interactions exist; it simply means no studies have yet reported an interaction with that particular drug.[22,40-56] (Revised*)

Marijuana and opioids

12. We found **INSUFFICIENT** evidence to determine whether or not there is an association between the availability of legal medical marijuana and the prevalence of opioid use.[57,58] (Added*)
13. We found **LIMITED** evidence that states with legal medical marijuana had a lower rate of opioid analgesic overdose deaths than would be expected based on trends in states without legal medical marijuana.[59] (Added*)
14. We found **MIXED** evidence for whether or not marijuana use is associated with a reduction in the number of patients using opioids or the amount of opioid use among chronic pain patients.[60,61] (Added*)
15. We found **MIXED** evidence for whether or not marijuana use is associated with a reduction in opioid use among individuals with a history of opioid addiction treatment or injection drug use.[62,63] (Added*)

Alternate methods of use

16. We found **INSUFFICIENT** evidence to determine whether dabbing concentrated marijuana is associated with an increase in marijuana tolerance or more severe withdrawal upon cessation of use compared to smoking marijuana.[64] (Added*)

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix J for dates of most recent literature review.

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

THC levels resulting from different exposures

1. It takes up to 4 hours after consuming an edible marijuana product to reach maximum blood levels of THC and feel the full effects. It is important to delay consuming another THC-containing product or engaging in safety-sensitive activities like driving until the effects from the first edible serving are known, especially for new or less-than-weekly users.
2. Smoking or vaporizing more than 10mg THC, or consuming an edible marijuana product with more than 15mg THC can lead to a blood THC level above 5ng/mL, which can be used to support a conviction for driving under the influence.

Secondhand (passive) exposure

3. Typical secondhand exposure to marijuana smoke is unlikely to result in a failed workplace urine test or a failed driving impairment blood test.
4. Extreme secondhand exposure to marijuana smoke (such as one hour of exposure in an unventilated space), may be associated with psychomotor impairment and an increase in heart rate. (Added*)

Drug-drug interactions

5. Use caution when taking medications and marijuana at the same time. Some medications have known interactions with marijuana, and others may have interactions that have not yet been identified.

Marijuana and opioids

6. Rates of overdose death from opioid pain relievers may be reduced in states with legal medical marijuana compared to states without. (Added*)
7. There is conflicting research on whether or not marijuana use is associated with a decrease in opioid use by chronic pain patients. (Added*)
8. There is conflicting research on whether or not marijuana use is associated with a decrease in opioid use by individuals with a history of opioid addiction treatment or injection drug use.(Added*)

---

*Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix J for dates of most recent literature review.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality issues

- Monitor data on THC content of marijuana products in Colorado.
- Monitor airborne THC/cannabinoid/by-products in future test chamber studies.
- Increase sample size in future pharmacologic studies.

Surveillance

- Monitor type, amount, potency and timing of marijuana consumed in correlation with impairment.
- Monitor health effects of secondhand marijuana smoke exposure.
- Add method of use questions (including vaporization and dabbing) to existing population-based surveys.
- Conduct targeted surveys of marijuana users (non-population-based surveys), including detailed questions on method, amount, potency and frequency of use.

Education

- Educate the public on potential interactions when using marijuana with medications.
- Educate the public about the potential effects of secondhand marijuana smoke and encourage safe and responsible use.
- Ensure marijuana smoking is prohibited in all venues where tobacco smoking is not permitted.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- More research to identify interactions between marijuana and prescription drugs.
- Research to better characterize the pharmacokinetics/pharmacodynamics of cannabinoids, via various methods of marijuana use.
- Study possible differences in health effects of different methods of marijuana use.
- Analysis of chemicals released or produced by different methods of marijuana use.
- Identify biomarkers to assess secondhand marijuana smoke exposures.
- Further research on potential short-term and long-term health effects of secondhand marijuana smoke exposure, particularly in children.
- Impacts of secondhand marijuana vapor.
- Research on the relationship between marijuana use and opioid use at the individual level, both in the general population and in relevant subpopulations.

Table 2

Specific drug/drug classes with published clinical evidence of interactions with marijuana. Some drugs with published clinical evidence of a lack of interaction with marijuana are also included. These are marked with *. (Y=Yes, N= No, P=Possible)

Concomitant Drug/Drug Class	Description of Interaction	Contra-indicated	Increased THC Effect	Increased CNS Depressant Effect	Increased Concomitant Drug Effect	Decreased Concomitant Drug Effect
Chlorpromazine	Marijuana smoking increased clearance of chlorpromazine, as did tobacco smoking.[41]	N				P
Clobazam	In subjects taking cannabidiol (CBD), mean clobazam levels were about 60-80% higher, and nCLB levels 300-500% higher. A decrease in the clobazam dose was required in subjects taking CBD.[55]	N		Y	P	
Clozapine	Possible increased clozapine metabolism by marijuana induction of CYP1A2 (similar to tobacco). Therefore cessation may lead to increased clozapine levels and toxicity. Single case report of clozapine toxicity after tobacco and marijuana cessation.[43]	N			P	P
CNS depressants	Additive drowsiness and CNS depression Includes: alcohol, opioids, sedative-hypnotics, barbiturates, benzodiazepine, buspirone, antihistamines, muscles relaxants, and many more.[22,40,42]	N		Y		
Disulfiram	Possible hypomanic/psychotic reaction.[40,42]	N	P			
Fluoxetine*	No change in fluoxetine efficacy and no serious adverse reactions in a 12 week clinical study of fluoxetine vs. placebo for marijuana-related depression.[45]	N				
Hexobarbital	May enhance CNS depressant effect. CBD decreased metabolism of hexabarbital but did not change its clinical effects.[44]	N		Y	P	
Hydrocortisone	THC increased serum cortisol, but effect is blunted in frequent users. Theoretical possibility of cushingoid syndrome.[46]	N			P	
Ketoconazole	Peak THC concentration was increased by 27%.[53]	N	P	P		
MAO Inhibitors	Possible enhancement of orthostatic hypotension.[40]	N				
Phenytoin	May enhance CNS depressant effect. In vitro, decreased phenytoin levels due to induction of metabolism by THC. Therefore, phenytoin levels may rise rapidly after THC cessation, causing toxicity. Intermittent THC use may cause transient subtherapeutic phenytoin levels. Case report of phenytoin toxicity after recreational use of phenytoin concomitantly with EtOH and marijuana.[40,48,51]	N		Y	P	P
Protease inhibitors	Statistically significant decrease in peak concentration of indinavir and nelfinavir with THC use.[47]	N				P
Theophylline	Smoked marijuana lowers theophylline concentrations, similar to tobacco. Unclear if only a smoking-related effect. No studies of oral marijuana/THC.[49,52]	N				P
Tricyclic antidepressants	May cause transient cognitive changes, delirium, or tachycardia.[56]	N	P		P	
Warfarin	Possible enhanced anticoagulant effect.[40,50,54]	N			P	

References

1. Hernandez E. Pilot program eyes pot-DUI devices. *The Denver Post*. January 9, 2016, 2016.
2. Cao S, Yang C, Gan Y, Lu Z. The Health Effects of Passive Smoking: An Overview of Systematic Reviews Based on Observational Epidemiological Evidence. *PLoS One*. 2015;10(10):e0139907.
3. Dechanont S, Maphanta S, Butthum B, Kongkaew C. Hospital admissions/visits associated with drug-drug interactions: a systematic review and meta-analysis. *Pharmacoepidemiol Drug Saf*. 2014;23(5):489-497.
4. Kantor ED, Rehm CD, Haas JS, Chan AT, Giovannucci EL. Trends in Prescription Drug Use Among Adults in the United States From 1999-2012. *JAMA*. 2015;314(17):1818-1831.
5. Chan LN, Anderson GD. Pharmacokinetic and pharmacodynamic drug interactions with ethanol (alcohol). *Clin Pharmacokinet*. 2014;53(12):1115-1136.
6. Zevin S, Benowitz NL. Drug interactions with tobacco smoking. An update. *Clin Pharmacokinet*. 1999;36(6):425-438.
7. Colorado Department of Public Health and Environment. Adult Health Data, Behavioral Risk Factor Surveillance System. *Colorado Health and Environmental Data* 2015; http://www.chd.dphe.state.co.us/topics.aspx?q=Adult_Health_Data.
8. U.S. Department of Health & Human Services. Opioids: The Prescription Drug & Heroin Overdose Epidemic. 2016; https://www.hhs.gov/opioids/. Accessed December 21, 2016.
9. Substance Abuse and Mental Health Services Administration. National Survey on Drug Use and Health: Comparison of 2012-2013 and 2013-2014 Population Percentages (50 States and the District of Columbia). https://www.samhsa.gov/data/sites/default/files/NSDUHsaeShortTermCHG2014/NSDUHsaeShortTermCHG2014.htm2015.
10. Sifferlin A. Can Medical Marijuana Help End the Opioid Epidemic? *Time*, http://time.com/4419003/can-medical-marijuana-help-end-the-opioid-epidemic/ 2016.
11. Berghaus G, Sticht G, Grellner W. *Meta-analysis of empirical studies concerning the effects of medicines and illegal drugs including pharmacokinetics on safe driving*. Center for Traffic Sciences at the University of Wurzburg;2011.
12. Huestis MA, Sampson AH, Holicky BJ, Henningfield JE, Cone EJ. Characterization of the absorption phase of marijuana smoking. *Clin Pharmacol Ther*. 1992;52(1):31-41.
13. Ramaekers JG, Moeller MR, van Ruitenbeek P, Theunissen EL, Schneider E, Kauert G. Cognition and motor control as a function of Delta9-THC concentration in serum and oral fluid: limits of impairment. *Drug Alcohol Depend*. 2006;85(2):114-122.
14. Reeve VC, Grant JD, Robertson W, Gillespie HK, Hollister LE. Plasma concentrations of delta-9-tetrahydrocannabinol and impaired motor function. *Drug Alcohol Depend*. 1983;11(2):167-175.
15. Bosker WM, Kuypers KP, Theunissen EL, et al. Medicinal Delta(9) -tetrahydrocannabinol (dronabinol) impairs on-the-road driving performance of occasional and heavy cannabis users but is not detected in Standard Field Sobriety Tests. *Addiction*. 2012;107(10):1837-1844.
16. Curran HV, Brignell C, Fletcher S, Middleton P, Henry J. Cognitive and subjective dose-response effects of acute oral Delta 9-tetrahydrocannabinol (THC) in infrequent cannabis users. *Psychopharmacology (Berl)*. 2002;164(1):61-70.
17. Huestis MA. Human cannabinoid pharmacokinetics. *Chem Biodivers*. 2007;4(8):1770-1804.
18. Lile JA, Kelly TH, Charnigo RJ, Stinchcomb AL, Hays LR. Pharmacokinetic and pharmacodynamic profile of supratherapeutic oral doses of Delta(9) -THC in cannabis users. *J Clin Pharmacol*. 2013;53(7):680-690.

19. Menetrey A, Augsburger M, Favrat B, et al. Assessment of driving capability through the use of clinical and psychomotor tests in relation to blood cannabinoids levels following oral administration of 20 mg dronabinol or of a cannabis decoction made with 20 or 60 mg Delta9-THC. *J Anal Toxicol*. 2005;29(5):327-338.

20. Perez-Reyes M, Lipton MA, Timmons MC, Wall ME, Brine DR, Davis KH. Pharmacology of orally administered 9 -tetrahydrocannabinol. *Clin Pharmacol Ther*. 1973;14(1):48-55.

21. Abrams DI, Vizoso HP, Shade SB, Jay C, Kelly ME, Benowitz NL. Vaporization as a smokeless cannabis delivery system: a pilot study. *Clin Pharmacol Ther*. 2007;82(5):572-578.

22. Abramovici H. Information for Health Care Professionals. In: Canada H, ed, 2013.

23. Niedbala RS, Kardos KW, Fritch DF, et al. Passive cannabis smoke exposure and oral fluid testing. II. Two studies of extreme cannabis smoke exposure in a motor vehicle. *J Anal Toxicol*. 2005;29(7):607-615.

24. Niedbala S, Kardos K, Salamone S, Fritch D, Bronsgeest M, Cone EJ. Passive cannabis smoke exposure and oral fluid testing. *J Anal Toxicol*. 2004;28(7):546-552.

25. Rohrich J, Schimmel I, Zorntlein S, et al. Concentrations of delta9-tetrahydrocannabinol and 11-nor-9-carboxytetrahydrocannabinol in blood and urine after passive exposure to Cannabis smoke in a coffee shop. *J Anal Toxicol*. 2010;34(4):196-203.

26. Cone EJ, Johnson RE. Contact highs and urinary cannabinoid excretion after passive exposure to marijuana smoke. *Clin Pharmacol Ther*. 1986;40(3):247-256.

27. Cone EJ, Johnson RE, Darwin WD, et al. Passive inhalation of marijuana smoke: urinalysis and room air levels of delta-9-tetrahydrocannabinol. *J Anal Toxicol*. 1987;11(3):89-96.

28. Morland J, Bugge A, Skuterud B, Steen A, Wethe GH, Kjeldsen T. Cannabinoids in blood and urine after passive inhalation of Cannabis smoke. *J Forensic Sci*. 1985;30(4):997-1002.

29. Law B, Mason PA, Moffat AC, King LJ, Marks V. Passive inhalation of cannabis smoke. *J Pharm Pharmacol*. 1984;36(9):578-581.

30. Mason AP, Perez-Reyes M, McBay AJ, Foltz RL. Cannabinoids in plasma after passive inhalation of marijuana smoke. *JAMA*. 1983;249(4):475-476.

31. Mule SJ, Lomax P, Gross SJ. Active and realistic passive marijuana exposure tested by three immunoassays and GC/MS in urine. *J Anal Toxicol*. 1988;12(3):113-116.

32. Perez-Reyes M, di Guiseppi S, Davis KH. Passive inhalation of marijuana smoke and urinary excretion cannabinoids. *JAMA*. 1983;249(4):475.

33. Norchem Lab. Urine Drug Test Information Sheet: Marijuana. http://www.norchemlab.com/wp-content/uploads/2011/10/marijuana.pdf. Accessed 8/8/2014.

34. Herrmann ES, Cone EJ, Mitchell JM, et al. Non-smoker exposure to secondhand cannabis smoke II: Effect of room ventilation on the physiological, subjective, and behavioral/cognitive effects. *Drug Alcohol Depend*. 2015;151:194-202.

35. Cone EJ, Bigelow GE, Herrmann ES, et al. Non-smoker exposure to secondhand cannabis smoke. I. Urine screening and confirmation results. *J Anal Toxicol*. 2015;39(1):1-12.

36. Moore C. Response to "Is THCCOOH a useful determinant for passive inhalation in oral fluid THC testing?". *J Anal Toxicol*. Vol 36. United States2012:358.

37. Moore C, Coulter C, Uges D, et al. Cannabinoids in oral fluid following passive exposure to marijuana smoke. *Forensic Sci Int*. 2011;212(1-3):227-230.

38. Walsh JM, Cone EJ, Crouch DJ, Caplan YH. Is THC-COOH a useful determinant for passive inhalation in oral fluid THC testing? *J Anal Toxicol*. Vol 36. United States2012:291.

39. Cone EJ, Bigelow GE, Herrmann ES, et al. Nonsmoker Exposure to Secondhand Cannabis Smoke. III. Oral Fluid and Blood Drug Concentrations and Corresponding Subjective Effects. *J Anal Toxicol*. 2015;39(7):497-509.
40. Lexi-Comp Online. *Interaction Lookup*, http://www.uptodate.com.hsl-ezproxy.ucdenver.edu/.
41. Chetty M, Miller R, Moodley SV. Smoking and body weight influence the clearance of chlorpromazine. *Eur J Clin Pharmacol*. 1994;46(6):523-526.
42. Unimed Pharmaceuticals. Marinol (Dronabinol) package insert. 2004.
43. Zullino DF, Delessert D, Eap CB, Preisig M, Baumann P. Tobacco and cannabis smoking cessation can lead to intoxication with clozapine or olanzapine. *Int Clin Psychopharmacol*. 2002;17(3):141-143.
44. Benowitz NL, Nguyen TL, Jones RT, Herning RI, Bachman J. Metabolic and psychophysiologic studies of cannabidiol-hexobarbital interaction. *Clin Pharmacol Ther*. 1980;28(1):115-120.
45. Cornelius JR, Bukstein OG, Douaihy AB, et al. Double-blind fluoxetine trial in comorbid MDD-CUD youth and young adults. *Drug Alcohol Depend*. 2010;112(1-2):39-45.
46. D'Souza DC, Ranganathan M, Braley G, et al. Blunted psychotomimetic and amnestic effects of delta-9-tetrahydrocannabinol in frequent users of cannabis. *Neuropsychopharmacology*. 2008;33(10):2505-2516.
47. Kosel BW, Aweeka FT, Benowitz NL, et al. The effects of cannabinoids on the pharmacokinetics of indinavir and nelfinavir. *Aids*. 2002;16(4):543-550.
48. Bland TM, Haining RL, Tracy TS, Callery PS. CYP2C-catalyzed delta9-tetrahydrocannabinol metabolism: kinetics, pharmacogenetics and interaction with phenytoin. *Biochem Pharmacol*. 2005;70(7):1096-1103.
49. Gardner MJ, Tornatore KM, Jusko WJ, Kanarkowski R. Effects of tobacco smoking and oral contraceptive use on theophylline disposition. *Br J Clin Pharmacol*. 1983;16(3):271-280.
50. Ge B, Zhang Z, Zuo Z. Updates on the clinical evidenced herb-warfarin interactions. *Evid Based Complement Alternat Med*. 2014;2014:957362.
51. Jessen K. Recreational use of phenytoin, marijuana, and alcohol: a case report. *Neurology*. 2004;62(12):2330.
52. Jusko WJ, Gardner MJ, Mangione A, Schentag JJ, Koup JR, Vance JW. Factors affecting theophylline clearances: age, tobacco, marijuana, cirrhosis, congestive heart failure, obesity, oral contraceptives, benzodiazepines, barbiturates, and ethanol. *J Pharm Sci*. 1979;68(11):1358-1366.
53. Stott C, White L, Wright S, Wilbraham D, Guy G. A Phase I, open-label, randomized, crossover study in three parallel groups to evaluate the effect of Rifampicin, Ketoconazole, and Omeprazole on the pharmacokinetics of THC/CBD oromucosal spray in healthy volunteers. *Springerplus*. 2013;2(1):236.
54. Yamreudeewong W, Wong HK, Brausch LM, Pulley KR. Probable interaction between warfarin and marijuana smoking. *Ann Pharmacother*. 2009;43(7):1347-1353.
55. Geffrey AL, Pollack SF, Bruno PL, Thiele EA. Drug-drug interaction between clobazam and cannabidiol in children with refractory epilepsy. *Epilepsia*. 2015;56(8):1246-1251.
56. Wilens TE, Biederman J, Spencer TJ. Case study: adverse effects of smoking marijuana while receiving tricyclic antidepressants. *J Am Acad Child Adolesc Psychiatry*. 1997;36(1):45-48.
57. Kim JH, Santaella-Tenorio J, Mauro C, et al. State Medical Marijuana Laws and the Prevalence of Opioids Detected Among Fatally Injured Drivers. *Am J Public Health*. 2016;106(11):2032-2037.
58. Bradford AC, Bradford WD. Medical Marijuana Laws Reduce Prescription Medication Use In Medicare Part D. *Health Aff (Millwood)*. 2016;35(7):1230-1236.

59. Bachhuber MA, Saloner B, Cunningham CO, Barry CL. Medical cannabis laws and opioid analgesic overdose mortality in the United States, 1999-2010. *JAMA Intern Med*. 2014;174(10):1668-1673.

60. Boehnke KF, Litinas E, Clauw DJ. Medical Cannabis Use Is Associated With Decreased Opiate Medication Use in a Retrospective Cross-Sectional Survey of Patients With Chronic Pain. *J Pain*. 2016;17(6):739-744.

61. Haroutounian S, Ratz Y, Ginosar Y, et al. The Effect of Medicinal Cannabis on Pain and Quality-of-Life Outcomes in Chronic Pain: A Prospective Open-label Study. *Clin J Pain*. 2016;32(12):1036-1043.

62. Kral AH, Wenger L, Novak SP, et al. Is cannabis use associated with less opioid use among people who inject drugs? *Drug and Alcohol Dependence*. 2015;153:236-241.

63. Scavone JL, Sterling RC, Weinstein SP, Van Bockstaele EJ. Impact of cannabis use during stabilization on methadone maintenance treatment. *Am J Addict*. 2013;22(4):344-351.

64. Loflin M, Earleywine M. A new method of cannabis ingestion: the dangers of dabs? *Addict Behav*. 2014;39(10):1430-1433.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 6

Marijuana Use and Driving

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Ashley Brooks-Russell, PhD, MPH
Assistant Professor
Injury Prevention, Education and Research Program, Colorado School of Public Health
(2014, 2016)

Michael F. Wempe, PhD
Associate Research Professor, Department of Pharmaceutical Sciences, University of Colorado Anschutz Medical Campus
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2016)

Kim Siegel, MD, MPH
Occupational Medicine Resident, University of Colorado Denver
(2014)

Mike Kosnett, MD, MPH
Associate Clinical Professor, Division of Clinical Pharmacology and Toxicology, Department of Medicine, University of Colorado School of Medicine, Department of Environmental and Occupational Health, Colorado School of Public Health
(2014)

Reviewers

Kristina T. Phillips, PhD
Clinical Psychologist and Professor, School of Psychological Sciences, University of Northern Colorado
(2016)

Laura Borgelt, PharmD
Associate Dean and Professor
Departments of Clinical Pharmacy and Family Medicine, University of Colorado Anschutz Medical Campus
(2014, 2016)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of driving impairment and motor vehicle crash risk relative to amounts of marijuana used and to blood THC levels. It also includes reviews of evidence indicating how long it takes after marijuana use for impairment to resolve.

There are more than 80 crashes in Colorado each day, on average, and 12 percent of them cause injuries or fatalities.[1] Motor vehicle crashes are the leading cause of death among 10-24 year olds.[2] About 30 percent of all driving fatalities in Colorado are alcohol related.[3] Marijuana legalization has raised concern about the impact it may have on motor vehicle crashes. Marijuana is known to cause slowed reaction time and poorer motor coordination and attention.[4] In 2014, more than 18 percent of current marijuana users reported driving after using marijuana.[5] A Denver initiative passed in November 2016, allowing businesses to obtain marijuana use permits, has further raised concern for marijuana-impaired driving.[6] The different methods of marijuana use, such as edibles and vaporizing, complicate matters further because they may lead to different levels of impairment and require different wait times to allow the impairment to resolve. It is extremely important to investigate these topics to determine the impact marijuana use has on driving impairment and motor vehicle crashes and how it is affected by different methods of use, amounts used, and time since using.

Definitions

Levels of marijuana use

- Daily or near-daily use: 5-7 days/week.
- Weekly use: 1-4 days/week.
- Less-than-weekly use: less than 1 day/week.

Tetrahydrocannabinol (THC) - the main psychoactive component of marijuana.

Vaporization of marijuana (vaping) - a method of marijuana use in which marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

Key findings

The committee found that the risk of a motor vehicle crash increases among drivers with recent marijuana use. Furthermore, the higher the blood THC level, the higher the motor vehicle crash risk. In addition, using alcohol and marijuana together increases impairment and the risk of a motor vehicle crash even more than using either substance alone. For less-than-weekly marijuana users, using marijuana containing 10 milligrams or more of THC is likely to impair the ability to safely drive, bike, or perform other safety-sensitive activities. This applies to smoking, eating, or drinking the marijuana or marijuana product. Waiting at least six hours after smoking marijuana containing less than 35 milligrams of THC likely will allow sufficient time for the impairment to resolve among less-than-weekly users. The waiting time is longer for eating or drinking marijuana products. It is necessary for marijuana users who use it less-than-weekly to wait at least eight hours for impairment to resolve after eating or drinking less than 18 milligrams of THC. Data on doses that cause impairment and time for impairment to resolve is lacking for frequent marijuana users.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

The committee recommended improved testing and documentation of marijuana involvement in motor vehicle crashes and impaired driving encounters. This includes testing for THC and its metabolites in drivers, and accurately recording the timing of blood testing relative to the time impairment was suspected. If such data becomes more consistent, research should use blood THC levels rather than self-reported use, when possible. Centralized reporting of these levels would help both with surveillance and research. There are significant intervention opportunities for public education on marijuana-related impairment, including the dangers of driving after using marijuana, especially when combined with alcohol, and the amount of time a person should wait after using various types and doses of marijuana products before driving. However, in order to measure the impact of these educational interventions over time, additional questions are needed on population-based surveys such as the Behavioral Risk Factor Surveillance System (BRFSS) to measure self-reported impaired driving behaviors and perceptions of risk associated with impaired driving.

The committee identified several research gaps including the need for more research on the relationship of THC levels in saliva, blood and urine, and how these biomarkers relate to measures of functional impairment. Research focusing on impairment in daily or near-daily marijuana users is needed, as the relationship between timing of use, THC levels and impairment may differ from these effects in less-than-weekly users. Improved testing methods for impairment should be researched further, in order to develop best methods, either using alternate biological testing or physical and cognitive tests of impairment.

Table 1 Findings summary: Marijuana use and driving

* = applies only to less-than-weekly users. → = results in/produces. For an explanation of the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
Impairment and crash risk	Increased motor vehicle crash risk with recent use	THC blood level and motor vehicle crash risk		Risk of motor vehicle crash differs based on frequency of use	
	Increased risk of driving impairment at blood THC of 2-5 ng/mL*	Higher blood THC in impaired drivers now than in the past			
	Smoking >10 mg THC leads to driving impairment*				
	Orally ingesting >10 mg THC leads to driving impairment*				
	Combined use with alcohol increases crash risk				
Time to wait before driving		Waiting ≥ 6 hrs after smoking about 35 mg → driving impairment resolves/nearly resolves*		How long to wait after smoking ≥ 35 mg for impairment to resolve	
	Waiting ≥ 6 hrs after smoking < 18 mg → driving impairment resolves/nearly resolves*			How long daily or near-daily users should wait before driving	
	Waiting ≥ 8 hrs after orally ingesting < 18 mg → driving impairment resolves/nearly resolves*			How long to wait after vaporizing, dermal application, or other methods of use	

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix K.

Impairment and crash risk

1. We found **SUBSTANTIAL** evidence that recent marijuana use by a driver increases their risk of motor vehicle crash.[7-11](Revised[*])
2. We found **MODERATE** evidence for a positive relationship between THC blood level and motor vehicle crash risk.[12-15] (Revised*)
3. We found **SUBSTANTIAL** evidence that for marijuana users who use less-than-weekly, there is meaningful driving impairment with a whole blood THC of 2-5 ng/mL.[8,16-18]
4. We found **SUBSTANTIAL** evidence that for marijuana users who use less-than-weekly, smoking more than about 10 mg THC (or part of a currently available marijuana cigarette) is likely to meaningfully impair driving ability.[16,17,19-30]
5. We found **SUBSTANTIAL** evidence that for marijuana users who use less-than-weekly, orally ingesting 10 mg or more of THC is likely to meaningfully impair driving ability.[17,20,31,32]
6. We found **MODERATE** evidence that blood THC levels of marijuana-impaired drivers are higher now than in the past.[33]
7. We found **INSUFFICIENT** evidence to determine whether or not motor vehicle crash risk differs for users who use less-than-weekly compared to daily or near-daily users.[34-37]

Combined marijuana and alcohol use

8. We found **SUBSTANTIAL** evidence that the combined use of marijuana and alcohol increases impairment and motor vehicle crash risk more than use of either substance alone.[12,14,15,38-42]

Time to wait before driving

9. We found **SUBSTANTIAL** evidence that delaying driving for at least 6 hours after smoking less than 18 mg THC allows THC-induced impairment to resolve or nearly resolve for users who use less-than-weekly.[8,16,17,19,26,43]
10. We found **MODERATE** evidence that delaying driving at least 6 hours after smoking about 35 mg THC allows THC-induced impairment to resolve or nearly resolve for users who use less-than-weekly.[22,25,26]
11. We found **SUBSTANTIAL** evidence that delaying driving at least 8 hours after oral ingestion of less than 18 mg THC allows THC-induced impairment to resolve or nearly resolve for users who use less-than-weekly.[17,20,32,44]

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix K for dates of most recent literature review.

12. We found **INSUFFICIENT** evidence to determine the amount of time necessary to wait after smoking more than 35 mg THC to allow THC-induced impairment to resolve for users who use less-than-weekly.[17,22,45]
13. We found **INSUFFICIENT** evidence to determine the amount of time necessary to delay driving to allow THC-induced impairment to resolve or nearly resolve for daily or near-daily users after using marijuana.[8,21,25,29,46,47]
14. We found **INSUFFICIENT** evidence to determine the amount of time to delay driving after other methods of marijuana use (such as vaporizing or application of dermal or mucosal preparations).

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

1. Driving soon after using marijuana increases the risk of a motor vehicle crash. (Revised[*])
2. Using alcohol and marijuana together increases impairment and the risk of a motor vehicle crash more than using either substance alone.
3. The typical marijuana cigarette or joint in Colorado contains approximately 0.5 grams of marijuana, and the THC content in marijuana ranges from 12-23% THC; therefore, a typical joint contains between 60-115 mg THC. The standard serving size for a marijuana edible is 10 mg.
    a) For less-than-weekly marijuana users, smoking, eating, or drinking marijuana containing 10 mg or more of THC is likely to cause impairment that affects your ability to drive, bike, or perform other safety-sensitive activities.
    b) Wait at least 6 hours after <u>smoking</u> marijuana containing less than 35 mg THC before driving, biking, or performing other safety-sensitive activities. If you have smoked more than 35 mg, wait longer.
    c) Wait at least 8 hours after <u>eating or drinking</u> marijuana containing less than 18 mg THC before driving, biking, or performing other safety-sensitive activities. If you have consumed more than 18 mg, wait longer.
4. Use caution when driving, biking, or performing other safety-sensitive activities after using any form of marijuana or marijuana product.

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix K for dates of most recent literature review.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality

- Use better quality measures of marijuana use exposure, for example, blood THC levels instead of self-reported cannabis use, for studies of impairment and accidents.
- Increase testing for THC and its metabolites in drivers, especially fatally injured drivers and at-fault drivers.
- Accurately record timing of THC blood testing relevant to motor vehicle crashes and driving under the influence of drugs (DUID).

Surveillance

- Monitor perceptions of the risk associated with driving after using marijuana and self-report of personally doing so.
- Centralize reporting of blood THC levels (not just presence/absence of THC) for driving under the influence of drugs (DUID).
- Monitor method of use and dose of marijuana consumed in correlation with impairment.

Education

- Educate the public on marijuana-related impairment (driving, biking, and safety sensitive activities), including riding with impaired drivers.
- Educate the public on minimum time to wait before driving, biking, or participating in safety sensitive activities after using various types and doses of marijuana products.
- Educate the public on the combined effects and increased risk when using marijuana with alcohol or other substances.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Research to further clarify the relationship of saliva and urine levels to blood levels and relationship of all biomarkers to measures of functional impairment.
- Study the difference in impairment based on frequency of use/tolerance.
- Pharmacokinetic/pharmacodynamic and impairment research using doses consistent with the THC content of currently available marijuana products.
- Research on duration of driving impairment after oral marijuana and after high-dose smoked marijuana.
- Research to improve road-side marijuana testing.
- Research to identify reliable methods of assessing tolerance to marijuana in frequent users and to determine the extent to which tolerance affects impairment.
- Identification of better methods for measuring meaningful impairment.
- Research to determine whether THC metabolite ratios may be helpful in defining a better biomarker for impairment.
- Research to determine impairment after other methods of marijuana use (vaporizing, mucosal and dermal preparations).

References

1. Colorado State Patrol. Traffic Safety Statistics. 2016; https://www.colorado.gov/pacific/csp/traffic-safety-statistics. Accessed December 28, 2016.
2. CDC WONDER. Multiple Causes of Death Files, 1999-2014. http://wonder.cdc.gov/ucd-icd10.html: Centers for Disease Control and Prevention; 2016.
3. Colorado Task Force on Drunk & Impaired Driving. *Colorado Task Force on Drunk & Impaired Driving 2015 Annual Report*. 2016.
4. Hall W, Degenhardt L. Adverse health effects of non-medical cannabis use. *Lancet*. 2009;374(9698):1383-1391.
5. New data show 13.6 percent of Colorado adults use marijuana [press release]. June 15, 2015.
6. Baca R. Initiative 300: Everything you need to know about Denver's social cannabis use measure. *The Denver Post*2016.
7. Asbridge M, Hayden JA, Cartwright JL. Acute cannabis consumption and motor vehicle collision risk: Systematic review of observational studies and meta-analysis. *Bmj*. 2012;344:e536.
8. Hartman RL, Huestis MA. Cannabis effects on driving skills. *Clin Chem*. 2013;59(3):478-492.
9. Lowenstein SR, Koziol-McLain J. Drugs and traffic crash responsibility: A study of injured motorists in Colorado. *The Journal of Trauma: Injury, Infection, and Critical Care*. 2001;50(2):313-320.
10. Gjerde H, Strand MC, Morland J. Driving under the influence of non-alcohol drugs--An update Part I: Epidemiological Studies. *Forensic Sci Rev*. 2015;27(2):89-113.
11. Rogeberg O, Elvik R. The effects of cannabis intoxication on motor vehicle collision revisited and revised. *Addiction*. 2016;111(8):1348-1359.
12. Drummer OH, Gerostamoulos J, Batziris H, et al. The involvement of drugs in drivers of motor vehicles killed in Australian road traffic crashes. *Accident Analysis & Prevention*. 2004;36(2):239-248.
13. Kuypers KP, Legrand SA, Ramaekers JG, Verstraete AG. A case-control study estimating accident risk for alcohol, medicines and illegal drugs. *PLoS One*. 2012;7(8):e43496.
14. Laumon B, Gadegbeku B, Martin JL, Biecheler MB, Group SAM. Cannabis intoxication and fatal road crashes in France: population based case-control study. *Bmj*. 2005;331(7529):1371.
15. Poulsen H, Moar R, Pirie R. The culpability of drivers killed in New Zealand road crashes and their use of alcohol and other drugs. *Accid Anal Prev*. 2014;67:119-128.
16. Berghaus G, Scheer N, Schmidt P. Effects of cannabis on psychomotor skills and driving performance - a metaanalysis of experimental studies. 1995; http://casr.adelaide.edu.au/T95/paper/s16p2.html. Accessed 8/31/2014.
17. Berghaus G, Sticht G, Grellner W. *Meta-analysis of empirical studies concerning the effects of medicines and illegal drugs including pharmacokinetics on safe driving.* Center for Traffic Sciences at the University of Wurzburg;2011.
18. Grotenhermen F, Leson G, Berghaus G, et al. Developing limits for driving under cannabis. *Addiction*. 2007;102(12):1910-1917.
19. Ramaekers JG, Moeller MR, van Ruitenbeek P, Theunissen EL, Schneider E, Kauert G. Cognition and motor control as a function of Delta9-THC concentration in serum and oral fluid: limits of impairment. *Drug Alcohol Depend*. 2006;85(2):114-122.
20. Curran HV, Brignell C, Fletcher S, Middleton P, Henry J. Cognitive and subjective dose-response effects of acute oral Delta 9-tetrahydrocannabinol (THC) in infrequent cannabis users. *Psychopharmacology (Berl)*. 2002;164(1):61-70.

21. Hart CL, van Gorp W, Haney M, Foltin RW, Fischman MW. Effects of acute smoked marijuana on complex cognitive performance. *Neuropsychopharmacology*. 2001;25(5):757-765.

22. Hunault CC, Mensinga TT, Bocker KB, et al. Cognitive and psychomotor effects in males after smoking a combination of tobacco and cannabis containing up to 69 mg delta-9-tetrahydrocannabinol (THC). *Psychopharmacology (Berl)*. 2009;204(1):85-94.

23. Kelly TH, Foltin RW, Emurian CS, Fischman MW. Performance-based testing for drugs of abuse: dose and time profiles of marijuana, amphetamine, alcohol, and diazepam. *J Anal Toxicol*. 1993;17(5):264-272.

24. Lenne MG, Dietze PM, Triggs TJ, Walmsley S, Murphy B, Redman JR. The effects of cannabis and alcohol on simulated arterial driving: Influences of driving experience and task demand. *Accid Anal Prev*. 2010;42(3):859-866.

25. Ramaekers JG, Kauert G, Theunissen EL, Toennes SW, Moeller MR. Neurocognitive performance during acute THC intoxication in heavy and occasional cannabis users. *J Psychopharmacol*. 2009;23(3):266-277.

26. Ramaekers JG, Kauert G, van Ruitenbeek P, Theunissen EL, Schneider E, Moeller MR. High-potency marijuana impairs executive function and inhibitory motor control. *Neuropsychopharmacology*. 2006;31(10):2296-2303.

27. Ronen A, Chassidim HS, Gershon P, et al. The effect of alcohol, THC and their combination on perceived effects, willingness to drive and performance of driving and non-driving tasks. *Accid Anal Prev*. 2010;42(6):1855-1865.

28. Ronen A, Gershon P, Drobiner H, et al. Effects of THC on driving performance, physiological state and subjective feelings relative to alcohol. *Accid Anal Prev*. 2008;40(3):926-934.

29. Schwope DM, Bosker WM, Ramaekers JG, Gorelick DA, Huestis MA. Psychomotor performance, subjective and physiological effects and whole blood Delta(9)-tetrahydrocannabinol concentrations in heavy, chronic cannabis smokers following acute smoked cannabis. *J Anal Toxicol*. 2012;36(6):405-412.

30. Weinstein A, Brickner O, Lerman H, et al. A study investigating the acute dose-response effects of 13 mg and 17 mg Delta 9- tetrahydrocannabinol on cognitive-motor skills, subjective and autonomic measures in regular users of marijuana. *J Psychopharmacol*. 2008;22(4):441-451.

31. Bosker WM, Kuypers KP, Theunissen EL, et al. Medicinal Delta(9) -tetrahydrocannabinol (dronabinol) impairs on-the-road driving performance of occasional and heavy cannabis users but is not detected in Standard Field Sobriety Tests. *Addiction*. 2012;107(10):1837-1844.

32. Menetrey A, Augsburger M, Favrat B, et al. Assessment of driving capability through the use of clinical and psychomotor tests in relation to blood cannabinoids levels following oral administration of 20 mg dronabinol or of a cannabis decoction made with 20 or 60 mg Delta9-THC. *J Anal Toxicol*. 2005;29(5):327-338.

33. Vindenes V, Strand DH, Kristoffersen L, Boix F, Morland J. Has the intake of THC by cannabis users changed over the last decade? Evidence of increased exposure by analysis of blood THC concentrations in impaired drivers. *Forensic Sci Int*. 2013;226(1-3):197-201.

34. Blows S, Ivers RQ, Connor J, Ameratunga S, Woodward M, Norton R. Marijuana use and car crash injury. *Addiction (Abingdon, England)*. 2005;100(5):605-611.

35. Chipman ML, Macdonald S, Mann RE. Being "at fault" in traffic crashes: does alcohol, cannabis, cocaine, or polydrug abuse make a difference? *Inj Prev*. 2003;9(4):343-348.

36. Mann RE, Adlaf E, Zhao J, et al. Cannabis use and self-reported collisions in a representative sample of adult drivers. *J Safety Res*. 2007;38(6):669-674.

37. Pulido J, Barrio G, Lardelli P, Bravo MJ, Regidor E, de la Fuente L. Association between cannabis and cocaine use, traffic injuries and use of protective devices. *Eur J Public Health*. 2011;21(6):753-755.

38. Mura P, Kintz P, Ludes B, et al. Comparison of the prevalence of alcohol, cannabis and other drugs between 900 injured drivers and 900 control subjects: results of a French collaborative study. *Forensic Sci Int*. 2003;133(1-2):79-85.

39. Sewell RA, Poling J, Sofuoglu M. The effect of cannabis compared with alcohol on driving. *Am J Addict*. 2009;18(3):185-193.

40. Dubois S, Mullen N, Weaver B, Bedard M. The combined effects of alcohol and cannabis on driving: Impact on crash risk. *Forensic Sci Int*. 2015;248:94-100.

41. Fierro I, González-Luque JC, Álvarez FJ. The relationship between observed signs of impairment and THC concentration in oral fluid. *Drug and Alcohol Dependence*. 2014;144:231-238.

42. Hartman RL, Brown TL, Milavetz G, et al. Controlled vaporized cannabis, with and without alcohol: Subjective effects and oral fluid-blood cannabinoid relationships. *Drug Test Anal*. 2015;10.1002/dta.1839.

43. Cone EJ, Johnson RE. Contact highs and urinary cannabinoid excretion after passive exposure to marijuana smoke. *Clin Pharmacol Ther*. 1986;40(3):247-256.

44. Huestis MA. Human cannabinoid pharmacokinetics. *Chem Biodivers*. 2007;4(8):1770-1804.

45. Hunault CC, Bocker KB, Stellato RK, Kenemans JL, de Vries I, Meulenbelt J. Acute subjective effects after smoking joints containing up to 69 mg Delta9-tetrahydrocannabinol in recreational users: a randomized, crossover clinical trial. *Psychopharmacology (Berl)*. 2014;231(24):4723-4733.

46. Bosker WM, Karschner EL, Lee D, et al. Psychomotor function in chronic daily Cannabis smokers during sustained abstinence. *PLoS One*. 2013;8(1):e53127.

47. Wolff K, Johnston A. Cannabis use: a perspective in relation to the proposed UK drug-driving legislation. *Drug Test Anal*. 2014;6(1-2):143-154.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 7

Marijuana Use and Gastrointestinal and Reproductive Effects

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Andrew Monte, MD
Emergency Medicine Physician, University of Colorado
Medical Toxicologist, Rocky Mountain Poison and Drug Center
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2016)

Madeline Morris, BS
Graduate Student, Colorado School of Public Health
(2014)

David Goff Jr., MD, PhD
Dean and Professor, Colorado School of Public Health
(2014)

Reviewer

Ken Gershman, MD, MPH
Manager
Marijuana Research Grants Program, Colorado Department of Public Health and Environment
(2014, 2016)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana use and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of gastrointestinal diseases, particularly cyclic vomiting, and infertility or abnormal reproductive function.

Gastrointestinal diseases affect 60 to 70 million people in the United States,[1] and caused more than 20 million hospitalizations in 2010.[2] Both tobacco and alcohol contribute to some of these diseases, and it is possible marijuana could as well. One condition of concern, reported by emergency department providers, is cyclic vomiting among long-time, frequent marijuana users. Analysis of 2015 data from the Behavioral Risk Factor Surveillance System (BRFSS), completed for this report, estimated that 6 percent of adults in Colorado use marijuana daily or near-daily. Potential connections between marijuana use and cyclic vomiting or other gastrointestinal diseases are important to clarify.

Many women who want to become pregnant are unable. Eleven percent of women 15-44 years of age in the United States have used infertility services,[3] often at great expense. Many men also have conditions that can prevent a desired pregnancy, such as low sperm count. Because normal reproductive function is dependent on so many factors, any substance that has effects throughout the body could potentially contribute to infertility. Marijuana use in Colorado is highest among individuals of reproductive age. Analysis of 2015 data from the BRFSS, completed for this report, estimated that 26 percent of 18-25 year olds and 18 percent of 26-34 year olds in Colorado were current marijuana users. It is important to evaluate possible associations between infertility and marijuana use.

Definitions

Cannabinoid hyperemesis syndrome - a term currently used by some medical professionals to describe cyclic vomiting occurring in long-time marijuana users. A formal medical definition, including clinical diagnostic criteria, has not yet been established.

Cyclic vomiting - episodes of severe, repeated vomiting.

Abnormal male reproductive function - abnormal sperm count, concentration, motility or structure, or abnormal reproductive hormone levels.

Abnormal female reproductive function - abnormal ovulation, implantation, placenta formation, or reproductive hormone levels.

Levels of marijuana use

- Daily or near-daily use: 5-7 days/week.
- Weekly use: 1-4 days/week.
- Less-than-weekly use: less than 1 day/week.

Key findings

Evidence shows that long-time, daily or near-daily marijuana use is associated with cyclic vomiting. This condition has been called cannabinoid hyperemesis syndrome. In such cases, stopping marijuana use may relieve the vomiting. There is conflicting research on whether or not marijuana use is associated with male infertility or abnormal reproductive function, and research is lacking on female reproductive function related to marijuana use.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

The committee recommends that health care systems and providers improve the documentation of marijuana use history during hospitalizations and emergency department visits, including timing, potency and amount of last marijuana use and measures of cumulative lifetime use. Because cannabinoid hyperemesis syndrome is an emerging medical concern, public health should assess and monitor its prevalence among marijuana users, and educate the public about the potential for cyclic vomiting with long-time, daily or near-daily marijuana use.

It is also important to reach a consensus on diagnostic criteria for cannabinoid hyperemesis syndrome. Treatment of the condition should be studied using randomized, controlled trials, including an assessment of the effectiveness of marijuana cessation. High-quality observational research is needed to further assess the effects of marijuana use on reproductive function.

Table 1 Findings summary: Marijuana use and gastrointestinal and reproductive effects

For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process.

Substantial	Moderate	Limited	Insufficient	Mixed
	Cyclic vomiting with long-time, daily or near-daily use (cannabinoid hyperemesis syndrome)	Relief from cyclic vomiting by stopping marijuana use	Female infertility or altered reproductive function	Male infertility or altered reproductive function

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix L.

1. We found **MODERATE** evidence that long-time, daily or near-daily marijuana use is associated with cases of cyclic vomiting (some medical experts have called this cannabinoid hyperemesis syndrome).[4-8] (Added[*])
2. We found **LIMITED** evidence that marijuana users who experience cyclic vomiting have found relief by stopping marijuana use.[6,8,9] (Added*)
3. We found **MIXED** evidence for whether or not marijuana use is associated with male infertility or abnormal reproductive function (such as abnormal sperm count, concentration, motility or structure, or abnormal reproductive hormone levels).[10-13] (Revised*)
4. We found **INSUFFICIENT** evidence to determine whether or not marijuana use is associated with female infertility or abnormal reproductive function (such as abnormal ovulation, implantation, placenta formation, or reproductive hormone levels).[14] (Added*)

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix L for dates of most recent literature review.

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

1. Long-time, daily or near-daily marijuana use is associated with cyclic vomiting, which some medical experts have called cannabinoid hyperemesis syndrome. (Added*)
2. Marijuana users who experience cyclic vomiting may find relief by stopping marijuana use. (Added*)
3. There is conflicting research on whether or not marijuana use is associated with male infertility or reproductive function.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality

- Improved documentation of marijuana use history during hospitalizations and emergency department visits, including timing, potency and amount of last marijuana use and measures of cumulative lifetime use.

Surveillance

- Population based analyses to evaluate the prevalence of cannabinoid hyperemesis syndrome or cyclic vomiting among marijuana users, including separate rates for medical versus recreational users.

Education

- Public education about the potential for cyclic vomiting with long-time, daily or near-daily marijuana use.

* Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix L for dates of most recent literature review.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- High quality studies assessing reproductive function related to marijuana use.
- Consensus diagnostic criteria for cannabinoid hyperemesis syndrome (CHS) to be used in subsequent research.
- Determination of the molecular etiology of CHS.
- Clinical studies of CHS treatment, including the effectiveness of marijuana cessation.

References

1. National Institute of Diabetes and Digestive and Kidney Diseases. *Opportunities & Challenges in Digestive Diseases Research: Recommendations of the National Commission on Digestive Diseases*. National Institutes of Health;2009.
2. National Center for Health Statistics. National Hosptial Discharge Survey, United States 2010 https://www.cdc.gov/nchs/fastats/hospital.htm: Centers for Disease Control and Prevention.
3. National Center for Health Statistics. Key Statistics from the National Survey of Family Growth. https://www.cdc.gov/nchs/nsfg/key_statistics.htm. Accessed December 27, 2016.
4. Wallace EA, Andrews SE, Garmany CL, Jelley MJ. Cannabinoid hyperemesis syndrome: literature review and proposed diagnosis and treatment algorithm. *South Med J*. 2011;104(9):659-664.
5. Soriano-Co M, Batke M, Cappell MS. The cannabis hyperemesis syndrome characterized by persistent nausea and vomiting, abdominal pain, and compulsive bathing associated with chronic marijuana use: a report of eight cases in the United States. *Dig Dis Sci*. 2010;55(11):3113-3119.
6. Simonetto Da, Oxentenko AS, Herman ML, Szostek JH. Cannabinoid hyperemesis: a case series of 98 patients. *Mayo Clinic Proceedings*. 2012;87(2):114-119.
7. Kim HS, Anderson JD, Saghafi O, Heard KJ, Monte AA. Cyclic vomiting presentations following marijuana liberalization in Colorado. *Acad Emerg Med*. 2015;22(6):694-699.
8. Allen JH, de Moore GM, Heddle R, Twartz JC. Cannabinoid hyperemesis: cyclical hyperemesis in association with chronic cannabis abuse. *Gut*. 2004;53(11):1566-1570.
9. Namin F, Patel J, Lin Z, et al. Clinical, psychiatric and manometric profile of cyclic vomiting syndrome in adults and response to tricyclic therapy. *Neurogastroenterol Motil*. 2007;19(3):196-202.
10. Pacey AA, Povey AC, Clyma JA, et al. Modifiable and non-modifiable risk factors for poor sperm morphology. *Hum Reprod*. 2014;29(8):1629-1636.
11. Povey AC, Clyma JA, McNamee R, et al. Modifiable and non-modifiable risk factors for poor semen quality: a case-referent study. *Hum Reprod*. 2012;27(9):2799-2806.
12. Block RI, Farinpour R, Schlechte JA. Effects of chronic marijuana use on testosterone, luteinizing hormone, follicle stimulating hormone, prolactin and cortisol in men and women. *Drug Alcohol Depend*. 1991;28(2):121-128.
13. Gundersen TD, Jorgensen N, Andersson AM, et al. Association Between Use of Marijuana and Male Reproductive Hormones and Semen Quality: A Study Among 1,215 Healthy Young Men. *Am J Epidemiol*. 2015;182(6):473-481.
14. Mueller BA, Daling JR, Weiss NS, Moore DE. Recreational drug use and the risk of primary infertility. *Epidemiology*. 1990;1(3):195-200.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 8

Marijuana Use and Injury

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Ashley Brooks-Russell, PhD, MPH
Assistant Professor
Injury Prevention, Education and Research Program, Colorado School of Public Health
(2014, 2016)

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Renee M. Johnson, PhD, MPH
Associate Professor
Department of Mental Health, Johns Hopkins Bloomberg School of Public Health
(2016)

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2014, 2016)

Katelyn E. Hall, MPH
Statistical Analyst
Retail Marijuana Health Monitoring Program, Colorado Department of Public Health and Environment
(2014)

Madeline Morris, BS
Graduate Student, Colorado School of Public Health
(2014)

Dr. David Goff Jr., MD, PhD
Dean and Professor, Colorado School of Public Health
(2014)

Reviewers

Heath Harmon, MPH
Director of Health Divisions, Boulder County Public Health
(2016)

Ashley Brooks-Russell, PhD, MPH
Assistant Professor, Colorado School of Public Health
(2014)

Ken Gershman, MD, MPH
Manager
Medical Marijuana Research Grants Program, Colorado Department of Public Health and Environment
(2014)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of workplace, recreational and other non-driving injuries (driving-related injuries are described in Chapter 12. Marijuana use and driving), burns from hash oil extraction or failed electronic smoking devices, and physical dating violence.

In Colorado, thousands of people are injured on the job each year, and a work-related death occurs every three to four days.[1] Outdoor recreational activities are extremely popular in Colorado, drawing participation from about two-thirds of residents annually,[2] and recreational injuries are common. Additionally, many of the tourists visiting Colorado - 64 million in 2013[3] – come to enjoy outdoor recreation. Unintentional injuries, excluding motor vehicle crashes, are responsible for 17 percent of all deaths among persons 10-24 years of age in the United States.[4] Marijuana use can cause unsteady gait, slower reaction time, impaired motor coordination, and impaired attention,[5,6] which are all factors that contribute to accidental injuries.

Analyses of 2015 Behavioral Risk Factor Surveillance System data, completed for this report, estimated that 26 percent of 18-25 year olds and 18 percent of 26-34 year olds in Colorado have used marijuana within the last month. These age groups make up a large portion of the workforce. Recreational activities are common among these 18-34 year olds, as well as adolescents. 2015 Healthy Kids Colorado Survey data, also analyzed for this report, estimate that 21 percent of Colorado high school students used marijuana within the last month. It is important to investigate possible associations between marijuana use and workplace, recreational and other non-driving injuries.

Recently, there have been increased reports of explosions related to hash oil extraction. In 2014, there were 32 hash oil extraction explosions in Colorado, which injured 30 people (most often burns).[7] Another emerging topic of concern has been the explosion of electronic smoking devices[8,9], which are used for both marijuana and nicotine. The devices have grown in popularity, and injuries resulting from explosions are increasing.[10] These topics should be evaluated.

Approximately 10 percent of U.S. high school students report having experienced physical dating violence,[11] and the prevalence is similar among college students.[12] The consequences of this violence are serious. Those who are victimized are at increased risk for a range of negative outcomes including poor health outcomes, depressive symptoms, unhealthy eating behavior, academic difficulties, and physical injury.[13-15] Alcohol use has been clearly linked with intimate partner violence,[16,17] and some have argued that marijuana use is also a contributing factor. It is important to identify factors that may contribute to dating violence, including examination of possible associations with marijuana use.

Definitions

Age groups

- Adolescent: 12 to 17 years of age.
- Young adult: 18 to 24 years of age.
- Adult: 25 years or older.
- Older adult: 65 years of age and older.

Electronic smoking device (vaporizer or e-cigarette) - a vaporizing device with a rechargeable battery that heats material such as marijuana flower (bud) or liquids containing THC or nicotine to produce vapor for inhalation. Used as an alternative to smoking marijuana or tobacco.

Hash oil extraction - a technique that removes THC (the psychoactive component of marijuana) from the plant material in a concentrated form. This concentrate can then be smoked, vaporized, mixed into food or drink, or used on the skin. A very common method of extraction uses butane, which is highly flammable.

Physical dating violence - physically aggressive behavior among current or former romantic, sexual/intimate, or dating partners, including hitting, kicking, choking, slapping, etc. Psychological, emotional, verbal or sexual violence were not included, nor were threats of violence.

Physical dating violence victimization (PDVV) - to be harmed by physical violence committed by a partner.

Physical dating violence perpetration (PDVP) - to commit physical violence against a partner.

Tetrahydrocannabinol (THC) - the main psychoactive component of marijuana.

Key findings

There is some evidence that marijuana use increases the risk of workplace injury. Evidence is conflicting for other types of non-driving injury, including marijuana use alone or in combination with alcohol. There have been many cases of severe burns resulting from explosions that occurred during home-extraction of hash oil through the use of butane. There also have been cases of electronic smoking devices exploding, leading to trauma and burns. Concerning dating violence, marijuana use by adolescent girls may be associated with their committing physical violence against their dating partners, and marijuana use by adolescent boys may be associated with their being victims of physical violence from their dating partners.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

The committee recommended more consistent collection of blood samples following recreational, workplace or any other injury requiring medical attention, including accurately recording the timing of testing, and specifying marijuana use as distinct from other substances. Improved collection of information on individual marijuana use history by amount, potency, frequency, and method is also important. The link between exposure to marijuana and adverse health outcomes, in both injury and chronic disease medical settings, cannot be adequately assessed until consistent, standardized data on individual marijuana use is collected during encounters with medical care settings, mental health settings and, when necessary, law enforcement. Collecting accurate exposure (or dose) information and injury outcome data will permit analysis of the data to determine the severity of injury and its possible relationship with marijuana use.

Surveillance or monitoring systems currently in place (e.g., hospitalization and emergency department data from the Colorado Hospital Association) can be interrogated to assess injuries potentially related to marijuana use. The committee recommended additional small-scale pilot projects to determine the relationship between marijuana use and injury in focused settings including recreational, workplaces, and where services are provided for the elderly. Monitoring the incidence of injuries caused by electronic device explosions and hash oil extraction explosions is also recommended.

Educational programs for adult users, their families, and health care providers are needed to ensure more information is shared about the potential risks of marijuana use and injury. Such information also should be available and distributed to customers at marijuana dispensaries. Education about the potential explosion of electronic smoking devices and at-home hash oil extractions is important.

The committee identified several research gaps including the need for more research on the relationship of THC levels in saliva, blood and urine, and how these biomarkers relate to measures of functional impairment. Research is also needed on differences in impairment levels based on marijuana use frequency and tolerance in daily or near-daily users versus other levels of use. More publicly accessible product safety research is needed for electronic smoking devices. Finally, more studies are needed that examine marijuana use as a predictor of risk behaviors, especially among adolescents, college attending young adults and non-college attending young adults.

Table 1 Findings summary: Marijuana use and injury

For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
Non-driving injury			Increased risk of workplace injury		Marijuana use and risk of non-driving injury
					Combined marijuana and alcohol use and non-driving injury
					Marijuana use and risk of recreational injury
Burns			Severe burns and hospitalization from hash oil extraction	Marijuana use and burns	
			Serious injury from exploding electronic smoking devices		
Physical Dating Violence			Physical dating violence perpetration by adolescent girls	Physical dating violence victimization in young adults	Physical dating violence perpetration by adolescent boys
			Physical dating violence victimization in adolescent boys		Physical dating violence victimization in adolescent girls
			Failure to show physical dating violence perpetration by young adult women or men		

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix M.

Workplace, recreational, other non-driving

1. We found **LIMITED** evidence that marijuana use increases workplace injury risk (non-driving injury).[18-20]
2. We found **MIXED** evidence for whether or not adults who use marijuana are at a higher risk of non-driving related injuries.[20-27]
3. We found **MIXED** evidence for whether or not adults who use marijuana and alcohol combined are at a higher risk of non-driving related injury than those who use either substance alone.[23,24,27-29]
4. We found **MIXED** evidence for whether or not adults who use marijuana are at a higher risk of injury due to recreational activity.[28,30,31]

Burns

5. We found **LIMITED** evidence that home extraction of hash oil has resulted in cases of severe burns requiring hospitalization.[32-36] (Added[*])
6. We found **LIMITED** evidence that electronic smoking devices have failed (exploded), resulting in cases of trauma and burn injury.[37-39] (Added*)
7. We found **INSUFFICIENT** evidence to determine whether or not there is an association between marijuana-use in the past 30-days and burn injury.[40] (Added*)

Physical dating violence

8. We found **LIMITED** evidence that marijuana use is associated with physical dating violence perpetration (PDVP) by adolescent girls.[41-44] (Added*)
9. We found **LIMITED** evidence that marijuana use is associated with physical dating violence victimization (PDVV) among adolescent boys.[45-47] (Added*)
10. We found **MIXED** evidence for whether or not marijuana use is associated with physical dating violence perpetration (PDVP) by adolescent boys.[43,44] (Added*)
11. We found **MIXED** evidence for whether or not marijuana use is associated with physical dating violence victimization (PDVV) among adolescent girls .[41,45,46] (Added*)
12. We found a **LIMITED** body of research that failed to show an association between marijuana use and physical dating violence perpetration (PDVP) by young adult men.[48,49] (Added*)
13. We found a **LIMITED** body of research that failed to show an association between marijuana use and physical dating violence perpetration (PDVP) by young adult women.[41,48,50,51] (Added*)
14. We found **INSUFFICIENT** evidence to determine whether or not marijuana use is associated with physical dating violence victimization (PDVV) among young adults.[52] (Added*)

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix M for dates of most recent literature review

Public health statements

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

1. Marijuana use may be associated with increased risk of non-driving related workplace injuries.
2. There is conflicting research on whether or not marijuana use alone or combined with alcohol increases the risk of other non-driving related injury among adults.
3. Use caution when driving, biking, or performing other safety-sensitive activities after using any form of marijuana or marijuana product.
4. Electronic smoking or vaporizing devices can explode, causing serious injury. (Added*)
5. Extracting hash oil yourself with flammable substances can cause severe burns requiring hospitalization. (Added[*])
6. Marijuana use by adolescent girls may be associated with a higher risk of committing physical violence against their dating partners. Marijuana use by adolescent boys may be associated with a higher risk of being the victim of physical violence from their dating partners.

[*] *Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix M for dates of most recent literature review.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) improving knowledge regarding population-based health effects of retail marijuana use, 2) developing and targeting public health education and prevention strategies for high-risk subpopulations.

Data quality

- Accurately record timing of THC blood testing, relevant to recreational, workplace or any other injury requiring medical attention, and specify marijuana use as distinct from other substances.
- Use better quality measure of marijuana use exposure, for example, blood THC levels instead of self-reported marijuana use, for studies of impairment and accidents.
- Ensure quality description of burns related to marijuana use or production.
- Improve the measures of marijuana exposure used in population-based studies.
- Report measures of association separately by age group (e.g. adolescent, young adult), sex, and other characteristics that may lead to differing findings.

Surveillance

- Improve and centralize reporting of blood THC levels (not just presence/absence of THC) for trauma and workplace injury surveillance.
- Develop small-scale surveillance projects to assess the use of marijuana among those injured in recreational activities.
- Monitor incidence of recreational injuries related to marijuana use.
- Monitor incidence of workplace injuries related to marijuana production or use.
- Monitor the prevalence of marijuana use and incidence of fall-related injuries among older adults.
- Monitor incidence of injuries caused by electronic device explosions and hash oil extraction explosions.

Education

- Educate the public on marijuana-related impairment, including related risks of recreational injuries, workplace injuries and falls in older adults.
- Educate the public about the potential hazards of exploding electronic smoking devices.
- Educate the public on the hazards and laws pertaining to at-home hash oil extraction.
- Expand public education about the link between marijuana use and risk behaviors among adolescents and young adults.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Research to further clarify the relationship of saliva and urine levels to blood levels and relationship of all biomarkers to measures of functional impairment.
- Study differences in impairment based on frequency of use/tolerance.
- Develop studies to evaluate risk of burn injuries among marijuana users.
- Study consumer product safety of electronic smoking devices.
- Increase the number of studies that examine marijuana use as a predictor of risk behaviors, especially among adolescents, college attending young adults and non-college attending young adults.
- Identify the independent effect of marijuana use on adolescent risk behaviors, adjusting for alcohol use and other potential confounders.

References

1. Colorado Department of Public Health and Environment. Workplace safety data and reports. 2016; https://www.colorado.gov/pacific/cdphe/workplace-safety-data-and-reports. Accessed December 27, 2016.
2. Outdoor Industry Association. *The Outdoor Recreation Economy: Colorado*. 2012.
3. Development Research Partners Inc. and Progress Colorado. Tourism continues as state's economic cornerstone. 2015; http://progressco.org/recreation-tourism-overview/. Accessed December 28, 2016.
4. CDC WONDER. About Underlying Cause of Death, 1999-2015. http://wonder.cdc.gov/ucd-icd10.html: Centers for Disease Control and Prevention.
5. Grotenhermen F. Pharmacokinetics and pharmacodynamics of cannabinoids. *Clin Pharmacokinet*. 2003;42(4):327-360.
6. Hall W, Degenhardt L. Adverse health effects of non-medical cannabis use. *Lancet*. 2009;374(9698):1383-1391.
7. Rocky Mountain High Intensity Drug Trafficing Area. *The Legalization of Marijuana in Colorado: The Impact*. September 2015 2015.
8. Whaley M. Some Colorado smokers burned by exploding e-cigarettes. *The Denver Post*. February 7, 2016, 2016.
9. Glaser A. Vape Pens and E-Cigs Are Blowing Up. Like, Literally. *Wired*, https://www.wired.com/2016/02/exploding-e-cigs-and-vape-pens/2016.
10. Eltman F. E-cigarette fires and injuries are on the rise, with faulty batteries suspected. *The Denver Post*. December 14, 2016, 2016.
11. Rothman EF, Xuan Z. Trends in Physical Dating Violence Victimization Among U.S. High School Students, 1999-2011. *J Sch Violence*. 2014;13(3):277-290.
12. Black MC, Basile, K.C., Breiding, M.J., Smith, S.G., Walters, M.L., Merrick, M.T., Chen, J., & Stevens, M.R. *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010 Summary Report*. Atlanta, GA: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention;2011.
13. Fletcher J. The effects of intimate partner violence on health in young adulthood in the United States. *Soc Sci Med*. 2010;70(1):130-135.
14. Bonomi AE, Anderson ML, Nemeth J, Rivara FP, Buettner C. History of dating violence and the association with late adolescent health. *BMC Public Health*. 2013;13:821.
15. Ackard DM, Eisenberg ME, Neumark-Sztainer D. Long-term impact of adolescent dating violence on the behavioral and psychological health of male and female youth. *J Pediatr*. 2007;151(5):476-481.
16. Foran HM, O'Leary KD. Alcohol and intimate partner violence: a meta-analytic review. *Clin Psychol Rev*. 2008;28(7):1222-1234.
17. Leonard KE. Alcohol and intimate partner violence: when can we say that heavy drinking is a contributing cause of violence? *Addiction*. 2005;100(4):422-425.
18. Shipp EM, Tortolero SR, Cooper SP, Baumler EG, Weller NF. Substance use and occupational injuries among high school students in South Texas. *Am J Drug Alcohol Abuse*. 2005;31(2):253-265.
19. Price JW. Marijuana and workplace safety: an examination of urine drug tests. *J Addict Dis*. 2014;33(1):24-27.

20. Wadsworth EJK, Moss SC, Simpson Sa, Smith aP. A community based investigation of the association between cannabis use, injuries and accidents. *Journal of psychopharmacology (Oxford, England).* 2006;20(1):5-13.

21. Polen MR, Sidney S, Tekawa IS, Sadler M, Friedman GD. Health care use by frequent marijuana smokers who do not smoke tobacco. *West J Med.* 1993;158(6):596-601.

22. Barrio G, Jiménez-Mejías E, Pulido J, Lardelli-Claret P, Bravo MJ, de la Fuente L. Association between cannabis use and non-traffic injuries. *Accid Anal Prev.* 2012;47:172-176.

23. Gerberich S. Marijuana Use and Injury Events Resulting in Hospitalization. *Annals of Epidemiology.* 2003;13(4):230-237.

24. Gmel G, Kuendig H, Rehm J, Schreyer N, Daeppen J-B. Alcohol and cannabis use as risk factors for injury--a case-crossover analysis in a Swiss hospital emergency department. *BMC Public Health.* 2009;9(1):40-40.

25. Tait RJ, Anstey KJ, Butterworth P. Incidence of self-reported brain injury and the relationship with substance abuse: findings from a longitudinal community survey. *BMC Public Health.* 2010;10(1):171-171.

26. Braun BL, Tekawa IS, Gerberich SG, Sidney S. Marijuana Use and Medically Attended Injury Events. *Ann Emerg Med.* 1998;32(3):353-360.

27. Vinson DC. Marijuana and other illicit drug use and the risk of injury: A case-control study. *Mo Med.* 2006;103(2):152-156.

28. Asbridge M, Mann R, Cusimano MD, Tallon JM, Pauley C, Rehm J. Cycling-related crash risk and the role of cannabis and alcohol: a case-crossover study. *Preventive Medicine.* 2014;66:80-86.

29. Woolard R, Nirenberg TD, Becker B, et al. Marijuana Use and Prior Injury among Injured Problem Drinkers. *Academic Emergency Medicine.* 2003;10(1):43-51.

30. Siwani R, Tombers NM, Rieck KL, Cofer SA. Comparative analysis of fracture characteristics of the developing mandible: the Mayo Clinic experience. *International journal of pediatric otorhinolaryngology.* 2014;78(7):1066-1070.

31. Chiolero A, Schmid H. Repeated self-reported injuries and substance use among young adolescents: the case of Switzerland. *Sozial- und Präventivmedizin.* 2002;47(5):289-297.

32. Bell C, Slim J, Flaten HK, Lindberg G, Arek W, Monte AA. Butane Hash Oil Burns Associated with Marijuana Liberalization in Colorado. *J Med Toxicol.* 2015;11(4):422-425.

33. Jensen G, Bertelotti R, Greenhalgh D, Palmieri T, Maguina P. Honey oil burns: a growing problem. *J Burn Care Res.* 2015;36(2):e34-37.

34. Porter CJ, Armstrong JR. Burns from illegal drug manufacture: case series and management. *J Burn Care Rehabil.* 2004;25(3):314-318.

35. Schneberk T, Valenzuela RG, Sterling G, Mallon WK. Hot Wax. *JEMS.* 2015;40(9):44-47, 52.

36. Williams GD. Hash-oil manufacture: an important factor in the occurrence of adult burns in Jamaica. *West Indian Med J.* 1988;37(4):210-214.

37. Colaianni CA, Tapias LF, Cauley R, Sheridan R, Schulz JT, Goverman J. Injuries Caused by Explosion of Electronic Cigarette Devices. *Eplasty.* 2016;16:ic9.

38. Roger JM, Abayon M, Elad S, Kolokythas A. Oral Trauma and Tooth Avulsion Following Explosion of E-Cigarette. *J Oral Maxillofac Surg.* 2016;10.1016/j.joms.2015.12.017.

39. United States Fire Administration. Electronic Cigarette Fires and Explosions. October 2014.

40. Jehle CC, Jr., Nazir N, Bhavsar D. The rapidly increasing trend of cannabis use in burn injury. *J Burn Care Res.* 2015;36(1):e12-17.

41. Epstein-Ngo QM, Cunningham RM, Whiteside LK, et al. A daily calendar analysis of substance use and dating violence among high risk urban youth. *Drug Alcohol Depend*. 2013;130(1-3):194-200.

42. Foshee VA, Reyes HL, Ennett ST. Examination of Sex and Race Differences in Longitudinal Predictors of the Initiation of Adolescent Dating Violence Perpetration. *J Aggress Maltreat Trauma*. 2010;19(5):492-516.

43. McNaughton Reyes HL, Foshee VA, Bauer DJ, Ennett ST. Proximal and time-varying effects of cigarette, alcohol, marijuana and other hard drug use on adolescent dating aggression. *J Adolesc*. 2014;37(3):281-289.

44. Rothman EF, Johnson RM, Azrael D, Hall DM, Weinberg J. Perpetration of physical assault against dating partners, peers, and siblings among a locally representative sample of high school students in Boston, Massachusetts. *Arch Pediatr Adolesc Med*. 2010;164(12):1118-1124.

45. Eaton DK, Davis KS, Barrios L, Brener ND, Noonan RK. Associations of dating violence victimization with lifetime participation, co-occurrence, and early initiation of risk behaviors among U.S. high school students. *J Interpers Violence*. 2007;22(5):585-602.

46. Shorey RC, Fite PJ, Choi H, Cohen JR, Stuart GL, Temple JR. Dating Violence and Substance Use as Longitudinal Predictors of Adolescents' Risky Sexual Behavior. *Prev Sci*. 2015;16(6):853-861.

47. Yan FA, Howard DE, Beck KH, Shattuck T, Hallmark-Kerr M. Psychosocial correlates of physical dating violence victimization among Latino early adolescents. *J Interpers Violence*. 2010;25(5):808-831.

48. Nabors EL. Drug use and intimate partner violence among college students: an in-depth exploration. *J Interpers Violence*. 2010;25(6):1043-1063.

49. Shorey RC, Stuart GL, McNulty JK, Moore TM. Acute alcohol use temporally increases the odds of male perpetrated dating violence: a 90-day diary analysis. *Addict Behav*. 2014;39(1):365-368.

50. Shorey RC, Stuart GL, Moore TM, McNulty JK. The temporal relationship between alcohol, marijuana, angry affect, and dating violence perpetration: A daily diary study with female college students. *Psychol Addict Behav*. 2014;28(2):516-523.

51. Testa M, Hoffman JH, Leonard KE. Female intimate partner violence perpetration: stability and predictors of mutual and nonmutual aggression across the first year of college. *Aggress Behav*. 2011;37(4):362-373.

52. Melander LA, Noel H, Tyler KA. Bidirectional, unidirectional, and nonviolence: a comparison of the predictors among partnered young adults. *Violence Vict*. 2010;25(5):617-630.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 9

Marijuana Use and Neurological, Cognitive and Mental Health Effects

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

***Allison Rosenthal, MPH**
Applied Epidemiology Fellow, Substance Abuse Mental Health Services Administration and Council of State and Territorial Epidemiologists
(2016)

Christian Thurstone, MD
Psychiatrist and Medical Director of Addiction Services, University of Colorado
Associate Professor of Psychiatry, Denver Health
(2016)

Christopher H. Domen, PhD, ABPP-CN
Assistant Professor, Department of Neurosurgery, University of Colorado School of Medicine
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Reviewers

Rebecca Helfand, PhD
Director of Data and Evaluation
Office of Behavioral Health, Colorado Department of Human Services
(2016)

Ken Gershman, MD, MPH
Manager
Marijuana Research Grants Program, Colorado Department of Public Health and Environment
(2014)

*This work was supported in part by an appointment to the Applied Epidemiology Fellowship Program administered by the Council of State and Territorial Epidemiologists (CSTE) and funded through the Centers for Disease Control and Prevention (CDC) Cooperative Agreement Number 1U38OT000143-04 by the Substance Abuse and Mental Health Services Administration.

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of the potential relationships between marijuana use and cognitive impairment, mental health disorders and substance abuse.

Many adults in the United States suffer from some form of mental illness. In 2015, approximately 18 percent of the adult U.S. population (43 million people), had a diagnosable mental, behavioral, or emotional disorder, according to the National Survey on Drug Use and Health.[1] While the effects of these disorders can range from mild impairment to severe disability, all have a detrimental individual impact. In addition, these disorders place a considerable financial burden on our health care system. The extent and impact of cognitive impairment is difficult to measure among the general adult population. Many adults may not realize if they have a cognitive impairment. Those who do may downplay and attempt to compensate for it, but cognitive impairments can greatly affect a person's quality of life.

Some researchers have suggested that marijuana use can cause lasting cognitive impairment or mental health disorders such as anxiety, depression, and psychosis. Known acute effects of marijuana use include fragmented thinking, disturbed memory, reduced motor coordination, anxiety and distorted awareness.[2,3] It is conceivable that ongoing marijuana use might cause some of these effects to be long-lasting. Many adults in Colorado use marijuana. Analysis of 2015 survey data, completed for this report, estimated that 13 percent of Colorado adults 18 years and older have used marijuana within the last month. About 6 percent use marijuana daily or near-daily. With at least one in 10 adults using marijuana, nearly one in five having a mental health disorder, and an uncertain number with cognitive impairment; it is extremely important to investigate the relationships between marijuana use, cognitive functioning and mental health.

Definitions

Levels of marijuana use

- Daily or near-daily use: 5-7 days/week.
- Weekly use: 1-4 days/week.
- Less-than-weekly use: less than 1 day/week.
- Acute use: used within the past few hours, such that the short-term effects or symptoms are still being experienced.

Cannabis use disorder - a formal diagnosis indicating two or more of these factors: hazardous use, social/interpersonal problems related to use, neglects major roles in order to use, legal problems, withdrawal, tolerance, uses more or longer than planned, repeated attempts to quit or reduce use, much time is spent using, physical or psychological problems related to use, and/or gives up activities in order to use;[4] commonly called addiction.

Dabbing - a method of marijuana use where a "dab" (small amount) of marijuana concentrate is placed on a pre-heated surface, creating concentrated marijuana vapor to be inhaled.

Marijuana addiction - an informal term which is more commonly used than cannabis use disorder, but the two are considered equivalent by the committee and many mental health professionals.

Psychotic disorders – these include schizophrenia, schizoaffective, schizophreniform, schizotypal, and delusional disorders. These formal diagnoses are made when a combination of psychotic symptoms are present (possibly combined with other mental health symptoms), the symptoms cause significant problems with work, relationships or self-care, and they have been present for six months or longer.[4]

Psychotic symptoms - these include auditory or visual hallucinations, difficulty separating real from imagined, perception that self or others can read minds, perceived ability to predict the future, feeling that an outside force is controlling thoughts or actions, fear that someone intends to harm them, belief they have supernatural gifts, apathy, social withdrawal, absent or blunted emotions, occurrences of unclear speech or inability to speak, or difficulty organizing thoughts to complete activities.[4]

Tetrahydrocannabinol (THC) - the main psychoactive component of marijuana.

Key findings

Strong evidence shows that daily or near-daily marijuana users are more likely to have impaired memory lasting a week or more after quitting. Evidence regarding other cognitive effects is either lacking or the results are mixed. An important acute effect of THC, the primary psychoactive component of marijuana, is psychotic symptoms, such as hallucinations, paranoia, delusional beliefs and feeling emotionally unresponsive during intoxication. These symptoms are worse with higher doses. Furthermore, daily or near-daily marijuana use is associated with developing a psychotic disorder such as schizophrenia. There is limited evidence that use of more potent marijuana is also associated with developing a psychotic disorder. Finally, marijuana users can develop cannabis use disorder (addiction[‡]) and daily or near-daily marijuana users can experience withdrawal symptoms when abstaining from marijuana. Evidence also shows there are treatments for marijuana addiction[‡] that can reduce use and dependence.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

Several important public health recommendations were identified. To facilitate future study on the effects of marijuana, it is important to improve data quality by systematically collecting information on the frequency, amount, potency, and method of marijuana use in both public health surveillance and clinical settings. To that end, improved measures of marijuana use and cumulative marijuana exposure should be developed and standardized. It also is important to better characterize the prevalence and patterns of marijuana use among Colorado adults, including breakdowns by age and other demographics. To better assess potential adverse outcomes, adult hospitalizations and emergency department visits related to marijuana use should be monitored using de-identified data available from the Colorado Hospital Association. Addiction[‡] treatment admissions should be monitored using data from the Colorado Office of Behavioral Health.

High-quality educational materials on the potential cognitive and mental health effects of marijuana use should be developed and distributed, including the risk specific to daily or near-daily marijuana use and use of high potency marijuana. The public should also be educated on the signs of marijuana abuse and addiction[‡] and treatment should be made available and accessible.

The committee also identified a number of important research gaps. Long-term studies on mental health and cognitive effects of marijuana use would help assess temporality and clarify associations. These should have well defined marijuana-use histories and evaluation of study groups with different levels or methods of marijuana use. Research should thoroughly identify potential confounding variables and measure and adjust for them. Studies using longer periods of abstinence are needed to evaluate the potential long-term effects in former users. Of special importance in Colorado, research studies are needed to determine the potential effects of higher potency marijuana and the effects of different methods of use (e.g., dabbing, edibles). Finally, there is no literature examining the potential adverse effects of other important cannabinoids such as cannabidiol (CBD).

[‡] In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

Table 1 Findings summary: Marijuana use and neurological, cognitive, and mental health effects

For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
Cognitive effects	Impaired memory for at least 7 days (daily or near-daily users)		Impaired decision-making up to 2 days after last use (weekly users)		Impaired executive functioning after short abstinence
Cognitive effects					Cognitive impairment for at least 28 days (daily or near-daily users)
Mental health effects	Acute psychotic symptoms during intoxication	Psychotic disorder (daily or near-daily users)	Diagnosis of psychotic disorder with use of potent marijuana	Bipolar Disorder diagnosis	Depression or Anxiety symptoms or diagnosis
Mental health effects			Failure to show psychotic symptoms or disorder with less-than-weekly use		
Substance use and addiction	Can develop marijuana addiction‡				
Substance use and addiction	Daily or near-daily users may experience withdrawal symptoms				
Substance use and addiction	Treatment of marijuana addiction‡ can reduce use and dependence				

‡In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix N.

Cognitive effects

1. We found **SUBSTANTIAL** evidence that adults who use marijuana daily or near-daily are more likely than non-users to have memory impairments for at least seven days after last use.[5-13]

2. We found **LIMITED** evidence that adults who use marijuana weekly are more likely than non-users to have impaired decision-making lasting up to two days after last use. [11,14]

3. We found **MIXED** evidence for whether or not adults who use marijuana are more likely than non-users to have impaired executive functioning, after not using for a short time.[5,6,8,9]

4. We found **MIXED** evidence for whether or not adults who use marijuana daily or near-daily are more likely than non-users to have impairment of memory or other cognitive functions for at least 28 days after last use.[6,8,15-17]

Mental health effects

5. We found **MIXED** evidence for whether or not adults who use marijuana are more likely than non-users to have symptoms or diagnosis of depression or anxiety.[18-25] (Revised[*])

6. We found **INSUFFICIENT** evidence to determine whether or not adults who use marijuana are more likely than non-users to have symptoms or diagnosis of bipolar disorder.[21,22] (Added*)

7. We found **SUBSTANTIAL** evidence that THC intoxication can cause acute psychotic symptoms, which are worse with higher doses.[26-31]

8. We found **MODERATE** evidence that adults who use marijuana daily or near-daily are more likely than non-users to be diagnosed with a psychotic disorder, such as schizophrenia.[32-34] (Revised*)

9. We found **LIMITED** evidence that individuals who use more potent marijuana (>10% THC) are more likely than non-users to be diagnosed with a psychotic disorder, such as schizophrenia.[32,33] (Added*)

10. We found a **LIMITED** body of research that failed to show an association between less-than-weekly marijuana use and psychotic symptoms or disorders.[30,31,35] (Added*)

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix N for dates of most recent literature review.

Substance use, abuse and addiction

11. We found **SUBSTANTIAL** evidence that marijuana users can develop cannabis use disorder.[36-38] (Added*)
12. We found **SUBSTANTIAL** evidence that individuals who use marijuana daily or near-daily can experience withdrawal symptoms when abstaining from marijuana.[39-46] (Added*)
13. We found **SUBSTANTIAL** evidence that some marijuana users who receive treatment for cannabis use disorder (including cognitive behavioral therapy, motivational enhancement/interviewing, multidimensional family therapy, and/or abstinence-based contingency management) can decrease their marijuana use and dependence.[47-54] (Added[*])

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

1. Daily or near-daily use of marijuana is strongly associated with impaired memory, persisting a week or more after quitting.
2. THC, a component of marijuana, can cause acute psychotic symptoms such as hallucinations, paranoia, delusional beliefs, and feeling emotionally unresponsive during intoxication. These symptoms are worse with higher doses.
3. Daily or near-daily use of marijuana is associated with development of psychotic disorders such as schizophrenia. (Added*)
4. Marijuana users can become addicted[‡] to marijuana. (Added*)
5. Daily or near-daily marijuana users can experience withdrawal symptoms when abstaining. (Added*)
6. There are treatments for marijuana addiction[‡] that can reduce use and dependence. (Added*)

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix N for dates of most recent literature review.

[‡] In this document, the term marijuana addiction is considered equivalent to cannabis use disorder (and addiction to another substance is considered equivalent to use disorder for that substance).

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality issues

- Standardize and improve data collection on potency, amount, frequency and method of marijuana use in medical records and other surveillance data sources.
- Specify marijuana use as separate from other drug use in medical records and other surveillance data sources.
- Improved measures to determine levels of marijuana use and cumulative marijuana exposure.
- Provide power calculations for smaller studies.

Surveillance

- Monitor adult patterns of use through surveys such as the Behavioral Risk Factor Surveillance Survey (BRFSS), including breakdowns by age and other demographics.
- Population-based monitoring of mental health conditions through surveys such as the Behavioral Risk Factor Surveillance System (BRFSS)
- Monitor marijuana-related hospitalizations and emergency department visits.
- Evaluate prevalence of cannabis use disorder and monitor trends and treatment rates, including breakdowns by age and other demographics.
- Evaluate prevalence of schizophrenia and monitor trends, including breakdowns by age and other demographics.

Education

- Public education concerning the potential cognitive and mental health effects of marijuana use.
- Communicate potential risks associated with daily or near-daily use and use of potent marijuana.
- Promote accurate information about cannabis use disorder.
- Promote availability and access to treatment for cannabis use disorder.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Longitudinal studies on mental health and cognitive effects to assess temporality.
- Expand evaluation of covariates and make proper statistical adjustments to account for their effects.
- Evaluate and provide information on the potency of marijuana in future studies and if different potencies are involved, categorize them and conduct separate analyses.
- Effects of higher potency marijuana, especially dabbing (high-dose rate).
- Effects of different methods of marijuana use.
- Effects of other cannabinoids, especially cannabidiol (CBD).
- More on duration of impact (after various lengths of abstinence).
- More studies are needed to assess the risk of increasing use or developing cannabis use disorder among groups with different levels of use, especially among users who use less-than-weekly.

References

1. United States Department of Health and Human Services; Substance Abuse and Mental Health Services Administration. *Key Substance Use and Mental Health Indicators in the United States: Results from the 2015 National Survey on Drug Use and Health*. September 2016.
2. Grotenhermen F. Pharmacokinetics and pharmacodynamics of cannabinoids. *Clin Pharmacokinet*. 2003;42(4):327-360.
3. Hall W, Degenhardt L. Adverse health effects of non-medical cannabis use. *Lancet*. 2009;374(9698):1383-1391.
4. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. Washington , DC2013.
5. Solowij N. Cognitive Functioning of Long-term Heavy Cannabis Users Seeking Treatment. *JAMA*. 2002;287(9):1123-1123.
6. Bolla KI, Brown K, Eldreth D, Tate K, Cadet JL. Dose-related neurocognitive effects of marijuana use. *Neurology*. 2002;59(9):1337-1343.
7. Roebke PV, Vadhan NP, Brooks DJ, Levin FR. Verbal learning in marijuana users seeking treatment: a comparison between depressed and non-depressed samples. *Am J Drug Alcohol Abuse*. 2014;10.3109/00952990.2013.875551:1-6.
8. Thames AD, Arbid N, Sayegh P. Cannabis use and neurocognitive functioning in a non-clinical sample of users. *Addict Behav*. 2014;39(5):994-999.
9. Sanchez-Torres AM, Basterra V, Rosa A, et al. Lifetime cannabis use and cognition in patients with schizophrenia spectrum disorders and their unaffected siblings. *European Archives of Psychiatry and Clinical Neuroscience*. 2013;263(8):643-653.
10. Rodgers J, Buchanan T, Scholey AB, Heffernan TM, Ling J, Parrott A. Differential effects of Ecstasy and cannabis on self-reports of memory ability: a web-based study. *Hum Psychopharmacol*. 2001;16(8):619-625.
11. Tamm L, Epstein JN, Lisdahl KM, et al. Impact of ADHD and cannabis use on executive functioning in young adults. *Drug Alcohol Depend*. 2013;133(2):607-614.
12. Pope HG, Jr., Gruber AJ, Hudson JI, Huestis MA, Yurgelun-Todd D. Neuropsychological performance in long-term cannabis users. *Arch Gen Psychiatry*. 2001;58(10):909-915.
13. Schoeler T, Kambeitz J, Behlke I, Murray R, Bhattacharyya S. The effects of cannabis on memory function in users with and without a psychotic disorder: findings from a combined meta-analysis. *Psychol Med*. 2016;46(1):177-188.
14. Fridberg DJ, Queller S, Ahn WY, et al. Cognitive Mechanisms Underlying Risky Decision-Making in Chronic Cannabis Users. *J Math Psychol*. 2010;54(1):28-38.
15. Pope HG, Gruber AJ, Hudson JI, Huestis MA, Yurgelun-Todd D. Neuropsychological Performance in Long-term Cannabis Users. *Arch Gen Psychiatry*. 2001;58(10):909-909.
16. Smith MJ, Cobia DJ, Wang L, et al. Cannabis-related working memory deficits and associated subcortical morphological differences in healthy individuals and schizophrenia subjects. *Schizophr Bull*. 2014;40(2):287-299.
17. Bayrakci A, Sert E, Zorlu N, Erol A, Saricicek A, Mete L. Facial emotion recognition deficits in abstinent cannabis dependent patients. *Compr Psychiatry*. 2015;58:160-164.
18. Lev-Ran S, Roerecke M, Le Foll B, George TP, McKenzie K, Rehm J. The association between cannabis use and depression: a systematic review and meta-analysis of longitudinal studies. *Psychol Med*. 2014;44(4):797-810.

19. Pacek LR, Martins SS, Crum RM. The bidirectional relationships between alcohol, cannabis, co-occurring alcohol and cannabis use disorders with major depressive disorder: results from a national sample. *J Affect Disord*. 2013;148(2-3):188-195.
20. Choi NG, DiNitto DM, Marti CN. Risk Factors for Self-reported Driving Under the Influence of Alcohol and/or Illicit Drugs Among Older Adults. *Gerontologist*. 2014;10.1093/geront/gnu070.
21. Cougle JR, Hakes JK, Macatee RJ, Chavarria J, Zvolensky MJ. Quality of life and risk of psychiatric disorders among regular users of alcohol, nicotine, and cannabis: An analysis of the National Epidemiological Survey on Alcohol and Related Conditions (NESARC). *J Psychiatr Res*. 2015;66-67:135-141.
22. Feingold D, Weiser M, Rehm J, Lev-Ran S. The association between cannabis use and mood disorders: A longitudinal study. *J Affect Disord*. 2015;172:211-218.
23. Huijbregts SC, Griffith-Lendering MF, Vollebergh WA, Swaab H. Neurocognitive moderation of associations between cannabis use and psychoneuroticism. *J Clin Exp Neuropsychol*. 2014;36(8):794-805.
24. Schuler MS, Vasilenko SA, Lanza ST. Age-varying associations between substance use behaviors and depressive symptoms during adolescence and young adulthood. *Drug Alcohol Depend*. 2015;157:75-82.
25. Kedzior KK, Laeber LT. A positive association between anxiety disorders and cannabis use or cannabis use disorders in the general population- a meta-analysis of 31 studies. *BMC Psychiatry*. 2014;14(1):136.
26. D'Souza DC, Perry E, MacDougall L, et al. The psychotomimetic effects of intravenous delta-9-tetrahydrocannabinol in healthy individuals: implications for psychosis. *Neuropsychopharmacology*. 2004;29(8):1558-1572.
27. Morrison PD, Zois V, McKeown DA, et al. The acute effects of synthetic intravenous Delta9-tetrahydrocannabinol on psychosis, mood and cognitive functioning. *Psychol Med*. 2009;39(10):1607-1616.
28. Morrison PD, Stone JM. Synthetic delta-9-tetrahydrocannabinol elicits schizophrenia-like negative symptoms which are distinct from sedation. *Hum Psychopharmacol*. 2011;26(1):77-80.
29. Englund A, Atakan Z, Kralj A, Tunstall N, Murray R, Morrison P. The effect of five day dosing with THCV on THC-induced cognitive, psychological and physiological effects in healthy male human volunteers: A placebo-controlled, double-blind, crossover pilot trial. *J Psychopharmacol*. 2016;30(2):140-151.
30. Mason O, Morgan CJ, Dhiman SK, et al. Acute cannabis use causes increased psychotomimetic experiences in individuals prone to psychosis. *Psychol Med*. 2009;39(6):951-956.
31. Morgan CJ, Rothwell E, Atkinson H, Mason O, Curran HV. Hyper-priming in cannabis users: a naturalistic study of the effects of cannabis on semantic memory function. *Psychiatry Res*. 2010;176(2-3):213-218.
32. van Os J, Bak M, Hanssen M, Bijl RV, de Graaf R, Verdoux H. Cannabis use and psychosis: a longitudinal population-based study. *Am J Epidemiol*. 2002;156(4):319-327.
33. Di Forti M, Marconi A, Carra E, et al. Proportion of patients in south London with first-episode psychosis attributable to use of high potency cannabis: a case-control study. *Lancet Psychiatry*. 2015;2(3):233-238.
34. Giordano GN, Ohlsson H, Sundquist K, Sundquist J, Kendler KS. The association between cannabis abuse and subsequent schizophrenia: a Swedish national co-relative control study. *Psychol Med*. 2015;45(2):407-414.
35. Van Dam NT, Earleywine M, DiGiacomo G. Polydrug use, cannabis, and psychosis-like symptoms. *Hum Psychopharmacol*. 2008;23(6):475-485.

36. Hasin DS, Saha TD, Kerridge BT, et al. Prevalence of Marijuana Use Disorders in the United States Between 2001-2002 and 2012-2013. *JAMA Psychiatry*. 2015;72(12):1235-1242.

37. Lopez-Quintero C, Perez de los Cobos J, Hasin DS, et al. Probability and predictors of transition from first use to dependence on nicotine, alcohol, cannabis, and cocaine: results of the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). *Drug Alcohol Depend*. 2011;115(1-2):120-130.

38. 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.

39. Budney AJ, Moore BA, Vandrey RG, Hughes JR. The time course and significance of cannabis withdrawal. *J Abnorm Psychol*. 2003;112(3):393-402.

40. Budney AJ, Novy PL, Hughes JR. Marijuana withdrawal among adults seeking treatment for marijuana dependence. *Addiction*. 1999;94(9):1311-1322.

41. Budney AJ, Radonovich KJ, Higgins ST, Wong CJ. Adults seeking treatment for marijuana dependence: a comparison with cocaine-dependent treatment seekers. *Exp Clin Psychopharmacol*. 1998;6(4):419-426.

42. Budney AJ, Vandrey RG, Hughes JR, Moore BA, Bahrenburg B. Oral delta-9-tetrahydrocannabinol suppresses cannabis withdrawal symptoms. *Drug Alcohol Depend*. 2007;86(1):22-29.

43. Budney AJ, Vandrey RG, Hughes JR, Thostenson JD, Bursac Z. Comparison of cannabis and tobacco withdrawal: severity and contribution to relapse. *J Subst Abuse Treat*. 2008;35(4):362-368.

44. Vandrey R, Budney AJ, Kamon JL, Stanger C. Cannabis withdrawal in adolescent treatment seekers. *Drug Alcohol Depend*. 2005;78(2):205-210.

45. Vandrey RG, Budney AJ, Hughes JR, Liguori A. A within-subject comparison of withdrawal symptoms during abstinence from cannabis, tobacco, and both substances. *Drug Alcohol Depend*. 2008;92(1-3):48-54.

46. Vandrey RG, Budney AJ, Moore BA, Hughes JR. A cross-study comparison of cannabis and tobacco withdrawal. *Am J Addict*. 2005;14(1):54-63.

47. Budney AJ, Higgins ST, Radonovich KJ, Novy PL. Adding voucher-based incentives to coping skills and motivational enhancement improves outcomes during treatment for marijuana dependence. *J Consult Clin Psychol*. 2000;68(6):1051-1061.

48. Copeland J, Swift W, Roffman R, Stephens R. A randomized controlled trial of brief cognitive-behavioral interventions for cannabis use disorder. *J Subst Abuse Treat*. 2001;21(2):55-64; discussion 65-56.

49. Dennis M, Godley SH, Diamond G, et al. The Cannabis Youth Treatment (CYT) Study: main findings from two randomized trials. *J Subst Abuse Treat*. 2004;27(3):197-213.

50. Hendriks V, van der Schee E, Blanken P. Treatment of adolescents with a cannabis use disorder: main findings of a randomized controlled trial comparing multidimensional family therapy and cognitive behavioral therapy in The Netherlands. *Drug Alcohol Depend*. 2011;119(1-2):64-71.

51. Rigter H, Henderson CE, Pelc I, et al. Multidimensional family therapy lowers the rate of cannabis dependence in adolescents: a randomised controlled trial in Western European outpatient settings. *Drug Alcohol Depend*. 2013;130(1-3):85-93.

52. Rooke S, Copeland J, Norberg M, Hine D, McCambridge J. Effectiveness of a self-guided web-based cannabis treatment program: randomized controlled trial. *J Med Internet Res*. 2013;15(2):e26.

53. Stanger C, Budney AJ, Kamon JL, Thostensen J. A randomized trial of contingency management for adolescent marijuana abuse and dependence. *Drug Alcohol Depend*. 2009;105(3):240-247.

54. Stanger C, Ryan SR, Scherer EA, Norton GE, Budney AJ. Clinic- and home-based contingency management plus parent training for adolescent cannabis use disorders. *J Am Acad Child Adolesc Psychiatry*. 2015;54(6):445-453 e442.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 10

Marijuana Use During Pregnancy and Breastfeeding

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2016)

***Teresa Foo, MD, MPH**
Marijuana Clinical Guidelines Coordinator, Colorado Department of Public Health and Environment
Clinical Instructor, University of Colorado
(2014)

Reviewers

Sharon Langendoerfer, MD
Retired Pediatrician and Neonatologist, Denver Health Medical Center
(2014, 2016)

Judith Shlay, MD, MSPH
Interim Director, Denver Public Health
Professor of Family Medicine, University of Colorado School of Medicine
(2014)

* Dr. Foo's work as a preventive medicine resident was supported by Grant Number D33HP25768 from the Health Resources and Services Administration (HRSA). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the HRSA.

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of adverse birth outcomes, effects of prenatal marijuana use on exposed offspring later in childhood or adolescence and effects of marijuana use by breastfeeding mothers.

Fetal development is a complex process that is dependent on conditions in the mother's body. It is sensitive to disruptions in her circulation, oxygen level, stress, hormones and other conditions and to chemicals passed from her blood to the fetus through the placenta. Three percent of all babies born in the United States have a birth defect.[1] Eight percent of Colorado babies are born at a low birth weight,[2] which puts them at risk for immediate health problems as well as inhibited growth, impaired cognitive development and chronic diseases later in life.[3]

Adverse effects of alcohol and tobacco consumption during pregnancy are well-documented. Women who smoke during pregnancy are more likely to have miscarriage and their babies are more likely to be premature, have low birth weight, have birth defects, or die from sudden infant death syndrome.[4] Babies of mothers who use alcohol during pregnancy are more likely to have birth defects, poor growth, and problems later in childhood with learning, memory, language, attention and coordination.[5] These known adverse effects of alcohol and tobacco use raise significant concern about the possible effects of marijuana use during pregnancy or breastfeeding.

Analysis of 2014 Pregnancy Risk Assessment Monitoring System (PRAMS) survey data, completed for this report, estimated that 5.7 percent of Colorado women who gave birth used marijuana during pregnancy and 4.5 percent used marijuana after delivery despite also breastfeeding. Marijuana's anti-nausea properties are a prominent reason women report using it during pregnancy.[6] It is critically important to investigate the effects of marijuana use during pregnancy on maternal and fetal health and the effects of use during pregnancy or breastfeeding on growth and development of children months or years after birth.

Definitions

Anencephaly – a neural tube defect that results in underdevelopment or the absence of portions of the brain, skull, and scalp.

Cannabidiol (CBD) – a non-psychoactive cannabinoid that is a component of marijuana.

Gastroschisis – a birth defect where the abdominal (belly) wall has failed to close properly. The resulting hole allows the intestines to protrude outside the fetus.

Low birth weight – a baby who weighs less than birth 5.5 pounds at birth, regardless of the gestational age.

Miscarriage – a baby born before reaching 20 weeks of pregnancy and therefore unable to survive.

Neural tube defects (NTD) - birth defects of the brain, spinal cord or spine. The defects occur in the embryo during the first few weeks of pregnancy.

Newborn behavior issues – may include fussiness and sleep difficulties occurring during the first 28 days after birth.

Preterm delivery - a birth that occurs more than three weeks before the baby is due — in other words, after less than 37 weeks of pregnancy.

Psychotic symptoms - these include auditory or visual hallucinations, difficulty separating real from imagined, perception that self or others can read minds, perceived ability to predict the future, feeling that an outside force is controlling thoughts or actions, fear that someone intends to harm them, belief they have supernatural gifts, feeling emotionally unresponsive, occurrences of unclear speech or inability to speak, or difficulty organizing thoughts to complete activities.

Ventricular septal defects – a congenital heart defect also known as a "hole in the heart." The defect occurs when the wall (septum) that separates the right and left ventricles of the heart does not form properly.

Small for gestational age (SGA) – a baby that is born smaller than 90 percent of babies of the same gestational age (number of weeks of pregnancy).

Stillbirth - the birth of a baby that has died in the womb after having reached at least 20 weeks of pregnancy (earlier instances being regarded as abortion or miscarriage).

Sudden infant death syndrome (SIDS) - The sudden and unexplained death of a seemingly healthy baby less than a year old.

Tetrahydrocannabinol (THC) - the main psychoactive component of marijuana.

Vaporization of marijuana (vaping) - a method of marijuana use in which marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

Key findings

The committee's findings about the effects of marijuana use during pregnancy fell primarily into two broad areas - effects seen at birth and effects seen months or years after birth. Biological evidence shows that THC, the main psychoactive component of marijuana, passes through the placenta to the fetus, so that the unborn child is exposed to THC if the mother uses marijuana. Marijuana use during pregnancy may be associated with an increased risk of heart defects or stillbirth. Stronger evidence was found for negative effects that are seen months or years after birth if a child's mother used marijuana while pregnant with the child. These include decreased growth and impaired cognitive function and attention. Decreased academic ability or increased depression symptoms may also occur. Finally, biological evidence shows that THC passes through breast milk to a breastfeeding child.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

Health care providers' current collection of information on marijuana use by frequency, amount, potency and method is limited. Adequate assessment of the link between marijuana use during pregnancy and adverse health outcomes must begin with consistent, standardized data collection about marijuana use from pregnant women at each pregnancy-related medical appointment and followed by collection of accurate birth outcome data. The committee recommended public health monitoring to help clarify the possible contribution of marijuana use to key birth outcomes.

Educational programs for pregnant women, their families, and health care providers who care for pregnant women are needed to ensure that more information is shared about the known health effects, and also about what is unknown at present. Routinely asking about marijuana use during pregnancy would improve the ability of health care providers to identify and assist women who would benefit from education about the risks to exposed offspring and therapeutic alternatives to marijuana to treat symptoms during pregnancy. Educational materials about the potential risks of marijuana use during pregnancy and breastfeeding should be available and distributed at marijuana dispensaries.

The committee identified several research gaps. Most topics reviewed in this chapter need further research. Additionally, two important topics without identified research are miscarriage and placental health. Further research is needed on the presence of THC in breast milk, its absorption and metabolism by infants, and any resulting health effects. Additional research should be conducted regarding the effects of different forms of marijuana (e.g., smoked, edible, tinctures), increased marijuana potency, and cannabinoids such as cannabidiol (CBD) on the health of exposed offspring.

Table 1 Findings summary: Marijuana use during pregnancy and breastfeeding - effects on exposed offspring

For an explanation of the classifications “Substantial,” “Moderate,” etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
Effects on birth outcome			Stillbirth		Birth defects including NTD, gastroschisis
			Isolated simple ventricular septal defects		Preterm delivery
					Decreased birth weight
					Low birth weight
					Small for gestational age
Effects on exposed offspring		Attention problems	Decreased academic ability	Psychosis Symptoms at adolescence	Frequency of marijuana use during adolescence
		Decreased IQ scores in young children	Increased depression symptoms	Future initiation of marijuana use	Newborn behavior issues
		Decreased cognitive function	Delinquent behavior		
		Decreased growth	Failure to show association with SIDS (with use during pregnancy)		
Breastfeeding				Breastfeeding and SIDS	Breastfeeding and infant motor development

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix O.

Passage of THC through the placenta

1. Biological evidence shows that THC is passed through the placentas of women who use marijuana during pregnancy and that the fetus absorbs and metabolizes the THC and passes THC metabolites in the meconium.[7-10] (Added[*])

Effects of marijuana use during pregnancy on outcomes seen at birth

Stillbirth

2. We found **LIMITED** evidence that maternal use of marijuana during pregnancy is associated with an increased risk of stillbirth.[11]

Birth defects

3. We found **MIXED** evidence for whether or not maternal use of marijuana during pregnancy is associated with birth defects.[12-14]
4. We found **MIXED** evidence for whether or not maternal use of marijuana during pregnancy is associated with neural tube defects such as anencephaly.[15-18]
5. We found **MIXED** evidence for whether or not maternal use of marijuana during pregnancy is associated with gastroschisis.[15,18,19]
6. We found **LIMITED** evidence that maternal use of marijuana during pregnancy is associated with isolated, simple ventricular septal defects (heart defects).[20]

Preterm delivery or abnormal birthweight

7. We found **MIXED** evidence for whether or not maternal use of marijuana during pregnancy is associated with preterm delivery.[12,21-27]
8. We found **MIXED** evidence for whether or not maternal use of marijuana during pregnancy is associated with decreased birth weight.[12,14,23,28-33]
9. We found **MIXED** evidence for whether or not maternal use of marijuana during pregnancy is associated with low-birth weight infants (birth weight <2,500g regardless of gestational age).[21,24,25,27,34,35]
10. We found **MIXED** evidence for whether or not maternal use of marijuana during pregnancy is associated with infants being born small for gestational age (birth weight less than 10th percentile for gestational age).[12,24,26]

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix O for dates of most recent literature review.

Effects of prenatal marijuana use on exposed offspring

Cognitive and academic

11. We found **MODERATE** evidence that maternal use of marijuana during pregnancy is associated with attention problems in exposed offspring.[36-39]
12. We found **MODERATE** evidence that maternal use of marijuana during pregnancy is associated with decreased IQ scores in exposed offspring.[40,41]
13. We found **MODERATE** evidence that maternal use of marijuana during pregnancy is associated with reduced cognitive function in exposed offspring.[42-44]
14. We found **LIMITED** evidence that maternal marijuana use during pregnancy is associated with decreased academic ability of exposed offspring.[45-47] (Revised[*])

Mental health and substance use

15. We found **LIMITED** evidence that maternal use of marijuana during pregnancy is associated with increased depression symptoms in exposed offspring.[48]
16. We found **INSUFFICIENT** evidence to determine whether or not maternal marijuana use during pregnancy is associated with psychosis symptoms in exposed adolescent offspring.[49]
17. We found **INSUFFICIENT** evidence to determine whether or not maternal marijuana use during pregnancy is associated with initiation of marijuana use by the exposed offspring during adolescence.[50]
18. We found **MIXED** evidence for whether or not maternal marijuana use during pregnancy is associated with frequency of marijuana use by the exposed offspring during adolescence.[50,51]

Other

19. We found **MODERATE** evidence that maternal use of marijuana during pregnancy is associated with decreased growth in exposed offspring.[52,53]
20. We found **LIMITED** evidence that maternal marijuana use during pregnancy is associated with delinquent behaviors in exposed offspring.[54]
21. We found **MIXED** evidence for whether or not maternal use of marijuana during pregnancy is associated with newborn behavior issues.[55-59]
22. We found a **LIMITED** body of research that failed to show association between maternal use of cannabis during pregnancy and SIDS.[60,61]

Presence of THC in breast milk

23. Biological evidence shows that THC is present in the breast milk of women who use marijuana.[62]
24. Biological evidence shows that infants who drink breast milk containing THC absorb and metabolize the THC.[62]

Effects of marijuana use while breastfeeding

25. We found **MIXED** evidence for whether or not an association exists between maternal use of marijuana while breastfeeding and motor development in exposed infants.[63,64]
26. We found **INSUFFICIENT** evidence to determine whether or not infant exposure to marijuana (either from maternal marijuana use during breastfeeding or infant exposure to marijuana smoke) is associated with SIDS.[60]

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix O for dates of most recent literature review.

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

1. There is no known safe amount of marijuana use during pregnancy.
2. THC can pass from mother to the unborn child through the placenta.
3. The unborn child is exposed to THC used by the mother during pregnancy.
4. Marijuana use during pregnancy may be associated with an increased risk of stillbirth.
5. Marijuana use during pregnancy may be associated with an increased risk of heart defects (isolated simple ventricular septal defect~~s~~) in exposed offspring.
6. Maternal use of marijuana during pregnancy is associated with negative effects on exposed offspring, including decreased cognitive function and attention. These effects may not appear until adolescence. (Revised[*])
7. Maternal use of marijuana during pregnancy may be associated with decreased academic ability in exposed offspring. This effect may not appear until adolescence.(Revised*)
8. Maternal use of marijuana during pregnancy is associated with negative effects on exposed offspring, including decreased growth.
9. Marijuana use during pregnancy may be associated with increased depression symptoms and delinquent behaviors in exposed offspring.
10. There are negative effects of marijuana use during pregnancy regardless of when it is used during pregnancy.
11. THC can be passed from the mother's breast milk, potentially affecting the baby.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality issues

- Standardization of data collection on frequency, amount, potency, and method of marijuana use in medical records and other surveillance data sources.
- Specify marijuana use as separate from other drug use in medical records and other surveillance data sources.
- Add blood or urine testing in addition to self-report of marijuana use among pregnant women in Colorado.

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix O for dates of most recent literature review.

Surveillance

- Monitor prevalence of marijuana use by pregnant and breastfeeding women, reasons for use and perception of risks, including breakdowns by age and other demographics.
- Enhanced surveillance for birth outcomes of concern.
- Collection of reported marijuana use in electronic health records, including details of use.

Education

- Education for pregnant women on known risks of marijuana use during pregnancy and breastfeeding.
- Education for health care providers on known risks, prevalence of use among different patient populations, reported reasons for use, etc.
- Consider age of pregnant mother in risk reduction/educational programming.
- Public education via different media platforms, including those specific for pregnant women.
- Engage dispensaries as partners to post or make available educational materials about marijuana use during pregnancy or breastfeeding.

Informational resources

- Marijuana Pregnancy and Breastfeeding Guidance for Colorado Health Care Providers (CDPHE)[65]
- Marijuana and Your Baby (CDPHE)[66]

Guidelines and recommendations

The links provided below are for additional information purposes only. The RMPHAC has not formally reviewed these guidelines and recommendations.

- American College of Obstetrics and Gynecology (ACOG)[67]
- The Academy of Breastfeeding Medicine (ABM)[68]

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Additional study on key birth outcomes and developmental outcomes months or years after birth, in relation to marijuana use during pregnancy.
- Study the effects of marijuana use during pregnancy on placental health
- Study possible association between marijuana use during pregnancy and miscarriage
- Additional research on the passage of THC into breast milk and metabolism by breastfeeding infants, including the length of time THC remains in breast milk.
- Study the effects of marijuana use while breastfeeding on growth and weight gain in infants.
- Study the effects of consuming marijuana edibles or vaping marijuana during pregnancy or breastfeeding.
- Impact of marijuana potency (THC content) on health effects of exposed offspring.
- Effect of cannabidiol (CBD) and other cannabinoid use during pregnancy and breastfeeding
- Include the reasons subjects use marijuana during pregnancy or breastfeeding in research.

References

1. Centers for Disease Control and Prevention. Birth Defects, Data & Statistics. 2016; https://www.cdc.gov/ncbddd/birthdefects/data.html. Accessed December 28, 2016,.
2. Colorado Department of Public Health and Environment. Low birth weight. 2016. https://www.colorado.gov/cdphe/low-birth-weight. Accessed December 28, 2016.
3. World Health Organization and UNICEF. *Low Birthweight: Country, Regional and Global Estimates*. 2004.
4. Centers for Disease Control and Prevention. Reproductive Health: Tobacco Use and Pregnancy. 2016; https://www.cdc.gov/reproductivehealth/maternalinfanthealth/tobaccousepregnancy/. Accessed December 28, 2016.
5. Centers for Disease Control and Prevention. Fetal Alcohol Spectrum Disorders (FASDs). 2016; https://www.cdc.gov/ncbddd/fasd/alcohol-use.html. Accessed December 28, 2016,
6. Roberson EK, Patrick WK, Hurwitz EL. Marijuana use and maternal experiences of severe nausea during pregnancy in Hawai'i. *Hawaii J Med Public Health*. 2014;73(9):283-287.
7. Joya X, Pujadas M, Falcon M, et al. Gas chromatography-mass spectrometry assay for the simultaneous quantification of drugs of abuse in human placenta at 12th week of gestation. *Forensic Sci Int*. 2010;196(1-3):38-42.
8. Marchei E, Pellegrini M, Pacifici R, et al. Quantification of Delta9-tetrahydrocannabinol and its major metabolites in meconium by gas chromatographic-mass spectrometric assay: assay validation and preliminary results of the "meconium project". *Ther Drug Monit*. 2006;28(5):700-706.
9. ElSohly MA, Stanford DF, Murphy TP, et al. Immunoassay and GC-MS procedures for the analysis of drugs of abuse in meconium. *J Anal Toxicol*. 1999;23(6):436-445.
10. ElSohly MA, Feng S. delta 9-THC metabolites in meconium: identification of 11-OH-delta 9-THC, 8 beta,11-diOH-delta 9-THC, and 11-nor-delta 9-THC-9-COOH as major metabolites of delta 9-THC. *J Anal Toxicol*. 1998;22(4):329-335.
11. Varner MW, Silver RM, Rowland Hogue CJ, et al. Association between stillbirth and illicit drug use and smoking during pregnancy. *Obstet Gynecol*. 2014;123(1):113-125.
12. Day N, Sambamoorthi U, Taylor P, et al. Prenatal marijuana use and neonatal outcome. *Neurotoxicol Teratol*. 1991;13(3):329-334.
13. Forrester MB, Merz RD. Risk of selected birth defects with prenatal illicit drug use, Hawaii, 1986-2002. *J Toxicol Environ Health A*. 2007;70(1):7-18.
14. Linn S, Schoenbaum SC, Monson RR, Rosner R, Stubblefield PC, Ryan KJ. The association of marijuana use with outcome of pregnancy. *Am J Public Health*. 1983;73(10):1161-1164.
15. David AL, Holloway A, Thomasson L, et al. A case-control study of maternal periconceptual and pregnancy recreational drug use and fetal malformation using hair analysis. *PLoS One*. 2014;9(10):e111038.
16. Shaw GM, Velie EM, Morland KB. Parental recreational drug use and risk for neural tube defects. *Am J Epidemiol*. 1996;144(12):1155-1160.
17. Suarez L, Brender JD, Langlois PH, Zhan FB, Moody K. Maternal exposures to hazardous waste sites and industrial facilities and risk of neural tube defects in offspring. *Ann Epidemiol*. 2007;17(10):772-777.
18. van Gelder MM, Reefhuis J, Caton AR, et al. Maternal periconceptional illicit drug use and the risk of congenital malformations. *Epidemiology*. 2009;20(1):60-66.

19. Forrester MB, Merz RD. Comparison of trends in gastroschisis and prenatal illicit drug use rates. *J Toxicol Environ Health A*. 2006;69(13):1253-1259.

20. Williams LJ, Correa A, Rasmussen S. Maternal lifestyle factors and risk for ventricular septal defects. *Birth Defects Res A Clin Mol Teratol*. 2004;70(2):59-64.

21. Bada HS, Das A, Bauer CR, et al. Low birth weight and preterm births: etiologic fraction attributable to prenatal drug exposure. *J Perinatol*. 2005;25(10):631-637.

22. Dekker GA, Lee SY, North RA, McCowan LM, Simpson NA, Roberts CT. Risk factors for preterm birth in an international prospective cohort of nulliparous women. *PLoS One*. 2012;7(7):e39154.

23. Fergusson DM, Horwood LJ, Northstone K, Childhood ASTALSoPa. Maternal use of cannabis and pregnancy outcome. *BJOG*. 2002;109(1):21-27.

24. Hayatbakhsh MR, Flenady VJ, Gibbons KS, et al. Birth outcomes associated with cannabis use before and during pregnancy. *Pediatr Res*. 2012;71(2):215-219.

25. Mark K, Desai A, Terplan M. Marijuana use and pregnancy: prevalence, associated characteristics, and birth outcomes. *Arch Womens Ment Health*. 2015;10.1007/s00737-015-0529-9.

26. Saurel-Cubizolles MJ, Prunet C, Blondel B. Cannabis use during pregnancy in France in 2010. *BJOG*. 2014;10.1111/1471-0528.12626.

27. Shiono PH, Klebanoff MA, Nugent RP, et al. The impact of cocaine and marijuana use on low birth weight and preterm birth: a multicenter study. *Am J Obstet Gynecol*. 1995;172(1 Pt 1):19-27.

28. El Marroun H, Tiemeier H, Steegers EA, et al. Intrauterine cannabis exposure affects fetal growth trajectories: the Generation R Study. *J Am Acad Child Adolesc Psychiatry*. 2009;48(12):1173-1181.

29. English DR, Hulse GK, Milne E, Holman CD, Bower CI. Maternal cannabis use and birth weight: a meta-analysis. *Addiction*. 1997;92(11):1553-1560.

30. Fried PA, O'Connell CM. A comparison of the effects of prenatal exposure to tobacco, alcohol, cannabis and caffeine on birth size and subsequent growth. *Neurotoxicol Teratol*. 1987;9(2):79-85.

31. Gray TR, Eiden RD, Leonard KE, Connors GJ, Shisler S, Huestis MA. Identifying prenatal cannabis exposure and effects of concurrent tobacco exposure on neonatal growth. *Clin Chem*. 2010;56(9):1442-1450.

32. Hingson R, Alpert JJ, Day N, et al. Effects of maternal drinking and marijuana use on fetal growth and development. *Pediatrics*. 1982;70(4):539-546.

33. Janisse JJ, Bailey BA, Ager J, Sokol RJ. Alcohol, tobacco, cocaine, and marijuana use: relative contributions to preterm delivery and fetal growth restriction. *Subst Abus*. 2014;35(1):60-67.

34. Conner SN, Carter EB, Tuuli MG, Macones GA, Cahill AG. Maternal marijuana use and neonatal morbidity. *Am J Obstet Gynecol*. 2015;10.1016/j.ajog.2015.05.050.

35. Schempf AH, Strobino DM. Illicit drug use and adverse birth outcomes: is it drugs or context? *J Urban Health*. 2008;85(6):858-873.

36. El Marroun H, Hudziak JJ, Tiemeier H, et al. Intrauterine cannabis exposure leads to more aggressive behavior and attention problems in 18-month-old girls. *Drug Alcohol Depend*. 2011;118(2-3):470-474.

37. Goldschmidt L, Day NL, Richardson GA. Effects of prenatal marijuana exposure on child behavior problems at age 10. *Neurotoxicol Teratol*. 2000;22(3):325-336.

38. Noland JS, Singer LT, Short EJ, et al. Prenatal drug exposure and selective attention in preschoolers. *Neurotoxicol Teratol*. 2005;27(3):429-438.

39. Fried PA, Smith AM. A literature review of the consequences of prenatal marihuana exposure. An emerging theme of a deficiency in aspects of executive function. *Neurotoxicol Teratol*. 2001;23(1):1-11.

40. Day NL, Richardson GA, Goldschmidt L, et al. Effect of prenatal marijuana exposure on the cognitive development of offspring at age three. *Neurotoxicol Teratol*. 1994;16(2):169-175.

41. Goldschmidt L, Richardson GA, Willford J, Day NL. Prenatal marijuana exposure and intelligence test performance at age 6. *J Am Acad Child Adolesc Psychiatry*. 2008;47(3):254-263.

42. Fried PA, Watkinson B, Gray R. Differential effects on cognitive functioning in 13- to 16-year-olds prenatally exposed to cigarettes and marihuana. *Neurotoxicol Teratol*. 2003;25(4):427-436.

43. Smith AM, Fried PA, Hogan MJ, Cameron I. Effects of prenatal marijuana on response inhibition: an fMRI study of young adults. *Neurotoxicol Teratol*. 2004;26(4):533-542.

44. Willford JA, Chandler LS, Goldschmidt L, Day NL. Effects of prenatal tobacco, alcohol and marijuana exposure on processing speed, visual-motor coordination, and interhemispheric transfer. *Neurotoxicol Teratol*. 2010;32(6):580-588.

45. Fried PA, Watkinson B, Siegel LS. Reading and language in 9- to 12-year olds prenatally exposed to cigarettes and marijuana. *Neurotoxicol Teratol*. 1997;19(3):171-183.

46. Goldschmidt L, Richardson GA, Cornelius MD, Day NL. Prenatal marijuana and alcohol exposure and academic achievement at age 10. *Neurotoxicol Teratol*. 2004;26(4):521-532.

47. Goldschmidt L, Richardson GA, Willford JA, Severtson SG, Day NL. School achievement in 14-year-old youths prenatally exposed to marijuana. *Neurotoxicol Teratol*. 2012;34(1):161-167.

48. Gray KA, Day NL, Leech S, Richardson GA. Prenatal marijuana exposure: effect on child depressive symptoms at ten years of age. *Neurotoxicol Teratol*. 2005;27(3):439-448.

49. Zammit S, Thomas K, Thompson A, et al. Maternal tobacco, cannabis and alcohol use during pregnancy and risk of adolescent psychotic symptoms in offspring. *Br J Psychiatry*. 2009;195(4):294-300.

50. Porath AJ, Fried PA. Effects of prenatal cigarette and marijuana exposure on drug use among offspring. *Neurotoxicol Teratol*. 2005;27(2):267-277.

51. Day NL, Goldschmidt L, Thomas CA. Prenatal marijuana exposure contributes to the prediction of marijuana use at age 14. *Addiction*. 2006;101(9):1313-1322.

52. Cornelius MD, Goldschmidt L, Day NL, Larkby C. Alcohol, tobacco and marijuana use among pregnant teenagers: 6-year follow-up of offspring growth effects. *Neurotoxicol Teratol*. 2002;24(6):703-710.

53. Fried PA, Watkinson B, Gray R. Growth from birth to early adolescence in offspring prenatally exposed to cigarettes and marijuana. *Neurotoxicol Teratol*. 1999;21(5):513-525.

54. Day NL, Leech SL, Goldschmidt L. The effects of prenatal marijuana exposure on delinquent behaviors are mediated by measures of neurocognitive functioning. *Neurotoxicol Teratol*. 2011;33(1):129-136.

55. de Moraes Barros MC, Guinsburg R, de Araújo Peres C, Mitsuhiro S, Chalem E, Laranjeira RR. Exposure to marijuana during pregnancy alters neurobehavior in the early neonatal period. *J Pediatr*. 2006;149(6):781-787.

56. Dreher MC, Nugent K, Hudgins R. Prenatal marijuana exposure and neonatal outcomes in Jamaica: an ethnographic study. *Pediatrics*. 1994;93(2):254-260.

57. Hayes JS, Lampart R, Dreher MC, Morgan L. Five-year follow-up of rural Jamaican children whose mothers used marijuana during pregnancy. *West Indian Med J*. 1991;40(3):120-123.

58. Lester BM, Dreher M. Effects of marijuana use during pregnancy on newborn cry. *Child Dev*. 1989;60(4):765-771.

59. Richardson GA, Day N, Taylor PM. The Effect of Prenatal Alcohol, Marijuana, and Tobacco Exposure on Neonatal Behavior. *Infant Behavior and Development*. 1989;12:199-209.

60. Klonoff-Cohen H, Lam-Kruglick P. Maternal and paternal recreational drug use and sudden infant death syndrome. *Arch Pediatr Adolesc Med*. 2001;155(7):765-770.

61. Scragg RK, Mitchell EA, Ford RP, Thompson JM, Taylor BJ, Stewart AW. Maternal cannabis use in the sudden death syndrome. *Acta Paediatr*. 2001;90(1):57-60.

62. Perez-Reyes M, Wall ME. Presence of delta9-tetrahydrocannabinol in human milk. *N Engl J Med*. 1982;307(13):819-820.

63. Astley SJ, Little RE. Maternal marijuana use during lactation and infant development at one year. *Neurotoxicol Teratol*. 1990;12(2):161-168.

64. Tennes K, Avitable N, Blackard C, et al. Marijuana: prenatal and postnatal exposure in the human. *NIDA Res Monogr*. 1985;59:48-60.

65. Colorado Department of Public Health and Environment. Marijuana Pregnancy and Breastfeeding Guidance For Colorado Health Care Providers. https://www.colorado.gov/pacific/sites/default/files/MJ_RMEP_Pregnancy-Breastfeeding-Clinical-Guidelines.pdf.

66. Colorado Department of Public Health and Environment. Marijuana and Your Baby. https://www.colorado.gov/pacific/sites/default/files/MJ_RMEP_Factsheet-Pregnancy-Breastfeeding.pdf.

67. The American College of Obstetricians and Gynecologists Committee Opinion. Marijuana Use During Pregnancy and Lactation. 2015, http://www.acog.org/Resources-And-Publications/Committee-Opinions/Committee-on-Obstetric-Practice/Marijuana-Use-During-Pregnancy-and-Lactation(637).

68. Reece-Stremtan S, Marinelli KA. ABM clinical protocol #21: guidelines for breastfeeding and substance use or substance use disorder, revised 2015. *Breastfeed Med*. 2015;10(3):135-141.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 11

Marijuana Use and Respiratory Effects

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Ken Gershman, MD, MPH
Manager
Marijuana Research Grants Program, Colorado Department of Public Health and Environment
(2016)

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

Todd Carlson, MD
Internal Medicine Resident, University of Colorado
(2014)

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health and Toxicology Branch, Colorado Department of Public Health and Environment
(2014)

Reviewers

Judith Shlay, MD, MSPH
Interim Director, Denver Public Health
Professor of Family Medicine, University of Colorado School of Medicine
(2016)

Russell Bowler, MD, PhD
Professor of Medicine, National Jewish Health and University of Colorado Anschutz Medical Campus
(2014)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of respiratory diseases like chronic obstructive pulmonary disease (COPD), chronic bronchitis and asthma, respiratory infections and lung function relative to smoked marijuana, as well as potential health effects of vaporized marijuana.

Respiratory diseases and illnesses are a major burden in both health impact and financial cost in the United States. COPD, a progressive lung disease, is the third leading cause of death in the United States.[1] In Colorado, it is estimated that in 2010 there were more than 120,000 adults being treated for COPD with a total medical treatment cost over $735 million.[2] Asthma affects even more Colorado residents, estimated at more than 450,000 in 2012.[3] The financial cost of asthma in the United States in 2007 was estimated at $56 billion.[4]

Inhalation of combustion products, from tobacco smoking to wood-burning stoves, has consistently been associated with respiratory diseases.[5,6] For example, tobacco smoking is known to be the most common cause of COPD.[7] The U.S. National Health and Nutrition Examination Survey (NHANES) recently found that daily marijuana users have higher levels of toxic combustion by-products than non-users.[8] Furthermore, exposure to harmful products from smoking marijuana may be exacerbated by the way a marijuana joint is typically smoked, with deep and prolonged inhalation and no filter. Investigating the long-term respiratory effects of smoking marijuana is very important.

Marijuana vaporizing (vaping) is increasing in popularity as an alternative to smoking marijuana.[9] Marijuana users in two separate surveys believed vaporizing marijuana to be less harmful or “healthier” than smoking marijuana.[9,10] It is important to identify the potential harms from vaporized marijuana relative to not using marijuana and also to compare them with the potential harms from smoked marijuana.

Definitions

Levels of marijuana use

- Daily or near-daily use: 5-7 days/week.
- Weekly use: 1-4 days/week.
- Less-than-weekly use: less than 1 day/week.
- Acute use: marijuana used within the past few hours, such that the short-term effects or symptoms are still being experienced.

Bullous lung disease - destruction of lung tissue causing pockets of air to replace lung tissue, diagnosed by imaging.

Chronic bronchitis - a long term cough with sputum production that is diagnosed by symptoms.

Chronic obstructive pulmonary disease (COPD) - a severe form of small airway obstruction characterized by long-term poor airflow from the lungs, with common symptoms including of shortness of breath and cough with sputum production, diagnosed by pulmonary function tests.

Combustion by-products – chemicals produced when a material is burned. These chemicals including carbon monoxide and polycyclic aromatic hydrocarbons.

Dabbing - a method of marijuana use where a "dab" (small amount) of marijuana concentrate is placed on a pre-heated surface, creating concentrated marijuana vapor to be inhaled.

Emphysema - the breakdown of lung tissue, typically causing air trapping, poor airflow and shortness of breath, diagnosed by imaging.

Pneumothorax - the collapse of a lung caused by air or fluid filling up the space around the lung, an emergency condition diagnosed by physical exam and/or imaging.

Polycyclic aromatic hydrocarbons - a group of more than 100 different chemicals released from burning coal, oil, gasoline, trash, tobacco, wood, or other organic substances.

Pulmonary function (tests) - measurements that show how well the lungs move air in and out and how well they exchange oxygen and carbon dioxide with the blood.

Small airway obstruction - a condition causing air to be trapped in the lungs, making it difficult to breathe the air out to make room for the next breath, diagnosed by pulmonary function tests.

Tetrahydrocannabinol (THC) - the main psychoactive component of marijuana.

Vaporization of marijuana (vaping) - a method of marijuana use in which marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

Key findings

The committee found strong evidence for an association between daily or near-daily marijuana use and chronic bronchitis with cough, wheezing and sputum production. Additionally, daily or near-daily marijuana use may be associated with bullous lung disease and pneumothorax in individuals younger than 40 years of age. Research is lacking on other aspects of lung health related to marijuana use. There is conflicting research regarding small airway obstruction and research is lacking concerning any possible association between marijuana use and COPD, emphysema or respiratory infections. A notable effect of acute use is a short-term improvement in lung airflow; however, evidence for long term benefits is lacking. Finally, smoked marijuana may deposit more particulate matter in the lungs per puff than tobacco smoking, and smokers who switch from marijuana smoking to marijuana vaporizing may have fewer respiratory symptoms and improved pulmonary function.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

Recommendations

Recommendations from the committee reflect the need for improvement and standardization of data collection. Information on frequency, amount, potency and method of marijuana use should be collected consistently in both clinical settings and public health surveillance tools. Determinations of cumulative marijuana exposure also need improvement. Better quality measures of recent marijuana use should be used, such as blood THC levels or urinary metabolites instead of self-reported marijuana use. Public health should use data available in the Colorado Central Cancer Registry to monitor new cases of lung cancer. Additionally, monitoring for the prevalence of more chronic conditions such as COPD and asthma should be conducted in collaboration with the Colorado Hospital Association (CHA) and the All-Payer Claims Database available through the Center for Improving Value in Health Care (CIVHC). Educational opportunities exist with both primary and specialized health care providers regarding the potential adverse health effects related to marijuana use and respiratory disease, including the importance of understanding the possible additive risks to lung health related to smoking both tobacco and marijuana.

Research gaps identified include the need for studies of COPD and lung function, including improved methods to assess cumulative marijuana exposure, older age groups, and adequate numbers of non-tobacco smokers to eliminate the confounding introduced by tobacco smoking. Prospective studies of groups of marijuana users, monitoring lung function and symptoms over long time periods, are needed to clarify relationships between long-term marijuana use and respiratory diseases. Additional research on the potential respiratory effects of different methods of marijuana use (including vaporizing and dabbing) is needed to assess the long-term safety of these methods.

Table 1 Findings summary: Marijuana use and respiratory effects

For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process.

	Substantial	Moderate	Limited	Insufficient	Mixed
Smoked marijuana	Chronic bronchitis with cough/wheeze/ sputum		More particulate matter deposits compared to tobacco	COPD	Long-term daily or near-daily marijuana use associated with airway obstruction
	Acute use improves airflow		Failure to show association between less-than-weekly marijuana use and airway obstruction	Emphysema	
			Bullous lung disease and pneumothorax under 40 years of age	Respiratory infections	
Vaporized marijuana			Fewer symptoms and improved lung function after switching to vaporizing	Health effects of vaporized marijuana	
				Effects of vaporized marijuana on asthma	

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix P.

Smoked marijuana

1. We found **LIMITED** evidence that smoking marijuana deposits more particulate matter per puff in the lungs compared to tobacco smoke.[11]
2. We found **SUBSTANTIAL** evidence that daily or near-daily marijuana smoking is associated with chronic bronchitis, including chronic cough, sputum production, and wheezing.[12-20]
3. We found **INSUFFICIENT** evidence to determine whether or not smoking marijuana is associated with chronic obstructive pulmonary disease (COPD).[20,23] (Revised[*])
4. We found **INSUFFICIENT** evidence to determine whether or not smoking marijuana is associated with emphysema.[16]
5. We found a **LIMITED** body of research that failed to show an association between less-than-weekly marijuana smoking and small airway obstruction.[19,22-25] (Added*)
6. We found **MIXED** evidence for whether or not long-term, daily or near-daily marijuana smoking is associated with small airway obstruction.[12,14-16,18-20,26] (Revised*)
7. We found **LIMITED** evidence that daily or near-daily marijuana smoking is associated with bullous lung disease leading to pneumothorax in individuals younger than 40 years of age.[27-30] (Revised*)
8. We found **INSUFFICIENT** evidence to determine whether or not smoking marijuana is associated with increased risk of respiratory infections.[17,31]
9. We found **SUBSTANTIAL** evidence that marijuana use (inhaled or oral) results in an immediate short-term improvement of lung airflow.[32-34]

Vaporized marijuana

10. We found **INSUFFICIENT** evidence to determine whether or not vaporizing marijuana is associated with long-term respiratory health effects[35].
11. We found **LIMITED** evidence that after one month, weekly or daily marijuana smokers who switched to vaporizing had fewer respiratory symptoms and improved pulmonary function.[36,37] (Added*)
12. We found **INSUFFICIENT** evidence to determine whether or not marijuana vaporization affects asthma symptoms. (Added*)

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix P for dates of most recent literature review.

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

1. Marijuana smoke may deposit more particulate matter in the lungs per puff compared to tobacco smoke.
2. Daily or near-daily marijuana smoking is strongly associated with chronic bronchitis, including chronic cough, sputum production and wheezing.
3. There is conflicting research on whether or not long-term daily or near-daily marijuana smoking is associated with decreased airflow from the lungs. (Revised[*])
4. Daily or near-daily marijuana smoking may be associated with a specific type of lung damage called bullous lung disease, resulting in a collapsed lung, in individuals younger than 40 years of age.
5. One-time marijuana use (edible or smoked) is strongly associated with immediate, short-term (1 to 6 hours) improved airflow in the lungs.
6. Compared with weekly or daily marijuana smoking, short-term marijuana vaporizing (vaping) may be associated with fewer respiratory symptoms and improved pulmonary function. (Added*)

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix P for dates of most recent literature review.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality issues

- Include marijuana use on questionnaires completed during spirometry and pulmonary function testing, including method of use, frequency, amount and potency.
- Improved measures to determine cumulative marijuana exposure.
- Better quality measures of recent marijuana use, such as blood THC levels or urinary metabolites instead of self-reported cannabis use.

Surveillance

- Monitor statewide prevalence of COPD, asthma and other respiratory diseases through existing population-based surveys.
- Monitor health care utilization related to respiratory disorders using Colorado Hospital Association and/or All-Payer Claims databases.

Education

- Public education on marijuana use and chronic respiratory diseases.
- Public education on the potential for additive risks to lung health related to smoking both tobacco and marijuana.
- Public education that smoking marijuana is not a long-term treatment for asthma.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Improved studies of COPD and lung function related to marijuana use, especially including adequate numbers of non-tobacco smokers, assessment of cumulative marijuana exposure, and older age groups.
- Prospective studies of groups of marijuana users' lung function and symptoms over time.
- Improved studies of bullous lung disease to better define its relationship to marijuana use.
- Research on the potential respiratory effects of different methods of marijuana use, including vaporizing and dabbing.

References

1. American Lung Association. Lung Health & Diseases, COPD. 2016; http://www.lung.org/lung-health-and-diseases/lung-disease-lookup/copd/?referrer=https://www.google.com/. Accessed December 19, 2016,.
2. Ford ES, Murphy LB, Khavjou O, Giles WH, Holt JB, Croft JB. Total and state-specific medical and absenteeism costs of COPD among adults aged >/= 18 years in the United States for 2010 and projections through 2020. *Chest*. 2015;147(1):31-45.
3. American Lung Association EaSU. *Estimated Prevalence and Incidence of Lung Disease*. May 2014 2014.
4. Barnett SB, Nurmagambetov TA. Costs of asthma in the United States: 2002-2007. *J Allergy Clin Immunol*. 2011;127(1):145-152.
5. Centers for Disease Control and Prevention. Smoking & Tobacco Use, Health Effects of Cigarette Smoking. 2016; https://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/effects_cig_smoking/. Accessed December 21, 2016, 2016.
6. Naeher LP, Brauer M, Lipsett M, et al. Woodsmoke health effects: a review. *Inhal Toxicol*. 2007;19(1):67-106.
7. Decramer M, Janssens W, Miravitlles M. Chronic obstructive pulmonary disease. *Lancet*. 2012;379(9823):1341-1351.
8. Wei B, Alwis KU, Li Z, et al. Urinary concentrations of PAH and VOC metabolites in marijuana users. *Environ Int*. 2016;88:1-8.
9. Lee DC, Crosier BS, Borodovsky JT, Sargent JD, Budney AJ. Online survey characterizing vaporizer use among cannabis users. *Drug Alcohol Depend*. 2016;159:227-233.
10. Malouff JM, Rooke SE, Copeland J. Experiences of marijuana-vaporizer users. *Subst Abus*. 2014;35(2):127-128.
11. Wu TC, Tashkin DP, Djahed B, Rose JE. Pulmonary hazards of smoking marijuana as compared with tobacco. *N Engl J Med*. 1988;318(6):347-351.
12. Bloom JW, Kaltenborn WT, Paoletti P, Camilli A, Lebowitz MD. Respiratory effects of non-tobacco cigarettes. *Br Med J (Clin Res Ed)*. 1987;295(6612):1516-1518.
13. Roth MD, Arora A, Barsky SH, Kleerup EC, Simmons M, Tashkin DP. Airway inflammation in young marijuana and tobacco smokers. *Am J Respir Crit Care Med*. 1998;157(3 Pt 1):928-937.
14. Sherrill DL, Krzyzanowski M, Bloom JW, Lebowitz MD. Respiratory effects of non-tobacco cigarettes: a longitudinal study in general population. *Int J Epidemiol*. 1991;20(1):132-137.
15. Tashkin DP, Coulson AH, Clark VA, et al. Respiratory symptoms and lung function in habitual heavy smokers of marijuana alone, smokers of marijuana and tobacco, smokers of tobacco alone, and nonsmokers. *Am Rev Respir Dis*. 1987;135(1):209-216.
16. Aldington S, Williams M, Nowitz M, et al. Effects of cannabis on pulmonary structure, function and symptoms. *Thorax*. 2007;62(12):1058-1063.
17. Moore BA, Augustson EM, Moser RP, Budney AJ. Respiratory effects of marijuana and tobacco use in a U.S. sample. *J Gen Intern Med*. 2005;20(1):33-37.
18. Taylor DR, Poulton R, Moffitt TE, Ramankutty P, Sears MR. The respiratory effects of cannabis dependence in young adults. *Addiction*. 2000;95(11):1669-1677.

19. Kempker JA, Honig EG, Martin GS. The effects of marijuana exposure on expiratory airflow. A study of adults who participated in the U.S. National Health and Nutrition Examination Study. *Ann Am Thorac Soc*. 2015;12(2):135-141.

20. Macleod J, Robertson R, Copeland L, McKenzie J, Elton R, Reid P. Cannabis, tobacco smoking, and lung function: a cross-sectional observational study in a general practice population. *Br J Gen Pract*. 2015;65(631):e89-95.

21. Tashkin DP, Shapiro BJ, Lee YE, Harper CE. Subacute effects of heavy marihuana smoking on pulmonary function in healthy men. *N Engl J Med*. 1976;294(3):125-129.

22. Hancox RJ, Poulton R, Ely M, et al. Effects of cannabis on lung function: a population-based cohort study. *Eur Respir J*. 2010;35(1):42-47.

23. Tan WC, Lo C, Jong A, et al. Marijuana and chronic obstructive lung disease: a population-based study. *CMAJ*. 2009;180(8):814-820.

24. Pletcher MJ, Vittinghoff E, Kalhan R, et al. Association between marijuana exposure and pulmonary function over 20 years. *JAMA*. 2012;307(2):173-181.

25. Taylor DR, Fergusson DM, Milne BJ, et al. A longitudinal study of the effects of tobacco and cannabis exposure on lung function in young adults. *Addiction*. 2002;97(8):1055-1061.

26. Tashkin DP, Simmons MS, Sherrill DL, Coulson AH. Heavy habitual marijuana smoking does not cause an accelerated decline in FEV1 with age. *Am J Respir Crit Care Med*. 1997;155(1):141-148.

27. Beshay M, Kaiser H, Niedhart D, Reymond MA, Schmid RA. Emphysema and secondary pneumothorax in young adults smoking cannabis. *Eur J Cardiothorac Surg*. 2007;32(6):834-838.

28. Hii SW, Tam JD, Thompson BR, Naughton MT. Bullous lung disease due to marijuana. *Respirology*. 2008;13(1):122-127.

29. Johnson MK, Smith RP, Morrison D, Laszlo G, White RJ. Large lung bullae in marijuana smokers. *Thorax*. 2000;55(4):340-342.

30. Fiorelli A, Accardo M, Vicidomini G, Messina G, Laperuta P, Santini M. Does cannabis smoking predispose to lung bulla formation? *Asian Cardiovasc Thorac Ann*. 2014;22(1):65-71.

31. Polen MR, Sidney S, Tekawa IS, Sadler M, Friedman GD. Health care use by frequent marijuana smokers who do not smoke tobacco. *West J Med*. 1993;158(6):596-601.

32. Tashkin DP, Shapiro BJ, Frank IM. Acute pulmonary physiologic effects of smoked marijuana and oral 9 -tetrahydrocannabinol in healthy young men. *N Engl J Med*. 1973;289(7):336-341.

33. Tashkin DP, Shapiro BJ, Frank IM. Acute effects of smoked marijuana and oral delta9-tetrahydrocannabinol on specific airway conductance in asthmatic subjects. *Am Rev Respir Dis*. 1974;109(4):420-428.

34. Tashkin DP, Shapiro BJ, Lee YE, Harper CE. Effects of smoked marijuana in experimentally induced asthma. *Am Rev Respir Dis*. 1975;112(3):377-386.

35. Gieringer D. Waterpipe Study. *Multidisciplinary Assocation for Psycheldelic Studies (MAPS)*. 1996;6(3).

36. Earleywine M, Barnwell SS. Decreased respiratory symptoms in cannabis users who vaporize. *Harm Reduct J*. 2007;4:11.

37. Van Dam NT, Earleywine M. Pulmonary function in cannabis users: Support for a clinical trial of the vaporizer. *Int J Drug Policy*. 2010;21(6):511-513.

Section 2

Scientific Literature Review on Potential Health Effects of Marijuana Use

Chapter 12

Unintentional Marijuana Exposures in Children

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment
(2016)

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment
(2016)

George Sam Wang, MD
Assistant Professor, University of Colorado Anschutz Medical Campus
Emergency Medicine Physician and Medical Toxicologist, Children's Hospital Colorado
Volunteer Faculty, Rocky Mountain Poison and Drug Center
(2016)

Reviewers

Judith Shlay, MD, MSPH
Interim Director, Denver Public Health
Professor of Family Medicine, University of Colorado School of Medicine
(2016)

George Sam Wang, MD
Assistant Professor, University of Colorado Anschutz Medical Campus
Emergency Medicine Physician and Medical Toxicologist, Children's Hospital Colorado
Volunteer Faculty, Rocky Mountain Poison and Drug Center
(2014)

Introduction

The Retail Marijuana Public Health Advisory Committee identified many important public health topics related to marijuana use and has reviewed the scientific evidence currently available regarding those topics. This chapter includes reviews of unintentional marijuana exposure relative to marijuana legalization and child-resistant packaging.

In 2014, the Rocky Mountain Poison and Drug Center [*](RMPDC) received nearly 25,000 calls about children under age five who had accidentally eaten or been exposed to medications or chemicals.[1] About one-third of RMPDC calls are referred to receive medical care. Parents and caregivers know that very young children naturally put things in their mouths, and, as they get older, eat things they mistake for candy or food they like. Many edible marijuana products are made by adding concentrated THC to existing foods that look exactly like foods or candies a child might normally eat. Medical providers report that children who ingest marijuana can experience loss of coordination, trouble breathing, difficulty waking up, or even coma.[2] Analysis of 2014 and 2015 Colorado Child Health Survey data, completed for this report, estimated that approximately 14,000 homes in Colorado had children 1-14 years old and marijuana in the home with potentially unsafe storage. It is important to investigate the extent and impact of unintentional marijuana exposures, especially in children.

Definitions

Tetrahydrocannabinol (THC) – the main psychoactive component of marijuana.

Unintentional marijuana exposures – ingesting a substance without knowing that it contains THC or other cannabinoids, more commonly observed with edible marijuana products.

Key findings

Findings from this review have important implications. The committee found strong evidence that more unintentional marijuana exposures of children occur in states with increased legal access to marijuana, and that the exposures can lead to significant clinical effects requiring hospitalization. Additionally, evidence shows that child resistant packaging prevents exposure to children from potentially harmful substances.

An important note for all key findings is that the available research evaluated the **association** between marijuana use and potential adverse health outcomes. This **association** does not prove that the marijuana use alone **caused** the effect. Despite the best efforts of researchers to account for confounding factors, there may be other important factors related to **causality** that were not identified. In addition, marijuana use was illegal everywhere in the United States prior to 1996. Research funding, when appropriated, was commonly sought to identify adverse effects from marijuana use. This legal fact introduces both funding bias and publication bias into the body of literature related to marijuana use. The Retail Marijuana Public Health Advisory Committee recognizes the limitations and biases inherent in the published literature and made efforts to ensure the information reviewed and synthesized is reflective of the current state of medical knowledge. Where information was lacking – for whatever reason – the committee identified this knowledge gap and recommended further research. This information will be updated as new research becomes available.

[*] See Section 3, Chapter 1 Rocky Mountain Poison and Drug Center data for analyses of calls related to marijuana.

Recommendations

As in many other medical specialties, there is a critical need to collect complete data on amount, type and potency of marijuana product ingested. For pediatric exposures, this data is critical for clinical management if emergency medical services or hospitalization is needed. It is also valuable for future research. Continued monitoring of data on poison center calls, emergency room visits and hospitalizations will provide prevalence data on unintentional exposures in the pediatric population. The committee identified multiple opportunities to educate parents and caregivers about safe adult use and safe storage. Further research is needed on unintentional marijuana exposures in children, including the impact of various environmental factors, beliefs, laws and regulations. Examples of possible research topics include the effects of child-resistant packaging requirements, point-of-sale education, marijuana marketing and perception of harm.

Table 1 Findings summary: Unintentional marijuana exposures in children
For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process.

Substantial	Moderate	Limited	Insufficient	Mixed
Legal marijuana access increases unintentional marijuana exposures in children	Child-resistant packaging reduces unintentional pediatric poisonings			

Evidence statements

Evidence statements are based on systematic scientific literature reviews performed by Colorado Department of Public Health and Environment staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee. For an explanation of the classifications "Substantial," "Moderate," etc., see Chapter 7. Systematic literature review process. For details about the studies reviewed, see Appendix Q.

1. We found **SUBSTANTIAL** evidence that more unintentional marijuana exposures among children occur in states with increased legal access to marijuana; and that the exposures can lead to significant clinical effects requiring medical attention.[3-5] (Revised*)
2. We found **MODERATE** evidence that the use of child-resistant packaging reduces unintentional pediatric poisonings from a wide range of hazardous household products including pharmaceutical products.[6-8]

Public health statements

Public health statements are plain language translations of the major findings (Evidence Statements) from the systematic literature reviews. These statements have been officially approved by the Retail Marijuana Public Health Advisory Committee.

1. Legal marijuana access is strongly associated with increased numbers of unintentional exposures in children which can lead to hospitalizations. (Revised[*])
2. While little data are available for marijuana, evidence indicates that child resistant packaging prevents exposure to children from potentially harmful substances.

[*] Revised = the statement has been adjusted since the 2014 edition of the report, due to new evidence. Added = the statement is new since the 2014 edition of the report. See Appendix Q for dates of most recent literature review.

Public health recommendations

Public health recommendations have been suggested and approved by the Retail Marijuana Public Health Advisory Committee with the goals of: 1) Improving knowledge regarding population-based health effects of retail marijuana use and 2) Developing and targeting public health education and prevention strategies for high-risk sub populations.

Data quality issues

- Data collection in cases of unintentional marijuana exposure should include amount, type and potency of the marijuana when possible.

Surveillance

- Monitor pediatric emergency department visits, hospitalizations and poison center calls resulting from unintentional marijuana exposure.

Education

- Educate parents and caregivers about keeping marijuana and marijuana products away from children and using child resistant packaging.

Research gaps

The Retail Marijuana Public Health Advisory Committee identifies important gaps in the scientific literature that may impact public health policies and prevention strategies. Colorado should support unbiased research to help fill the following research gaps identified by the committee.

- Studies are needed to evaluate the impact of various environmental factors, beliefs, laws and regulations on unintentional marijuana exposure. These studies should include specific factors such as perception of harm, marijuana marketing, point-of-sale education and marijuana packaging requirements.

References

1. Rocky Mountain Poison & Drug Center (RMPDC). *Colorado 2014 Annual Report*. 2015.
2. Children's Hospital Colorado. Acute Marijuana Intoxication. 2016; https://www.childrenscolorado.org/conditions-and-advice/conditions-and-symptoms/conditions/acute-marijuana-intoxication/. Accessed December 23, 2016,
3. Wang GS, Roosevelt G, Le Lait MC, et al. Association of unintentional pediatric exposures with decriminalization of marijuana in the United States. *Ann Emerg Med*. 2014;63(6):684-689.
4. Onders B, Casavant MJ, Spiller HA, Chounthirath T, Smith GA. Marijuana Exposure Among Children Younger Than Six Years in the United States. *Clin Pediatr (Phila)*. 2015;10.1177/0009922815589912.
5. Wang GS, Roosevelt G, Heard K. Pediatric marijuana exposures in a medical marijuana state. *JAMA Pediatr*. 2013;167(7):630-633.
6. Breault HJ. Five years with 5 million child-resistant containers. *Clin Toxicol*. 1974;7(1):91-95.
7. Clarke A, Walton WW. Effect of safety packaging on aspirin ingestion by children. *Pediatrics*. 1979;63(5):687-693.
8. Rodgers GB. The effectiveness of child-resistant packaging for aspirin. *Arch Pediatr Adolesc Med*. 2002;156(9):929-933.

Section 3

Monitoring Possible Marijuana-Related Health Effects in Colorado

Retail Marijuana Public Health Advisory Committee

Background

This chapter presents efforts of the Colorado Department of Public Health and Environment (CDPHE) to monitor the potential population-based health effects of legalized marijuana. Through 25-1.5-110, C.R.S., CDPHE was given statutory authority to:

- "...collect Colorado-specific data that reports adverse health events involving marijuana use from the all-payer claims database, hospital discharge data, and behavioral risk factors."

The purpose of this data collection and analysis was stated in 25-1.5-110 C.R.S. to "...monitor the emerging science and medical information relevant to the health effects associated with marijuana use." The data analyses reported in this chapter were reviewed by the Retail Marijuana Public Health Advisory Committee as outlined in 25-1.5-110 C.R.S. to help "...make recommendations as appropriate, for policies intended to protect consumers of marijuana or marijuana products and the general public."

This chapter focuses on the analysis of the two primary public health datasets used to monitor: 1) exposures to drugs and other toxic substances and 2) hospital and emergency department use.

We analyzed the data in this chapter using the following four time periods that reflect the status of marijuana legalization in Colorado:

- 2000 – prior to legalized medical marijuana
- 2001-2009 – medical marijuana legalized
- 2010-2013 – medical marijuana commercialized
- 2014-2016 – retail (recreational) marijuana legalized

Data sources

Rocky Mountain Poison and Drug Center data

The Rocky Mountain Poison and Drug Center (RMPDC) provides medical information to health care providers and the public to reduce toxicity, injury, and disease related to exposures of all kinds. RMPDC has been providing information and assistance to Colorado and the surrounding region for more than 50 years. RMPDC participates in the American Association of Poison Control Centers' National Poison Data System (NPDS). RMPDC and NPDS information is used by public health, pharmaceutical and medical institutions for research, education and prevention initiatives in Colorado and throughout the nation. Poison center call volume data are typically used as a surrogate data source to determine the potential for adverse health effects from exposure to chemicals, environmental agents, biotoxins and drugs. RMPDC data is one of the few near "real-time" data sources available to public health professionals. In this report marijuana exposure calls to RMPDC were examined from 2000 to 2016 to examine potential trends in relation to marijuana legalization periods.

Colorado Hospital Association data

The Colorado Hospital Association (CHA) collects data on hospitalizations and emergency department (ED) visits from participating hospitals in Colorado. The data include patient demographics, admit and discharge dates, and discharge diagnoses/billing codes and procedure codes. CHA has about 100 member hospitals, the vast majority of hospitals in Colorado. However, the database does not include inpatient mental health facilities, ambulatory surgical centers, long-term care facilities, military hospitals, and other outpatient treatment settings. The CHA dataset was used to investigate rates of hospitalizations and ED visits with marijuana-related billing codes.

Summary of key findings

The most prominent findings from Rocky Mountain Poison and Drug Center and Colorado Hospital Association data are described below. For additional results and details, see the individual chapters for RMPDC (page 239) and CHA (page 251).

RMPDC data

From 2000 to 2009, RMPDC marijuana exposure call volume remained fairly constant. In 2010, total annual marijuana exposure calls doubled, from 44 to 93. From 2010 to 2013, there was a slight additional increase in counts of marijuana exposure calls. Another large increase was seen in 2014, from 127 to 222. There were 229 marijuana exposure calls in 2015 and 201 in 2016. Most of these changes were due to calls involving marijuana only, with only a small increase in calls involving marijuana and other substances together.

For children ages 0-8 years, marijuana exposure calls averaged 5 per year from 2000 to 2009. They peaked in 2015 at 48 calls and dropped to 40 in 2016. Ages 9-17 years averaged 17 calls per year from 2000-2009, peaked at 63 in 2015 and dropped to 42 in 2016. Ages 18-24 years averaged 17 calls per year from 2000-2009, and increased to 35 in 2016. Adults age 25 years and older had the largest increase in the number of marijuana exposure calls, averaging 15 calls per year from 2000 to 2009 and peaking at 90 calls in 2014. Calls in this age group decreased to 78 in 2015 and 73 in 2016.

Nearly all calls for children ages 0-8 years were unintentional exposure in all time periods. From 2014 to 2016, unintentional exposures comprised 17 percent of calls for ages 9-17 years, 9 percent of calls for ages 18-24 years, and 23 percent of calls for ages 25 years and older. Data on type of marijuana product was only available for July 2014 to December 2016. For children ages 0-8 years, twice as many exposure calls were about edible marijuana products compared to smokeable products. In all other age groups, smokeable products were most common.

CHA data

The rates of hospitalizations and emergency department (ED) visits with poisonings possibly due to marijuana in children under 9 years old have increased over time since medical marijuana legalization in 2000, with the largest increase following medical marijuana commercialization in 2010. For 2014 and 2015, this rate was 14 per 100,000 hospitalizations and 9 per 100,000 ED visits. The number of hospitalizations and ED visits with poisonings possibly due to marijuana among children under 9 years old was higher in urban areas compared to rural areas.

When examining the rates of hospitalizations and ED visits with marijuana-related billing codes for all ages, there was an increasing trend in hospitalizations from 2001 to 2015, reaching 3,025 per 100,000. There was an increasing trend in ED visits from 2012 to 2014, reaching 1,039 per 100,000. ED visits declined in 2015 to 754 per 100,000. Rates of hospitalizations with marijuana-related billing codes were highest among males, adolescents and young adults, and blacks. Rates of ED visits were highest among males, young adults, and black and unknown races.

Rates of hospitalizations and ED visits with marijuana-related billing codes have increased throughout most counties in Colorado. In 2014, hospitalization rates tended to be highest in urban, mountain and southern counties and ED visit rates tended to be highest in mountain and southern counties.

Examination of primary diagnosis categories revealed that hospitalizations with marijuana-related billing codes were nine times more likely to have a primary diagnosis of a mental illness than those without marijuana-related billing codes. ED visits with marijuana-related billing codes were five times more likely to have a primary diagnosis of a mental illness than those without. Other primary diagnosis categories that were more likely among hospitalizations with marijuana-related billing codes were injuries and poisonings, diseases of the skin and subcutaneous tissue, diseases of the nervous system and sense organs, endocrine, nutritional, and metabolic diseases and immunity, and infectious and parasitic diseases. Among ED visits, unclassified codes and E codes were also more likely when a marijuana-related billing code was present.

Discussion

The data presented here provide important insights into 1) the yearly volume, trends over time and nature of marijuana exposure calls to the poison center among different age groups and 2) the rates of hospitalizations and emergency department visits for which a marijuana-related billing code was used, including patterns by age and other demographics. These data do have limitations. Changes in poison center calls, hospitalizations and emergency department visits might occur as a result of changes in the amount or type of marijuana use or an increased honesty in reporting marijuana use to health care providers. Changes in physician screening or reporting related to marijuana or changes in coding practices could affect the rates of hospitalizations and emergency department visits with marijuana-related billing codes. Some hospitalizations and ED visits with marijuana-related billing codes may not have been caused or contributed to by marijuana use. Finally, the poison center is not called in all cases of someone experiencing a marijuana-related adverse health symptoms or requiring medical attention following marijuana exposure. Nonetheless, these data reveal important trends.

Encouraging trends

- Marijuana exposure calls to the poison center appear to be decreasing since 2015, including unintentional exposures in children ages 0-8 years.
- The overall rate of emergency department visits with marijuana-related billing codes dropped 27 percent from 2014 to 2015 (2016 data is not available yet).

Trends to continue monitoring

- Marijuana exposure calls to the poison center continue to be higher in years after medical marijuana commercialization (2010-2016) than in previous years (2000-2009), including calls about children 0-8 years old with unintentional marijuana exposure.
- Edible marijuana products were involved in about 40 percent of marijuana exposure calls to the poison center. For children 0-8 years old, calls about edible marijuana were twice as common as calls about smokeable marijuana.
- The overall rate of hospitalizations with marijuana-related billing codes has increased each year since 2008.

- Among young adults (ages 18-25 years) in 2014 and 2015, about 8 percent of all hospitalizations and 2 percent of all emergency department visits had a marijuana-related billing code. This was higher than the rate among other age groups, and likely reflects the higher rate of marijuana use in this age group.
- Disparities in hospitalizations and emergency department visits also existed by sex and race, with higher rates among males and blacks across all time periods.
- Hospitalizations with marijuana-related billing codes are nine times more likely to have a primary mental health diagnosis compared to those without marijuana-related billing codes.

Recommendations and future directions

1. Continue using RMPDC and CHA data to monitor trends in potential marijuana health effects and assess the impact over time, especially among groups with higher rates of marijuana use.
2. Continue to monitor marijuana exposure calls, including intentionality and type of marijuana. CDPHE and RMPDC are working together to develop a surveillance protocol including additional information such as product name, source and potency.
3. Perform more detailed analyses on unintentional exposures to marijuana in children under age 9. This includes collecting additional primary data from medical records to assess the severity of the outcome, the source of the exposure and possible public health intervention strategies.
4. CDPHE is in the process of analyzing hospitalization and emergency department visit data to assess primary diagnoses in relation to marijuana-related billing codes, in particular for further clarification concerning mental health diagnoses.
5. Use the recent changes in hospitalization and emergency department visit coding (ICD-9 to ICD-10) to explore relationships between different marijuana-related billing codes and primary diagnoses.
6. CDPHE is evaluating death certificate and coroner's report data to determine how it can best be used in monitoring for potential-marijuana-related deaths.
7. CDPHE is working with a hospital in a Colorado ski town to collect new data regarding marijuana use associated with ski-related injuries.

Section 3

Monitoring Possible Marijuana-Related Health Effects in Colorado

Chapter 1

Rocky Mountain Poison and Drug Center (RMPDC) Data, 2000-2016

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Katelyn E. Hall, MPH
Statistical Analyst
Retail Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Shireen Banerji, PharmD, DABAT
Clinical Manager, Rocky Mountain Poison Center

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health, and Toxicology Branch, Colorado Department of Public Health and Environment

Reviewer

Ken Gershman, MD, MPH
Manager
Medical Marijuana Research Grants Program, Colorado Department of Public Health and Environment

Introduction

The Rocky Mountain Poison and Drug Center (RMPDC) provides medical information to health care providers and the public to reduce toxicity, injury, and disease related to exposures of all kinds. RMPDC has been providing information and assistance to Colorado and the surrounding region for more than 50 years. RMPDC participates in the American Association of Poison Control Centers' National Poison Data System (NPDS). RMPDC and NPDS information is used by public health, pharmaceutical and medical institutions for research, education and prevention initiatives in Colorado and throughout the nation. Poison Center call volume data are typically used as a surrogate data source to determine the potential for adverse health effects from exposure to chemicals, environmental agents, biotoxins, and drugs. RMPDC data are one of the few near "real-time" data sources available to public health professionals. These data have become an integral component of monitoring marijuana-related adverse health events[1-3]. In this report marijuana exposure calls to RMPDC were examined from 2000-2016 to examine potential trends in relation to marijuana legalization periods.

Methods

Human marijuana exposure calls to RMPDC were queried from NPDS using the marijuana generic category "cannabinoids and analogs" to assess counts of calls received regarding marijuana exposures (Appendix R). Calls with missing exposure information, exposures unrelated to marijuana, or exposures indicating *Medical Review Officer* were validated through a review of the call case notes by a pharmacist and physician. Exposures indicating synthetic marijuana analogs and THC medications like marinol, dronabinol, and cannabidiol were excluded from this analysis.

Counts of marijuana exposure calls were quantified by calendar year (2000-2016) for calls with marijuana exposures only and calls with marijuana in combination with other drug exposures. Counts of marijuana exposure calls were stratified into four age categories, intentionality (unintentional & intentional exposures), intentionality and age categories, and marijuana type (edibles, smokeables, & other) (Appendix R).

Results

There were 1,688 human marijuana exposure calls to RMPDC from 2000 to 2016 (See details about analytic population in Appendix Figure R.1). From 2000 to 2009, RMPDC marijuana exposure call volume remained fairly constant. However, in 2010 marijuana exposure calls significantly increased twofold compared to 2009 from 44 to 93. From 2010 to 2013 counts of marijuana exposure calls increased from 93 to 127 but the change was not significant. In 2014 marijuana exposure calls significantly increased compared to 2013 by 74.8% from 127 to 222. The number of marijuana exposures calls remained constant from 2014 (n=222) to 2015 (n=229).In 2016 the number of marijuana exposure calls decreased (n=201) but the change was not significant.

Beginning in 2012 larger proportions of the marijuana exposures calls were of marijuana only exposures (Figure 1). Ages 0-17 years and 25 years and older showed increased numbers of marijuana exposure calls in the *Medical Marijuana Commercialized* era (2010-2013) compared to the *Medical Marijuana Legalized* era (2001-2009), while ages 18-24 years remain fairly constant since the *Prior to Legalization of Medical Marijuana* era(2000) (Figure 2). In 2014 with the beginning of the *Retail Marijuana Legalized* era, all ages showed increased numbers of marijuana exposure calls compared to the *Medical Marijuana Commercialized* era (2010-2013) (Figure 2). This increase continued for ages 0-17 years in 2015. In 2016, only ages 18-24 years showed an increase in marijuana exposure calls (25 to 35 calls) after decreasing from 2014 to 2015 (31 to 25 calls)(Figure 2). All other ages showed a decrease in marijuana exposure calls in 2016 (Figure 2).

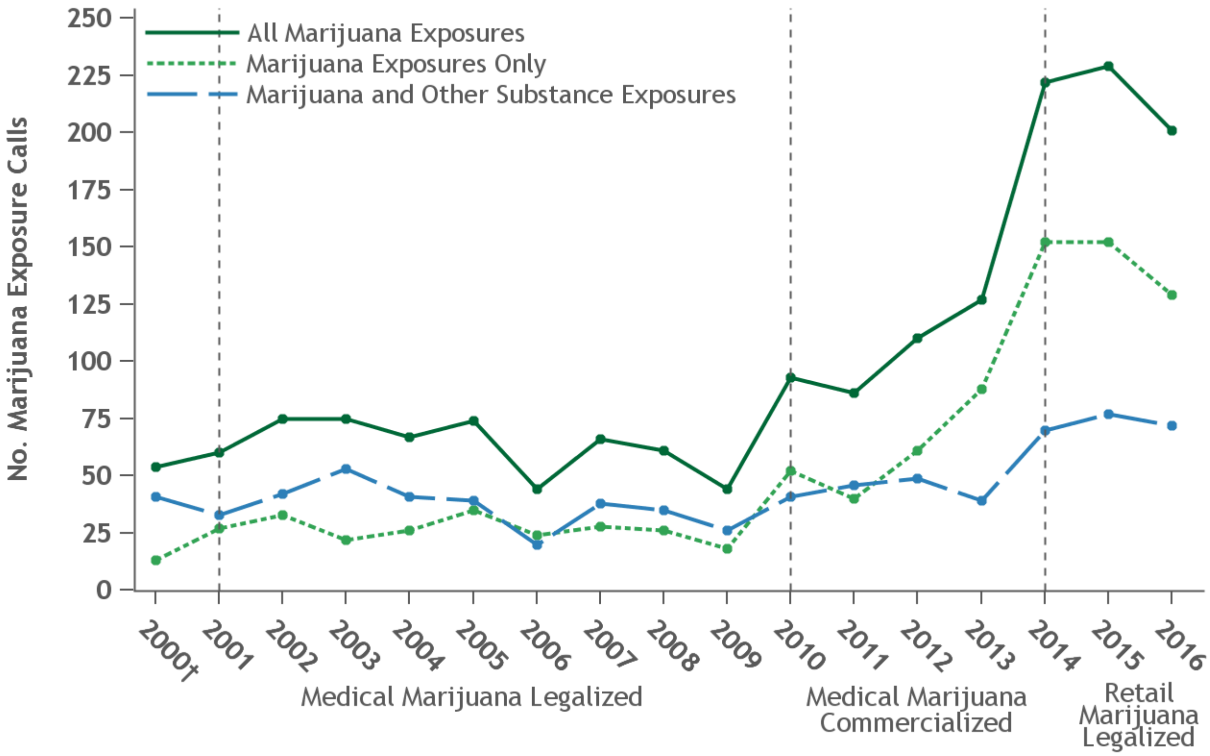
The numbers of intentional and unintentional marijuana exposure calls remained constant when examined from the *Prior to Legalization of Medical Marijuana* era (2000) through the *Medical Marijuana Legalized* era (2001-2009). However, both types of exposures began to increase in 2010 with the commercialization of medical marijuana and continued to increase through the legalization of retail marijuana and in 2015 (Figure 3). In 2016, both intentional and unintentional marijuana exposure calls decreased, from 139 to 113 and 80 to 73, respectively (Figure 3). Stratifying the calls into age groups by intentionality showed similar results where the number of marijuana exposure calls remained constant from 2000 to 2009 for both intentional and unintentional exposures (Figure 4). In 2010, numbers of intentional and unintentional marijuana exposure calls in all age groups began to increase; however, the highest numbers of unintentional marijuana exposures were among children 0-8 years old. The highest numbers of intentional marijuana exposures were in adults 25 years or older (Figure 4).

RMPDC began collecting information regarding the type of marijuana involved in the exposure call on July 1, 2014. Therefore the data were limited to July 1, 2014 to December 31, 2016 to examine the type of marijuana involved in the marijuana exposure calls. There were 529 marijuana exposure calls during this time period. Among these 38.3% (n=203) were edibles, 37.6% (n=199) were smokeables, and 24.0% (n=127) were other marijuana products (Figure 5). Among calls for children ages 0-8, edible marijuana products constitute 54.5% (n=60) of marijuana exposures, followed by smokeables (25.4%, n=28, typically eaten in this age group) and other marijuana products (22.7%, n=22) (Figure 6). Among ages 25 years and older, the proportion of edible (35.6%, n=69) and smokeable (37.6%, n=73) marijuana products were similar (Figure 6). Smokeable marijuana products represented the most prevalent type of exposures among those 9 to 24 years, followed by edibles and other marijuana products (Figure 6).

Limitations

Limitations of poison center data include self-selection bias: calls are self-reported; neither all individuals with symptoms, nor all health care providers managing patients with marijuana exposures call the poison center. Therefore, the number of cases reported is likely an underestimation and not necessarily a full representation of the population that needs the services of either RMPDC or urgent/emergency medical services for a toxic exposure.

Figure 1. Number of marijuana exposure calls to poison center by marijuana only and marijuana with other substances in Colorado



Produced by: EEOHT, CDPHE 2016.

*Counts significantly increased from previous year with a p value <0.003.

†Prior to legalized medical marijuana.

‡Data Source: National Poison Data System (NPDS) closed, human, marijuana exposure calls in Colorado from 2000 to 2016, n=1,688.

Major Findings

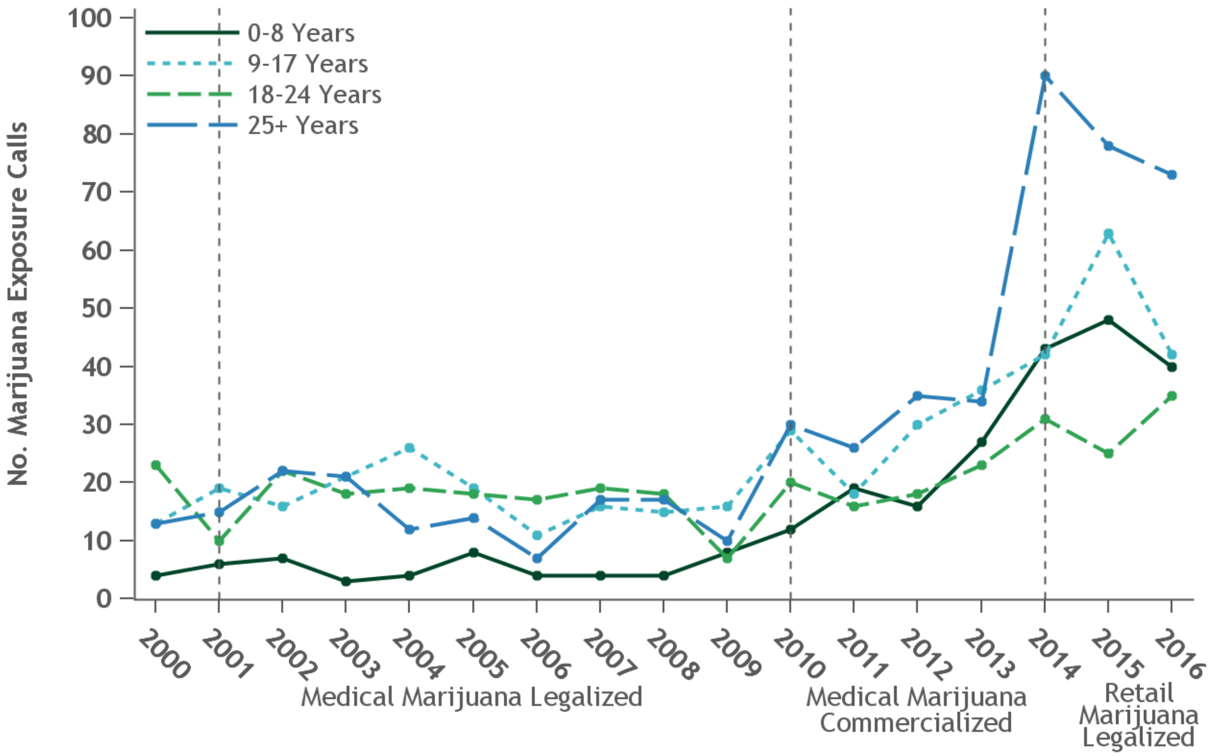
- Counts of calls remain fairly constant from 2000 to 2009.
- In 2010, marijuana exposure calls significantly increased from 44 to 93[a] and in 2014 calls related to marijuana significantly increased by 74.8% from 127 to 222.[b]
- In 2016, marijuana exposure calls decreased from 229 calls in 2015 to 201 calls.[c]

[a] *p* value<0.0001

[b] *p* value<0.0001

[c] For an explanation of terms and statistical comparisons used see Appendix R Table R.1.

Figure 2. Number of marijuana exposure calls to poison center by age group in Colorado



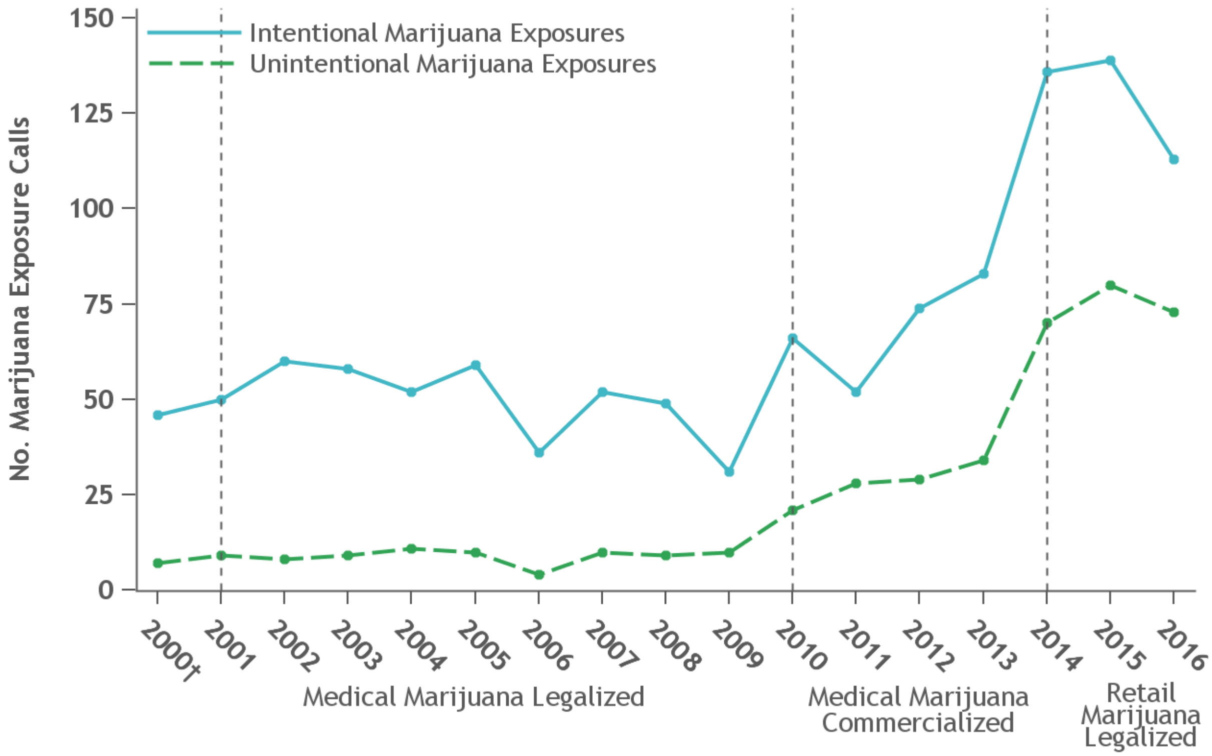
Produced by: EEOHT, CDPHE 2016.
†Data Source: National Poison Data System (NPDS) closed, human, marijuana exposure calls in Colorado from 2000 to 2016, n=1,542.

Major Findings

- Ages 0-17 years and 25 years and older showed increased numbers of marijuana exposure calls in the *Medical Marijuana Commercialized* era (2010-2013) compared to the *Medical Marijuana Legalized* era (2001-2009), while ages 18-24 years remain fairly constant since the *Prior to Legalization of Medical Marijuana* era (2000).
- In 2014, with the beginning of the *Retail Marijuana Legalized* era (2014-2016), all ages showed increased numbers of marijuana exposures calls compared to the *Medical Marijuana Commercialized* era (2010-2013).
- Marijuana exposure calls for 25 years and older increased from 34 in 2013 to peak at 90 in 2014, and then decreased in both 2015 (78) and 2016 (73).
- Marijuana exposure calls decreased from 2015 to 2016 in ages 0-8 years (48 to 40) and 9-17 years (63 to 42), and increased in ages 18-25 years (25 to 35).[d]

[d] For an explanation of terms and statistical comparisons used see Appendix R Table R.2.

Figure 3. Number of intentional and unintentional marijuana exposure calls to poison center in Colorado



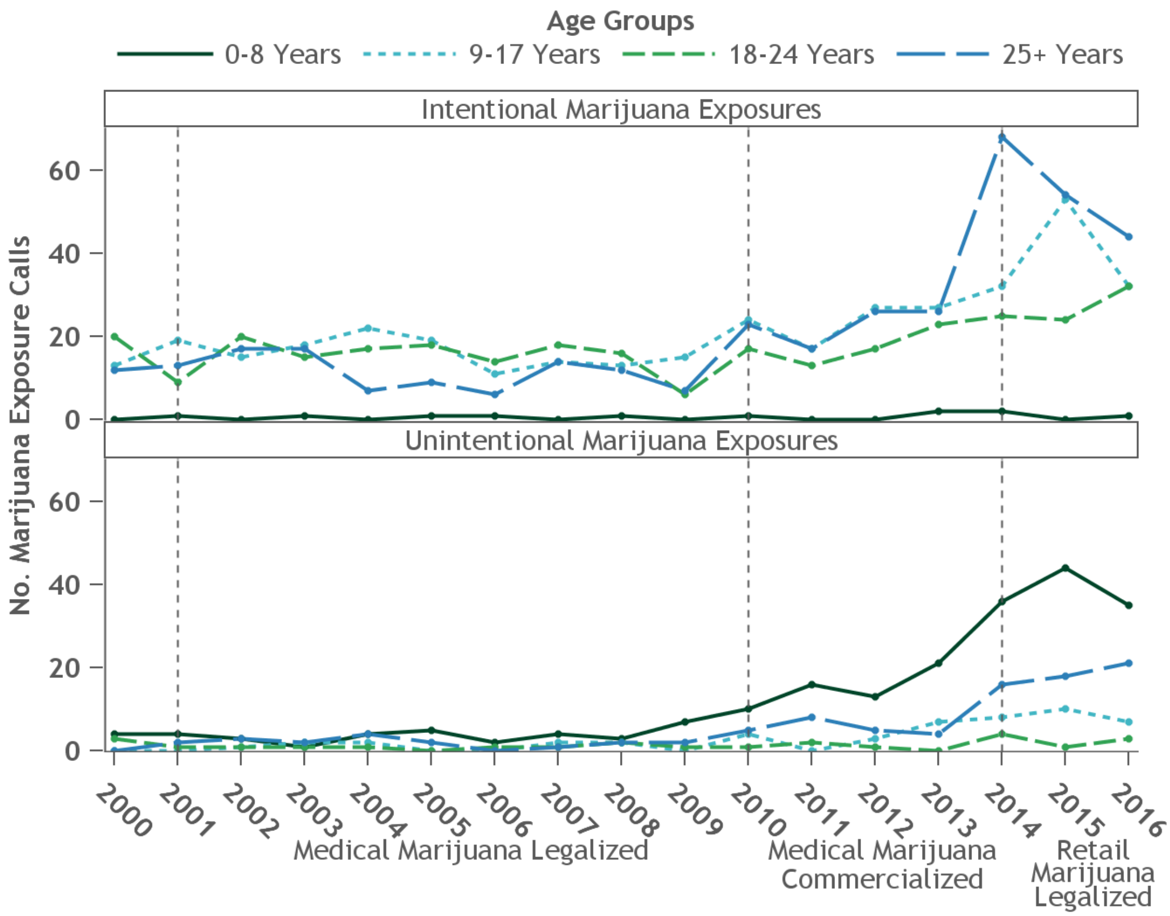
Produced by: EEOHT, CDPHE 2016.
†Prior to legalized medical marijuana.
‡Data Source: National Poison Data System (NPDS) closed, human, marijuana exposure calls in Colorado from 2000 to 2016, n=1,578.

Major Findings

- Numbers of both intentional and unintentional marijuana exposure calls remained constant from the *Prior to Legalization of Medical Marijuana* era (2000) through the *Medical Marijuana Legalized* era (2001-2009); however, they begin to increase in 2010 with the *Medical Marijuana Commercialized* era (2010-2013) and continued to increase through the *Retail Marijuana Legalized* era (2014-2016) until 2015.
- In 2016, both intentional and unintentional marijuana exposure calls decreased, from 139 and 80 in 2015 to 113 and 73, respectively; however, this trend was not significant.[e]

[e] For an explanation of terms and statistical comparisons used see Appendix R Table R.3.

Figure 4. Number of marijuana exposure calls to poison center by intention and age groups in Colorado



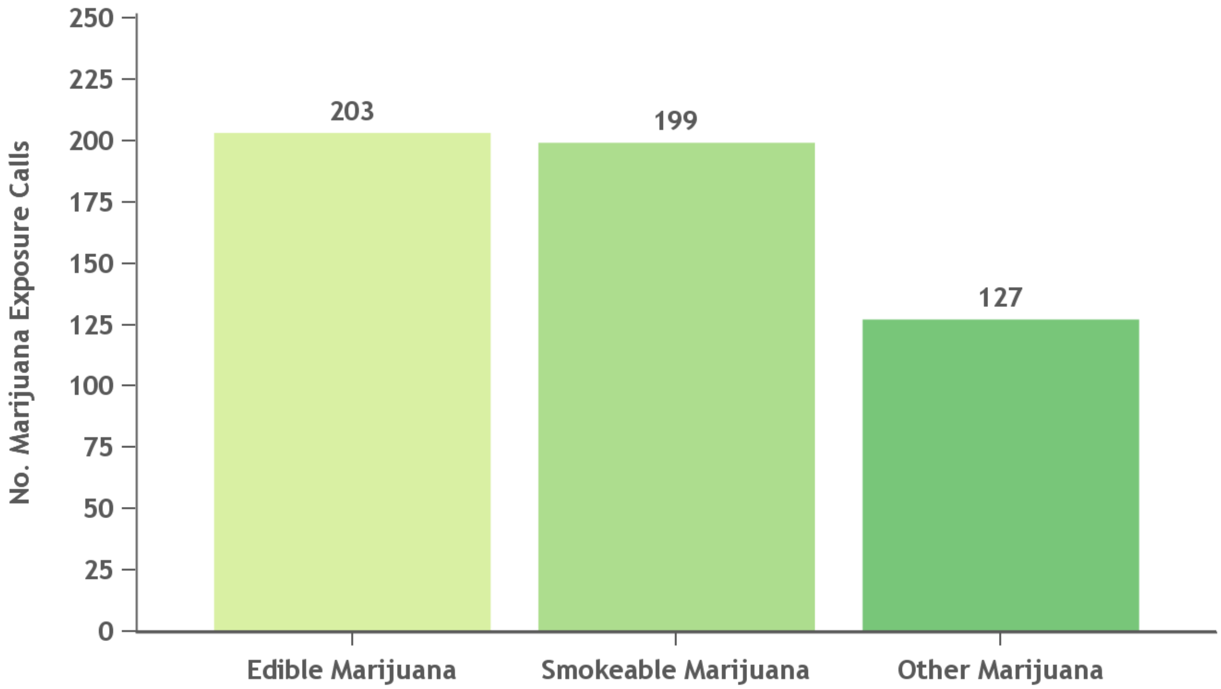
Produced by: EEOHT, CDPHE 2016.
†Data Source: National Poison Data System (NPDS) closed, human, marijuana exposure calls in Colorado from 2000 to 2016, n=1,437.

Major Findings

- Among all age groups, numbers of both intentional and unintentional marijuana exposures remained constant through the Medical Marijuana Legalized era (2000-2009).
- Numbers of intentional marijuana exposures began to increase among those aged 9 years and older in 2010 with those 25 years and older showing the largest increases.
- Numbers of unintentional marijuana exposures increased among all age groups beginning in 2010; however, those aged 0-8 years showed the largest increases.
- In 2016, intentional marijuana exposure among those 18-24 years increased (24 to 32) as well as unintentional marijuana exposure among those 25 years or older (18 to 21). Marijuana exposure calls, intentional and unintentional, among other age groups decreased or remained constant in 2016.[f]

[f] For an explanation of terms and statistical comparisons used see Appendix R Table R.4.

Figure 5. Number of marijuana exposure calls to poison center by marijuana type in Colorado, July 2014 to December 2016



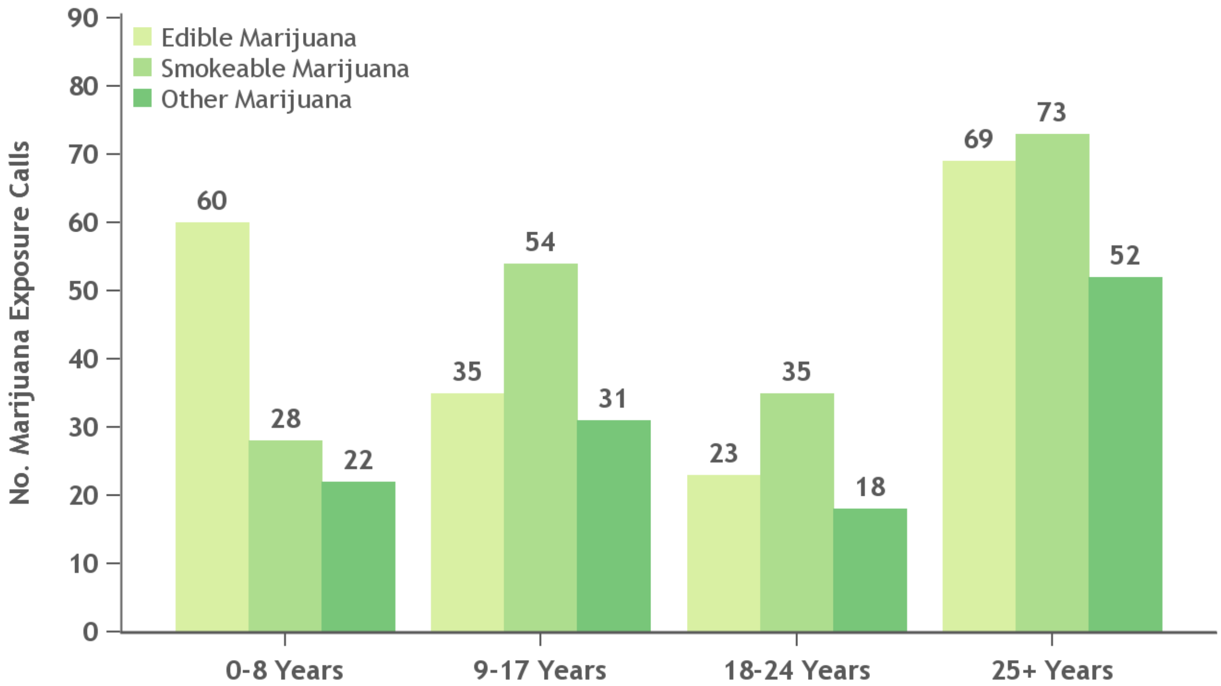
Produced by: EEOHT, CDPHE 2016.
*Data Source: National Poison Data System (NPDS) closed, human, marijuana exposure calls in Colorado from July 1, 2014 to December 31, 2016, n=529.

Major Findings

- There were 529 marijuana exposure calls from July 1, 2014 to December 31, 2016.
- Among marijuana exposure calls during this time period, 38.3% were edibles, 37.6% were smokeables, and 24.0% were other marijuana products.[g]

[g] For an explanation of terms and statistical comparisons used see Appendix R Table R.5.

Figure 6. Number of marijuana exposure calls to poison center by marijuana type and age groups in Colorado, July 2014 to December 2016



Produced by: EEOHT, CDPHE 2016.
†There were 29 calls not shown due to unknown age.
‡Data Source: National Poison Data System (NPDS) closed, human, marijuana exposure calls in Colorado from 2000 to 2016, n=529.

Major Findings

- Among children ages 0-8 years, edible marijuana products accounted for 54.5% (N=60) of marijuana exposures, followed by smokeables (25.4%, N=28) and other marijuana products (22.7%, N=22).
- Among those 9 to 24 years, the most prevalent type of marijuana exposures were smokeable marijuana products, followed by edibles and other marijuana products.
- Among ages 25 years and older, the number of marijuana exposure calls for edible and smokeable marijuana products were similar.[h]

[h] For an explanation of terms and statistical comparisons used see Appendix R Table R.5.

References

1. Davis JM, Mendelson B, Berkes JJ, Suleta K, Corsi KF, Booth RE. Public Health Effects of Medical Marijuana Legalization in Colorado. *Am J Prev Med*. 2015;10.1016/j.amepre.2015.06.034.
2. Onders B, Casavant MJ, Spiller HA, Chounthirath T, Smith GA. Marijuana Exposure Among Children Younger Than Six Years in the United States. *Clin Pediatr (Phila)*. 2015;10.1177/0009922815589912.
3. Wang GS, Roosevelt G, Le Lait MC, et al. Association of unintentional pediatric exposures with decriminalization of marijuana in the United States. *Ann Emerg Med*. 2014;63(6):684-689.

Section 3

Monitoring Possible Marijuana-Related Health Effects in Colorado

Chapter 2

Colorado Hospital Association (CHA) Data, 2000-September 2015

Retail Marijuana Public Health Advisory Committee

COLORADO
Department of Public Health & Environment

Authors

Katelyn E. Hall, MPH
Statistical Analyst
Retail Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Daniel I. Vigil, MD, MPH
Manager
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Elyse Contreras, MPH
Coordinator
Marijuana Health Monitoring and Research Program, Colorado Department of Public Health and Environment

Lisa Barker, MPH
Retail Marijuana Health Monitoring, Colorado Department of Public Health and Environment

Kevin Berg, MA
GIS Epidemiologist
Environmental Epidemiology, Colorado Department of Public Health and Environment

Kirk Bol, MSPH
Manager
Vital Statistics and Disease Registry Branch, Colorado Department of Public Health and Environment

Mike Van Dyke, PhD, CIH
Chief
Environmental Epidemiology, Occupational Health, and Toxicology Branch, Colorado Department of Public Health and Environment

Reviewer

Andrew Monte, MD
Emergency Medicine Physician, University of Colorado
Medical Toxicologist, Rocky Mountain Poison and Drug Center

Introduction

The Colorado Hospital Association (CHA) collects data on hospitalizations (HD) and emergency department (ED) discharges from participating hospitals in the state of Colorado. The data include patient demographics, admit and discharge dates, and discharge diagnoses/billing codes and procedure codes. There are roughly 100 member hospitals of CHA which includes the vast majority of hospitals in Colorado. However, the database does not include inpatient mental health facilities, ambulatory surgical centers, long term care facilities, military hospitals, and other outpatient treatment settings. The CHA dataset was used to investigate rates of HD and ED visits associated with possible marijuana exposures, diagnoses, and billing codes.

Methods

Marijuana-related billing codes

To determine HD and ED visits that were possibly associated with marijuana, four marijuana-related billing codes were used. The International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) is a U.S. Centers for Disease Control and Prevention modification of a set of codes established by the World Health Organization.[1,2] These billing codes are used to assign alphanumeric codes to patient diagnoses. On October 1, 2015 the nation updated its administrative coding from the ICD-9-CM system to ICD-10-CM. This analysis spans HD and ED visits from 2000 (2011 for ED visits) through September 2015. Analysis of the ICD-10-CM coded HD and ED visits will be completed once a full year of ICD-10-CM data is available. The four marijuana-related billing codes used were 305.20-305.23, 304.30-304.33, 969.6, and E854.1 and details about these codes can be found in Appendix S.

We examined HD and ED visit data in three different ways:

1. **Poisonings possibly due to marijuana in children under 9 years of age:** These data were chosen to represent unintentional use of marijuana by children and consisted of HD or ED visits that were coded with discharge codes related to poisoning by psychodysleptics.[3,4] Though psychodysleptic drugs include more than just marijuana, other drugs in this class have a low prevalence of use among children under 9 years of age. In addition, the age cut-off of 9 years was chosen to represent children who were unlikely to be intentionally using marijuana. This applies to Figure 1 and Map 1.
2. **Marijuana-related billing codes in listed diagnosis codes:** These data were chosen to represent the HD and ED visits where marijuana could be a causal, contributing, or coexisting factor noted by the physician during the HD or ED visit. HD and ED visits were included if they had a marijuana-related billing code in one or more of the up to 30 listed codes provided, but marijuana may not be a causal reason for the HD or ED visit. This applies to Figures 2-6 and Maps 2-6.
3. **Primary diagnoses:** Primary diagnoses were examined and compared for HD and ED visits with and without marijuana-related billing codes for all Colorado HD and ED visits from 2000 through September 2015 (2011 through September 2015 for ED visits). See Appendix S, Table S.7 for details. This applies to Figures 7 and 8.

Marijuana legalization eras

Rates of HD and ED visits were described over time by year. To evaluate the impact of changes in marijuana laws in Colorado, four marijuana legalization eras were chosen to display and compare these findings.

- 2000 – Prior to Legalized Medical Marijuana
- 2001-2009 – Medical Marijuana Legalized[5]
- 2010-2013 – Medical Marijuana Commercialized[6,7]
- 2014- September 2015 – Retail (Recreational) Marijuana Legalized[8]

Rates of HD and ED visits were calculated with the number of HD or ED visits with marijuana-related billing codes for a time period in the numerator and total number of HD or ED visits during that time period in the denominator. This proportion was multiplied by 100,000 (1,000 for county level data) to obtain a rate (Appendix S, Figure S.2). Rates of HD and ED visits were compared across years and marijuana legalization eras, and stratified by gender, age, race/ethnicity, and county (Appendix S). Prevalence of primary diagnosis categories were calculated for HD and ED visits with marijuana-related billing codes and for HD and ED visits without marijuana-related billing codes. Prevalence ratios and 95% confidence intervals were calculated comparing the prevalence of primary diagnosis categories by HD or ED visits with marijuana-related billing codes to HD or ED visits without marijuana-related billing codes for the top ten primary diagnosis categories (Appendix S, Figure S.3).

Results

The rates of HD and ED visits with poisonings possibly due to marijuana in children under 9 years old have increased over time since medical marijuana legalization in 2000 (Figure 1). However, this trend was only significant from medical marijuana legalization (2001-2009) to medical marijuana commercialization (2010-2013) (Figure 1). The number of HD and ED visits with poisonings possibly due to marijuana among children under 9 years was higher in urban areas compared to rural areas in Colorado (Map1).

When examining the rates of HD and ED visits with marijuana-related billing codes across years, there was an increasing trend in HD from 2001 to January through September 2015 with the highest rate of 1,260 per 100,000 in January through September 2015. There was also an increasing trend in ED visits from 2012 to 2014 with the highest rate of 1,039 per 100,000 in 2014. However, in January through September 2015 there was a decline in ED visits to 754 per 100,000 (Figure 2). When viewing the annual rates collapsed into marijuana legalization eras, the rate of HD with marijuana-related billing codes increased significantly from the legalization of medical marijuana (2001-2009) to the legalization of retail marijuana (2014-September 2015) (Figure 3). Furthermore, the decrease in ED visits observed in January through September of 2015 was no longer apparent when collapsed to marijuana legalization eras, and a significantly increasing trend was observed from the commercialization of medical marijuana (2011-2013) of 739 per 100,000 to the legalization of retail marijuana (2014-September 2015) of 913 per 100,000 (Figures 3).

The rates of HD with marijuana-related billing codes was highest in males (Figures 4.b), ages 9-24 years (Figures 5.b), and blacks (Figures 6.b). The rates of ED visits with marijuana-related billing codes was highest in males (Figures 4.a), ages 18-24 years (Figures 5.a), and black and unknown races (Figures 6.a).

Rates of HD marijuana-related billing codes have increased throughout most counties in Colorado since 2004, with the highest rates in Crowley county in 2014 (Maps 2, 3, & 4). Rates of ED visits marijuana-related billing codes have increased in throughout Colorado from 2011-2013 to 2014 (Maps 5 & 6). In 2014, the highest rates of ED visits with marijuana-related billing codes were in Summit County, while the highest numbers of ED visits were in Pueblo County (Map 6).

Examination of the 18 broad primary diagnosis categories for HD and ED visits revealed a nine-fold and five-fold increased prevalence of *mental illness* among HD and ED visits respectively with marijuana-related billing codes compared to HD and ED visits without marijuana-related billing codes (Figures 7 & 8). Also, there was a higher prevalence of *injuries and poisonings*, *diseases of the skin and subcutaneous tissue*, *diseases of the nervous system and sense organs, endocrine, nutritional, and metabolic diseases and immunity*, and *infectious and parasitic diseases* among HD with marijuana-related billing codes compared to HD without marijuana-related billing codes (Figure 8). The prevalence of *unclassified codes and E codes* was higher among ED visits with marijuana-related billing codes (Figure 7).

A summary of the results can be found with the following figures and detailed results can be found in Appendix S.

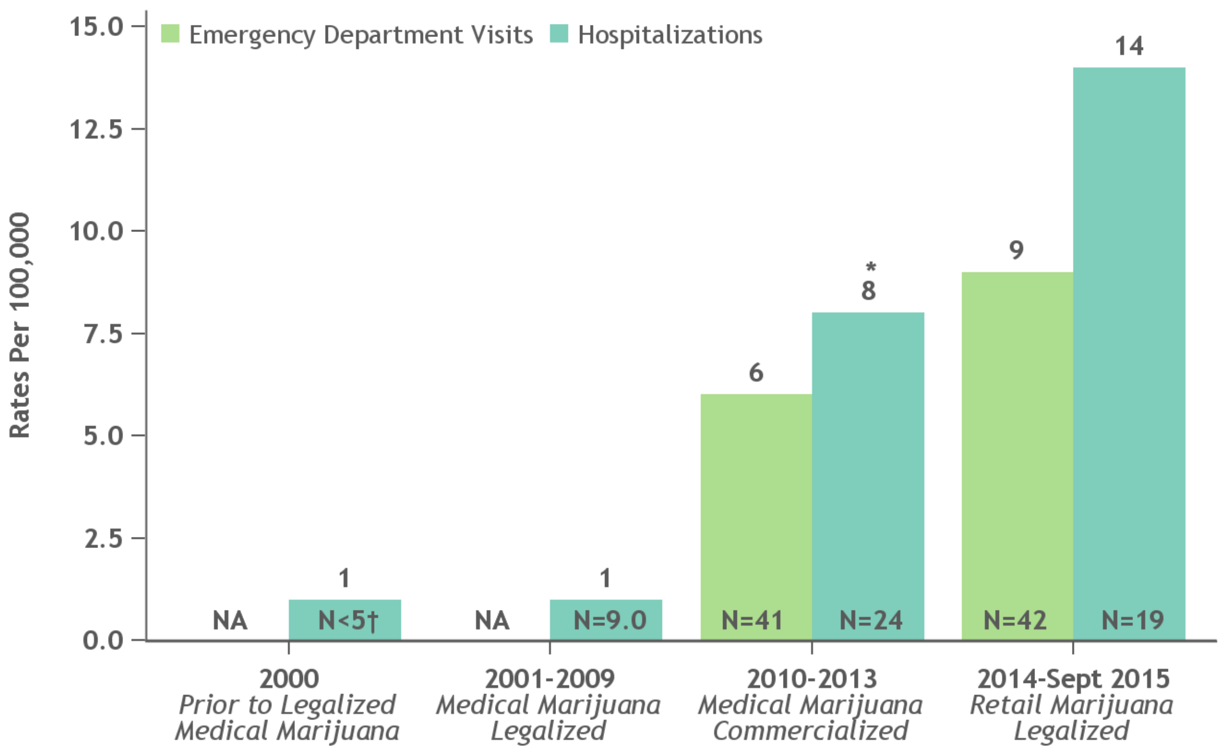
Limitations

The use of marijuana-related ICD-9-CM billing codes is not fully standardized and there may be differences in coding from hospital to hospital. This summary does not account for confounders like increases or changes in marijuana-related discharge coding by the hospitals. Changes in coding could have occurred due to an overall increased awareness regarding marijuana, changes in physician care or reporting related to marijuana, an increased honesty in patients reporting marijuana use to health care providers, or changes in coding practices by hospitals and emergency departments. Changes in marijuana coding could result in an over or underestimate HD and ED visit rates depending on the marijuana legalization era.

A major limitation is the inability to determine whether a discharge code is an exposure or diagnosis or if it is merely for billing. Furthermore, use of these billing codes does not necessarily indicate marijuana was the primary (or even secondary) reason for the HD or ED visit, rather the presence of a marijuana-related code reflects that marijuana use was noted by the treating physician. Therefore, this summary quantifies HD and ED visits with marijuana-related billing codes and does not quantify HD and ED visits due to marijuana. We hypothesize that this summary reflects marijuana use despite the limitations; however, it does not necessarily show the health care burden of marijuana use. Transition to ICD-10 coding may help clarify this issue.

In examining the 18 broad primary diagnosis categories in HD and ED visits with any mention of marijuana, causal associations between marijuana use and the diagnosis categories cannot be made. Furthermore, temporality between the associations found cannot be assessed; meaning it is unclear whether marijuana use preceded the primary diagnosis or the primary diagnosis preceded marijuana use. The associations found between HD and ED visits with marijuana coding and primary diagnosis categories point to specific health outcomes to direct future investigation and resources.

Figure 1. Children under 9 years of age; Rates of hospitalizations (HD) and emergency department (ED) visits with poisoning possibly due to marijuana in Colorado



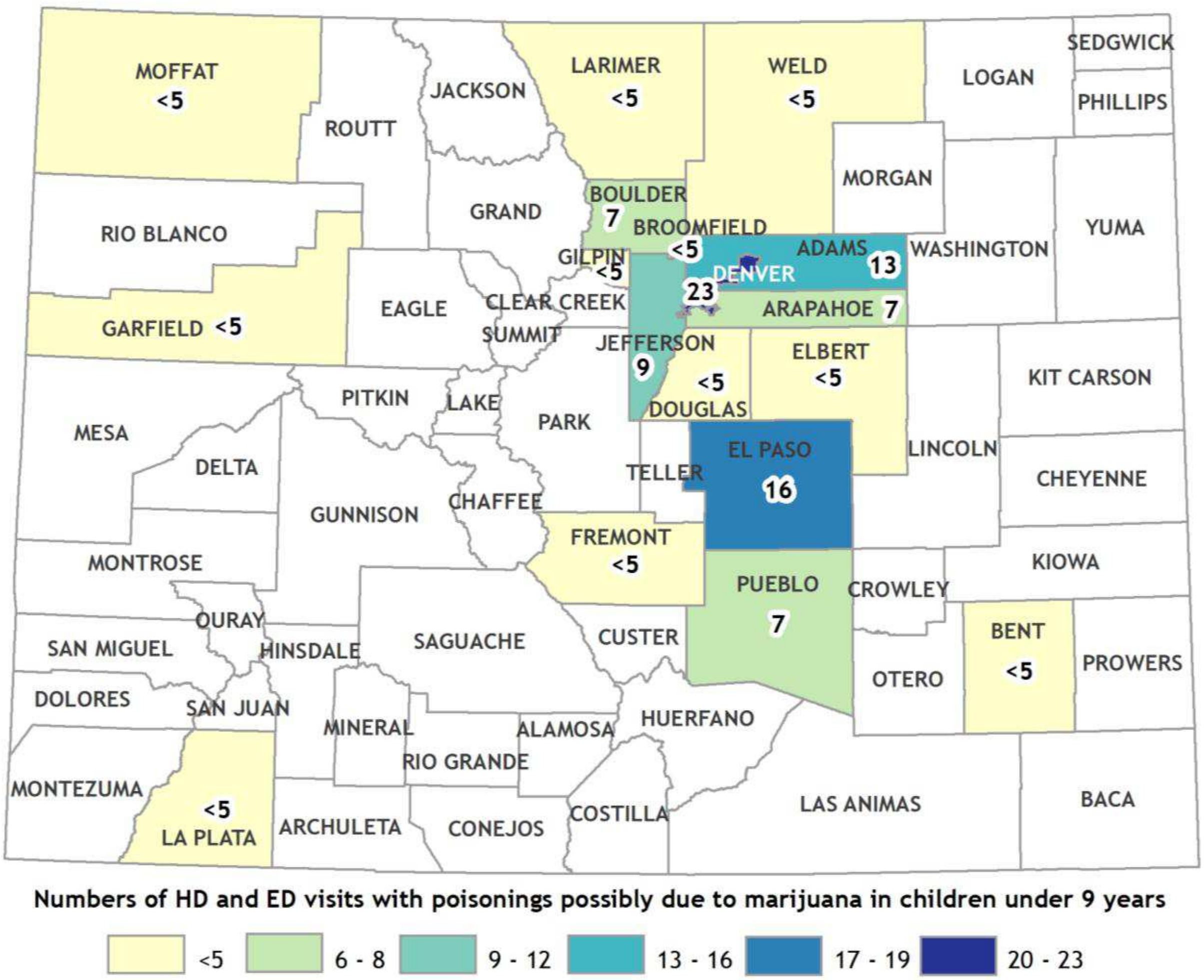
Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†ICD-9-CM codes 969.6 and E854.1, poisoning and accidental poisoning by psychodysleptics, were used to determine HD and ED visits with poisonings possibly due to marijuana.
‡The Ns are the total number of HD or ED visits with poisoning possibly due to marijuana in the specified time period.
§Data Source: Colorado Hospital Association 2000-Sept 2015 (2011-Sept 2015 for ED visits).

Major findings:

- For children under 9 years old, rates of HD and ED visits had an increasing trend across legalization eras.
- Rates of HD with poisonings possibly due to marijuana in children under 9 years old increased eight-fold from 2001-2009 to 2010-2013.[a]
- The highest rates for both HD and ED visits in children under 9 years old were in 2014 through September 2015, though these rates were not significantly different from the previous time period.[b]

[a] HD rate per 100,000 2001-2009: 1 2010-2013: 8: X^2= 30.0, p<0.001
[b] 2014 to Sept 2015: HD rate per 100,000 (14), ED rate per 100,000 (9)
For an explanation of statistical comparisons used, see Appendix S. For data, see Appendix S Table S.1.

Map 1. Numbers of hospitalizations (HD) and emergency department (ED) Visits with poisonings possibly due to marijuana in children Under 9 Years of age in Colorado, 2004-2014 by county.

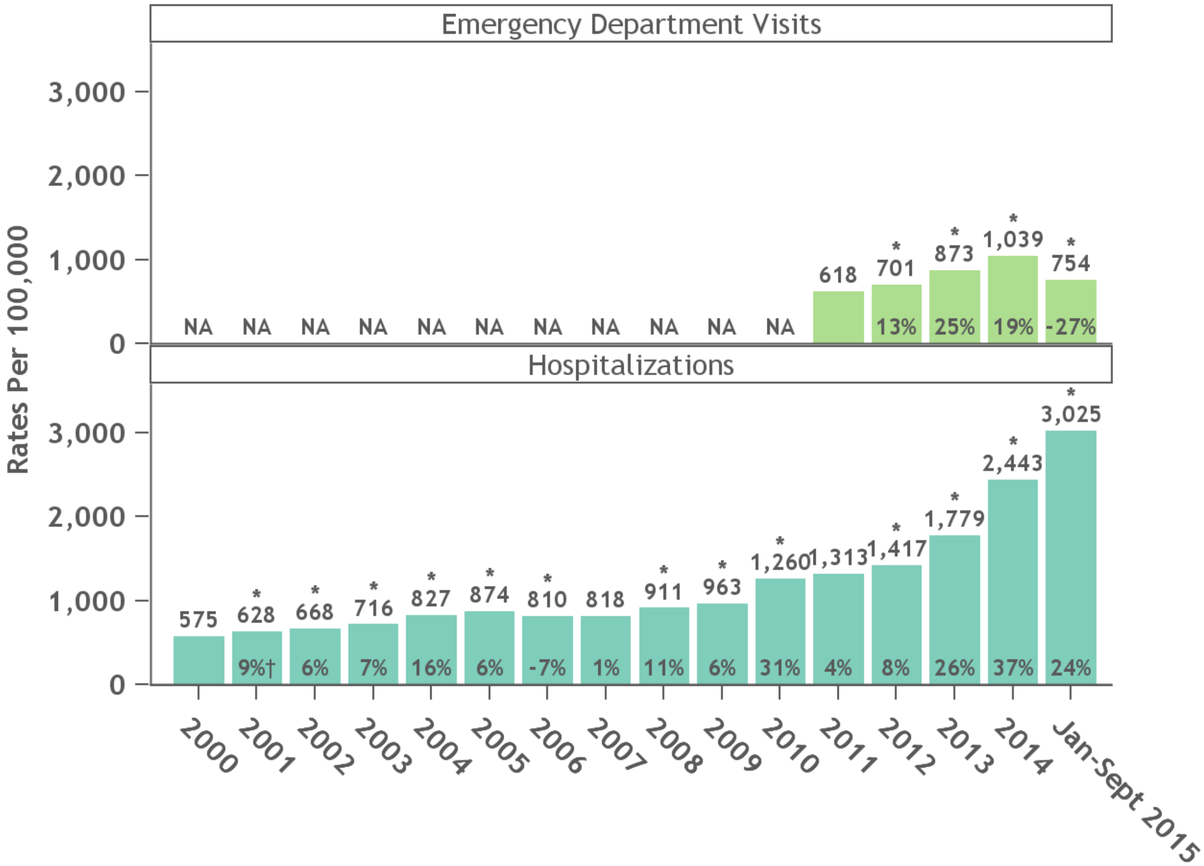


Produced by: EEOHT, CDPHE 2016
*Counties shown in white have no reported HD or ED visits with poisonings possibly due to marijuana in children under 9 years.
†ICD-9-CM codes 969.6 and E854.1 were used to determine HD and ED visits with poisonings possibly due to marijuana.
‡Data source: Colorado Hospital Association (CHA).

Major findings:

- Numbers of HD and ED visits were highest in Denver, El Paso, and Adams counties.
- Higher numbers of HD and ED visits were in urban areas compared to rural.

Figure 2. Rates of hospitalizations (HD) and emergency department (ED) visits with marijuana-related billing codes in Colorado.



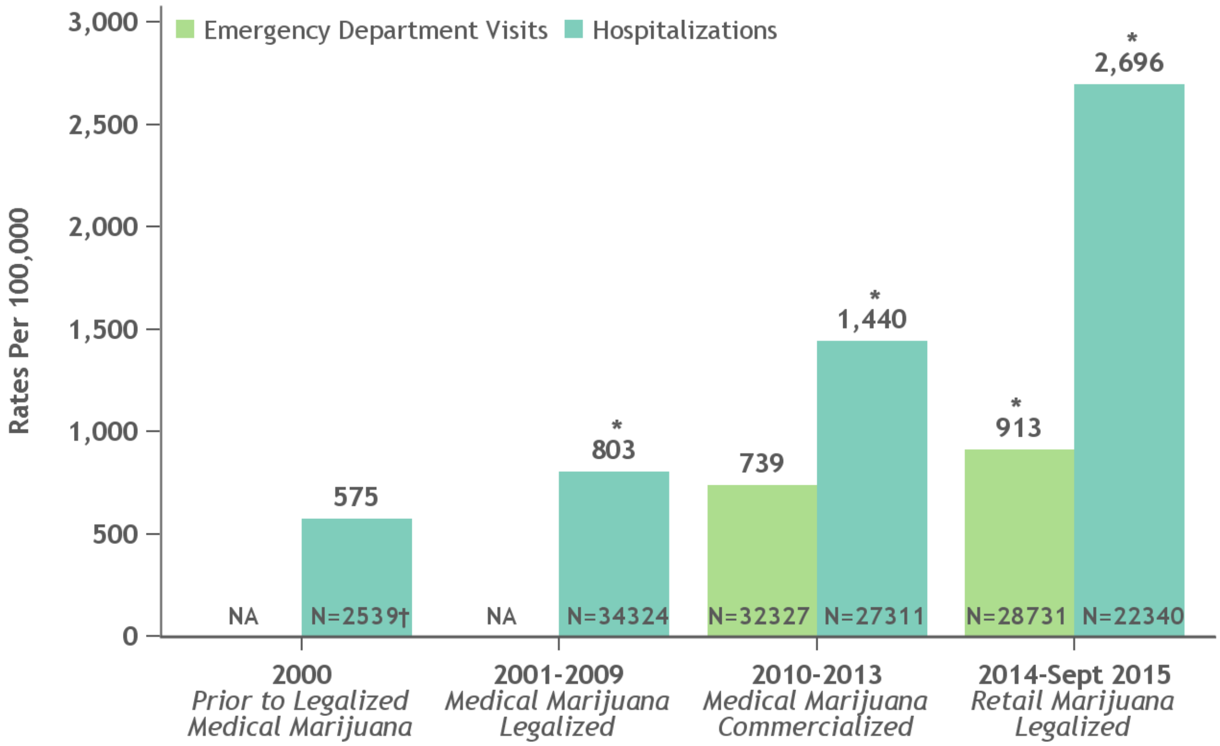
Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†The percent change in rates of HD and ED visits compared to the previous year.
‡ICD-9-CM codes 305.20-305.23, 304.30-304.33, 969.6, and E854.1 were used to determine HD and ED visits with marijuana-related billing codes.
§Data Source: Colorado Hospital Association 2000-Sept 2015 (2011-Sept 2015 for ED visits).

Major findings:

- Rates of ED visits with marijuana-related billing codes showed an increasing trend from 2012 to 2014 and then decreased from 2014 to January through September of 2015 by 27%.[c]
- Rates of HD with marijuana-related billing codes showed an increasing trend beginning in 2001 with the highest rate of HD in January through September 2015.[d]
- The largest increases in rates were from 2013 to 2014 of 37% for HD[e] and 2012 to 2013 of 25% for ED visits.[f]

[c] Rate of ED visits per 100,000 : 2012 (701), 2013 (873), 2014 (1039), Jan- Sept 2015 (754) increase 27%
[d] Rate of HD per 100,000: Jan- Sept 2015 (3025)
[e] Rate of HD per 100,000: 2013 (1779), 2014 (2443) Increase 37%
[f] Rate of ED per 100,000: 2012 (701), 2013 (873) Increase 25%
For an explanation of statistical comparisons used, see Appendix S. For data, see Appendix S Table S.2.

Figure 3. Rates of hospitalizations (HD) and emergency department (ED) visits with marijuana-related billing codes in Colorado.



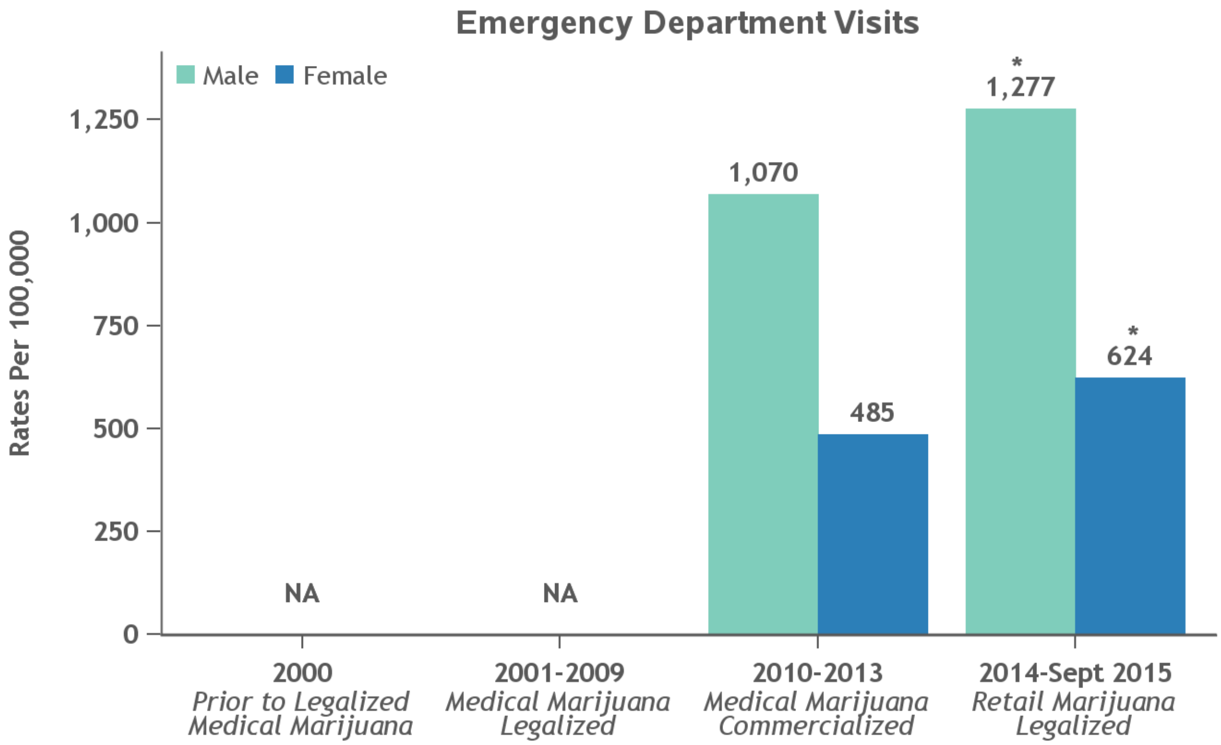
Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†The Ns are the total number of HD or ED visits with marijuana-related billing codes in the specified time period.
‡ICD-9-CM codes 305.20-305.23, 304.30-304.33, 969.6, and E854.1 were used to determine HD and ED visits with marijuana-related billing codes.
§Data Source: Colorado Hospital Association 2000-Sept 2015 (2011-Sept 2015 for ED visits).

Major findings:

- Rates of HD with marijuana-related billing codes significantly increased by each time period from 2000 to 2014 through September 2015 with the largest increase of 87.2% from 2010-2013 to 2014 through September 2015.[g]
- Rates of ED visits significantly increased by 23.5% from 2010-2013 to 2014 through September 2015.[h]
- The highest rates for both HD and ED visits with marijuana-related billing codes were in 2014 through September 2015.[i]

[g] Rates of HD per 100,000: 2000 (575) vs 2001-2009 (803) X^2= 686.5, p<0.001; 2001-2009 (803) vs 2010-2013 (1440) X^2= 5384.4, p<0.001; 2010-2013 (1440) vs 2014-Sept 2015 (2696) X^2= 5084.9, p<0.001
[h] Rates of ED per 100,000: 2010-2013 (739) vs 2014-Sept 2015 (913) : X^2= 686.5, p<0.001
[i] Highest rates per 100,000: HD 2014-Sept 2015 (2696), ED: 2014-Sept 2015 (913)
For an explanation of statistical comparisons used, see Appendix S. For data, see Appendix S table S.3.

Figure 4.a Rates of emergency department (ED) visits with marijuana-related billing codes by gender.



Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†ICD-9-CM codes 969.6 and E854.1 were used to determine ED visits with marijuana-related billing codes.
‡Data Source: Colorado Hospital Association 2011-Sept 2015.

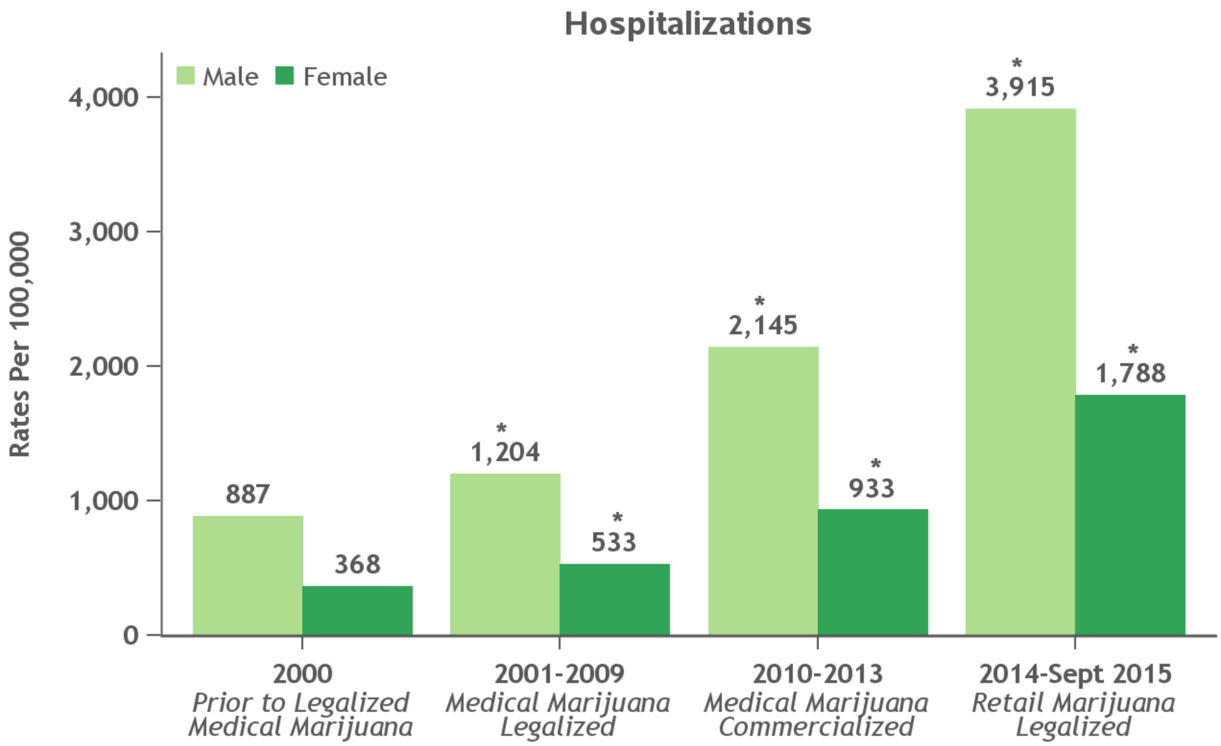
Major findings:

- Rates of ED visits significantly increased from 2011-2013 to 2014 through September 2015 for both males and females.[j]
- Males had consistently higher rates of ED visits with marijuana-related billing codes across time periods.

---

[j] Rate ED visits per 100,000: male 2011-2013 (1070) vs 2014-Sept 2015 (1277), X^2= 303.2, p<0.001; female 2011-2013 (485) vs 2014-Sept 2015 (624), X^2= 364.7, p<0.001
For an explanation of statistical comparisons used, see Appendix S. data, see Appendix S table S.4.

Figure 4.b Rates of hospitalizations (HD) with marijuana-related billing codes by gender.



Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†ICD-9-CM codes 969.6 and E854.1 were used to determine HD with marijuana-related billing codes.
‡Data Source: Colorado Hospital Association 2000-Sept 2015.

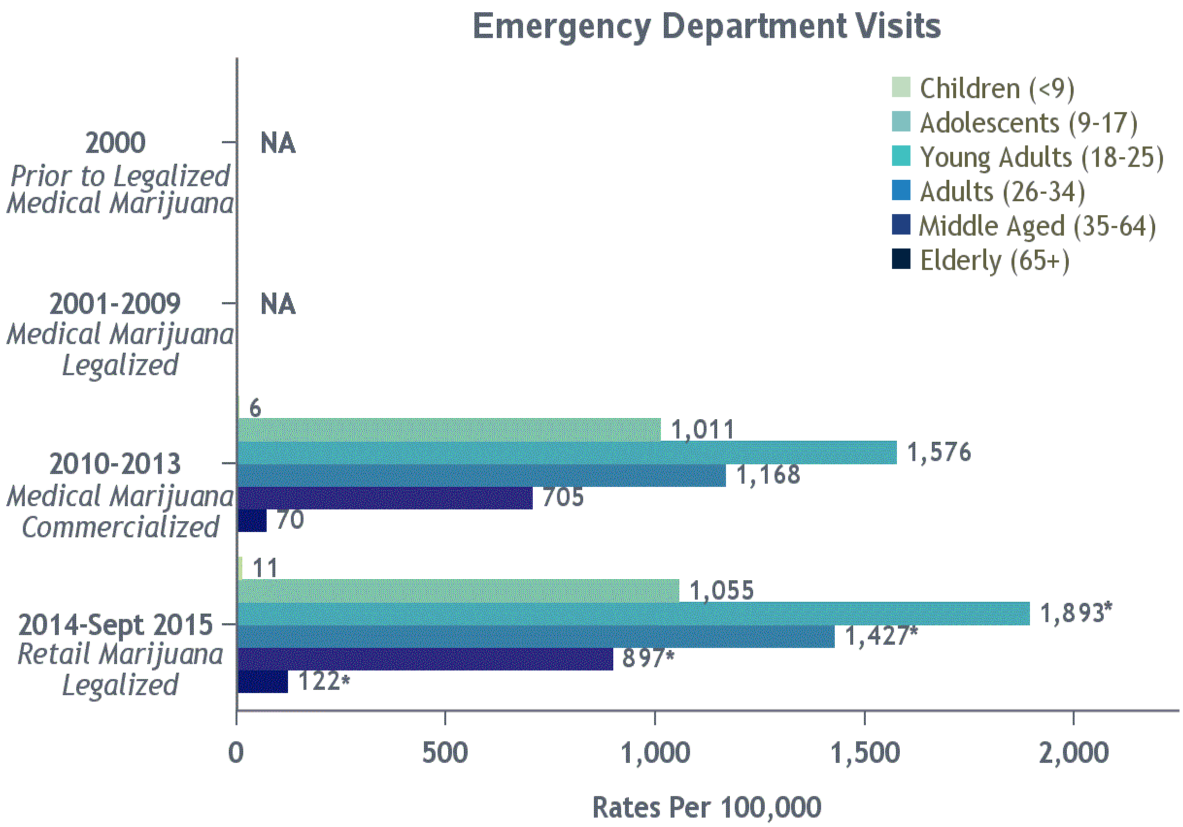
Major findings:

- Rates of HD with marijuana-related billing codes significantly increased each time period from year 2000 to 2014 through September 2015 for both males[k] and females.[l]
- Males had consistently higher rates of HD with possible marijuana exposures, diagnoses, or billing codes across time periods.

---

[k] Rate of male HD visits per 100,000: 2000 (887) vs 2001-2009 (1204), X^2= 138.7, p<0.001; 2001-2009 (1204) vs 2010-2013 (2145), X^2= 3252.5, p<0.001; 2010-2013 (2145) vs 2014-Sept 2015 (1277), X^2= 2926.8, p<0.001
[l] Rate of female HD visits per 100,000: 2000 (368) vs 2001-2009 (533), X^2= 128.0, p<0.001; 2001-2009 (533) vs 2010-2013 (933), X^2= 1895.8, p<0.001; 2010-2013 (933) vs 2014-Sept 2015 (1788), X^2= 2065.0, p<0.001
For an explanation of statistical comparisons used, see Appendix S. For data, see Appendix S table S.4.

Figure 5.a Rates of emergency department (ED) visits with marijuana-related billing codes by age categories.



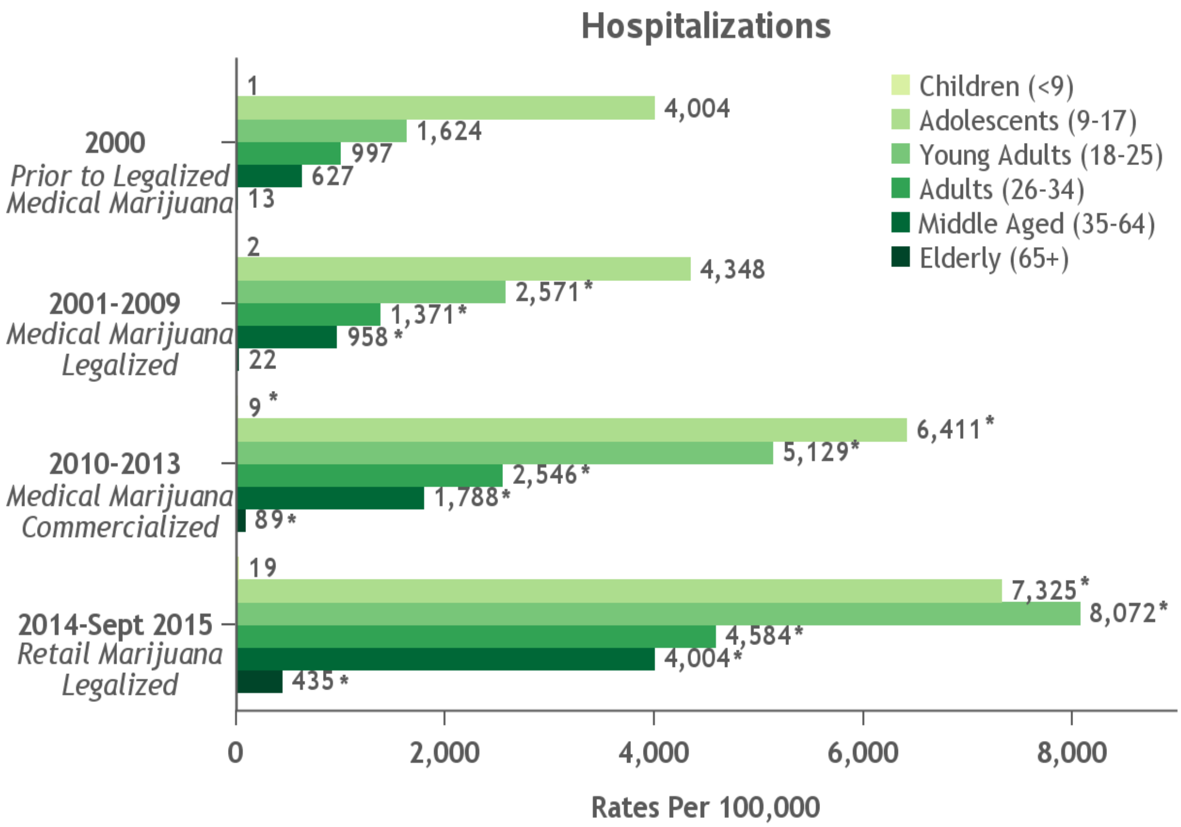
Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†ICD-9-CM codes 969.6 and E854.1 were used to determine ED visits with marijuana-related billing codes.
‡Data Source: Colorado Hospital Association 2011-Sept 2015.

Major findings:

- Rates of ED visits with marijuana-related billing codes significantly increased for all age groups except children and adolescents from 2011-2013 to 2014 through September 2015.[m]

[m] Rate of ED visits per 100,000: YA 2010-2013 (1576) vs 2014-Sept 2015 (1893), X^2= 154.3, p<0.001; adult 2010-2013 (1168) vs 2014-Sept 2015 (1427), X^2= 153.1, p<0.001; middle aged 2010-2013 (705) vs 2014-Sept 2015 (897), X^2= 289.5, p<0.001; elderly 2010-2013 (70) vs 2014-Sept 2015 (122), X^2= 64.4, p<0.001
For an explanation of statistical comparisons used, see Appendix S. For data, see Appendix S table S.5.

Figure 5.b Rates of hospitalizations (HD) with marijuana-related billing codes by age categories.



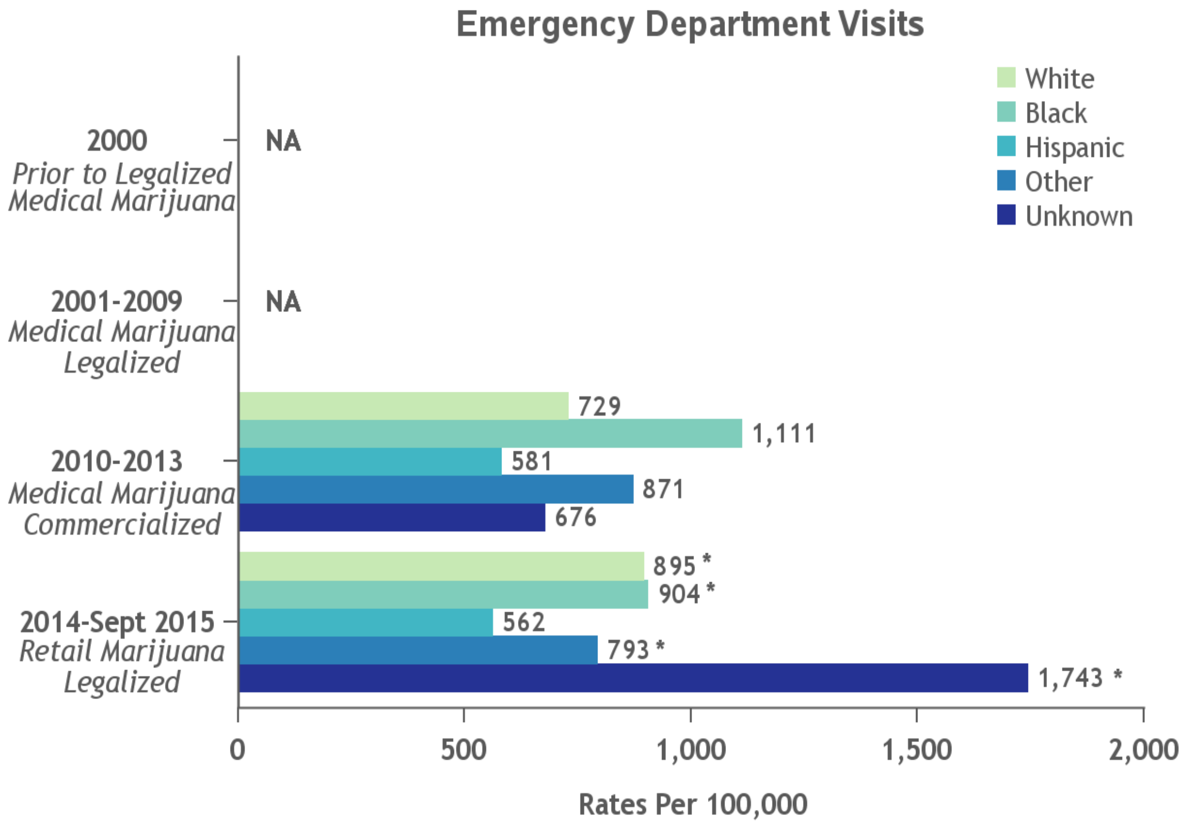
Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†ICD-9-CM codes 969.6 and E854.1 were used to determine HD with marijuana-related billing codes.
‡Data Source: Colorado Hospital Association 2000-Sept 2015.

Major findings:

- Rates of HD with marijuana-related billing codes significantly increased for all age groups from 2001-2009 to 2010-2013 and for those 9 and older for 2010-2013 to 2014 through September 2015.[n]

[n] Rate of HD visits per 100,000: Child 2001-2009 (2) vs 2010-2013 (2), X^2= 28.2, p<0.001; Adolescent 2001-2009 (4348) vs 2010-2013 (6411), X^2= 315.6, p<0.001; 2010-2013 (6411) vs 2014-Sept 2015 (7325), X^2= 19.6, p<0.001; YA 2000(1624) vs 2001-2009 (2571), X^2= 131.5, p<0.001; 2001-2009 (2571) vs 2010-2013 (5129), X^2= 2123.6, p<0.001; 2010-2013 (5129) vs 2014-Sept 2015 (8072), X^2= 634.9, p<0.001; Adult 2000(997) vs 2001-2009 (1371), X^2= 48.7, p<0.001; 2001-2009 (1371) vs 2010-2013 (2546), X^2= 1205.2, p<0.001; 2010-2013 (2546) vs 2014-Sept 2015 (4584), X^2= 904.0, p<0.001; middle aged 2000(627) vs 2001-2009 (958), X^2= 143.4, p<0.001; 2001-2009 (958) vs 2010-2013 (1788), X^2= 2384.5, p<0.001; 2010-2013 (1788) vs 2014-Sept 2015 (4004), X^2= 3754, p<0.001; Elderly 2001-2009 (22) vs 2010-2013 (89), X^2= 406.2, p<0.001; 2010-2013 (89) 2014-Sept 2015 (435), X^2= 1082.3, p<0.001 For an explanation of statistical comparisons used, see Appendix S. For data, see Appendix S table S.5.

Figure 6.a Rates of emergency department (ED) visits with marijuana-related billing codes by race/ethnicity.



Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†ICD-9-CM codes 969.6 and E854.1 were used to determine ED visits with marijuana-related billing codes.
‡Other race included Asian, Native American, and Other races. Unknown race was recorded as “unknown” not including missing data.
§Data Source: Colorado Hospital Association 2011-Sept 2015.

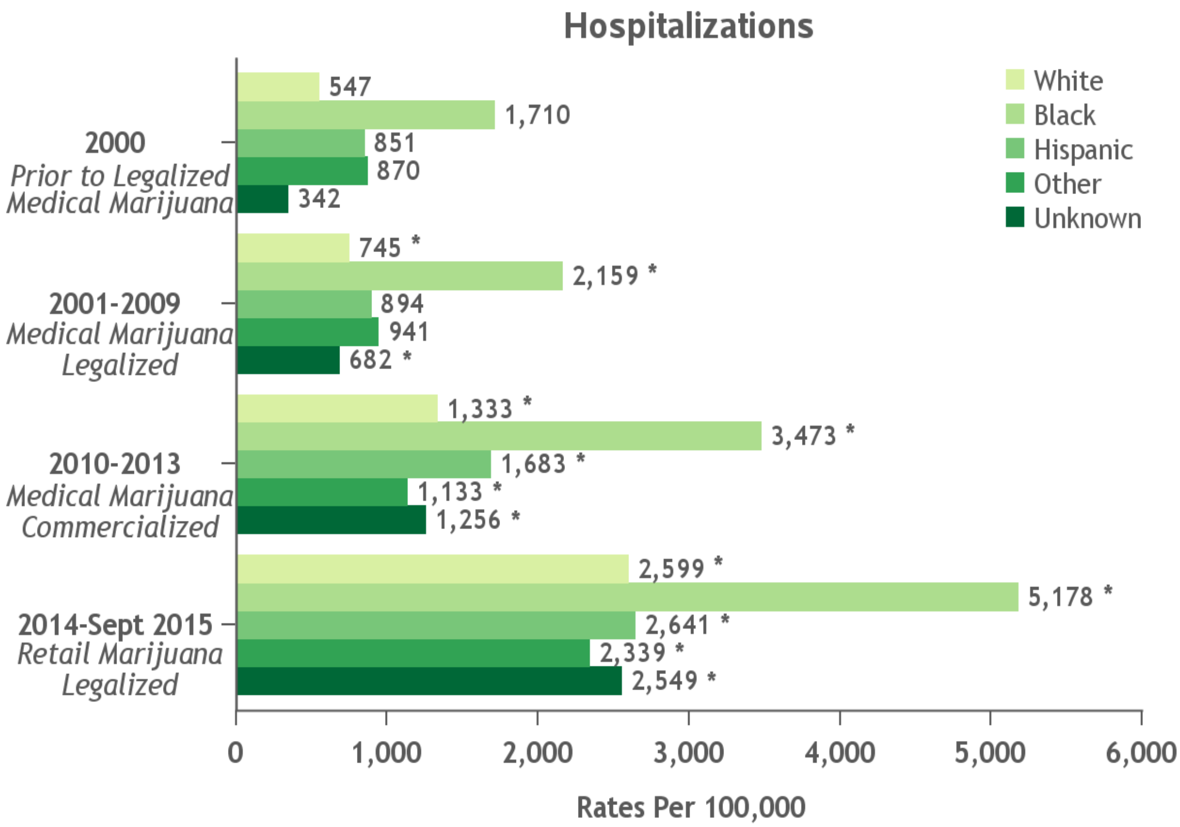
Major findings:

- Rates of ED visits with marijuana-related billing codes significantly increased from 2010-2013 to 2014 through September 2015 for White, Black, Other, and Unknown races.[o]

---

[o]Rate of ED visits per 100,000: White 2010-2013 (729) vs 2014-Sept 2015 (895), X^2= 409.0, p<0.001; Black 2010-2013 (1111) vs 2014-Sept 2015 (895), X^2= 50.7, p<0.001; Other 2010-2013 (581) vs 2014-Sept 2015 (562), X^2= 13.1, p<0.001; Unknown 2010-2013 (676) vs 2014-Sept 2015 (1743), X^2= 1509.3, p<0.001
For an explanation of statistical comparisons used, see Appendix S. For data, see Appendix S table S.6.

Figure 6.b Rates of hospitalizations (HD) with marijuana-related billing codes by race/ethnicity.



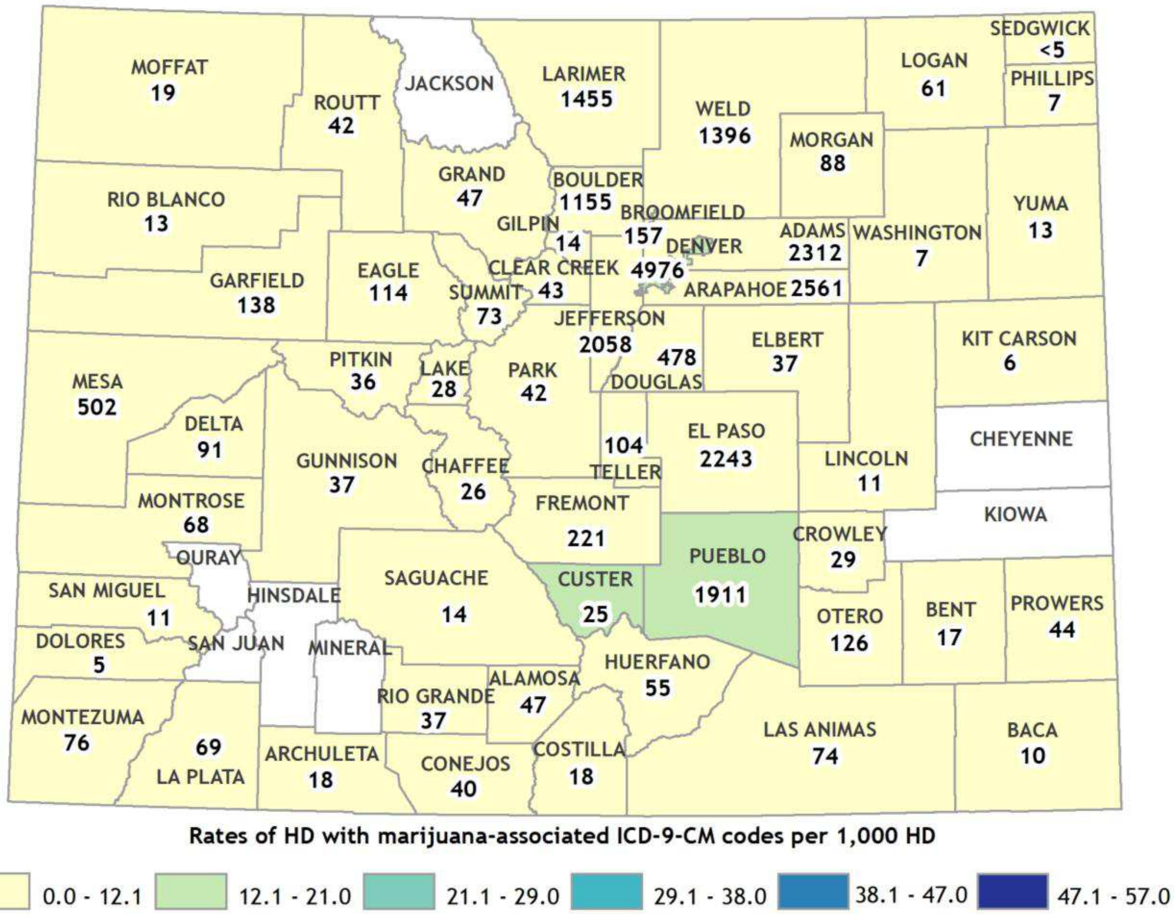
Produced by: EEOHT, CDPHE 2016
*Rate significantly increased from previous time period with a p-value <0.001.
†ICD-9-CM codes 969.6 and E854.1 were used to determine HD with marijuana-related billing codes.
‡Other race included Asian, Native American, and Other races. Unknown race was recorded as "unknown" not including missing data.
§Data Source: Colorado Hospital Association 2000-Sept 2015.

Major findings:

- Rates of HD with marijuana-related billing codes significantly increased each time period for White, Black, and Unknown races.[p]
- Rates of HD with marijuana-related billing codes for all races significantly increased each time period from 2001-2009 to 2014 through September 2015.[q]

[p] Rate of HD visits per 100,000: White 2000 (547) vs 2001-2009 (745), X^2= 122.0, p<0.001; 2001-2009 (745) vs 2010-2013 (1333), X^2= 3127.2, p<0.001; 2010-2013 (1333) vs 2014-Sept 2015 (2599), X^2= 3903.7, p<0.001; Black 2000 (1710) vs 2001-2009 (2159), X^2= 12.3, p<0.001; 2001-2009 (2159) vs 2010-2013 (3473), X^2= 362.5, p<0.001; 2010-2013 (3473) vs 2014-Sept 2015 (5178), X^2= 198.1, p<0.001; Unknown 2000 (342) vs 2001-2009 (682), X^2= 165.4, p<0.001; 2001-2009 (682) vs 2010-2013 (1256), X^2= 594.7, p<0.001; 2010-2013 (1256) vs 2014-Sept 2015 (2549), X^2= 431.2, p<0.001
[q] Rate of HD visits per 100,000: Hispanic 2001-2009 (894) vs 2010-2013 (1683), X^2= 793.8, p<0.001; 2010-2013 (1683) vs 2014-Sept 2015 (2641), X^2= 223.1, p<0.001; Other 2001-2009 (941) vs 2010-2013 (1133), X^2= 31.6, p<0.001; 2010-2013 (1133) vs 2014-Sept 2015 (2339), X^2= 455.1, p<0.001
For an explanation of statistical comparisons used, see Appendix S. For data, see Appendix S table S.6.

Map 2. Rates and numbers of hospitalizations (HD) with marijuana-related billing codes Per 1,000 HD in all ages in Colorado From 2004-2009.

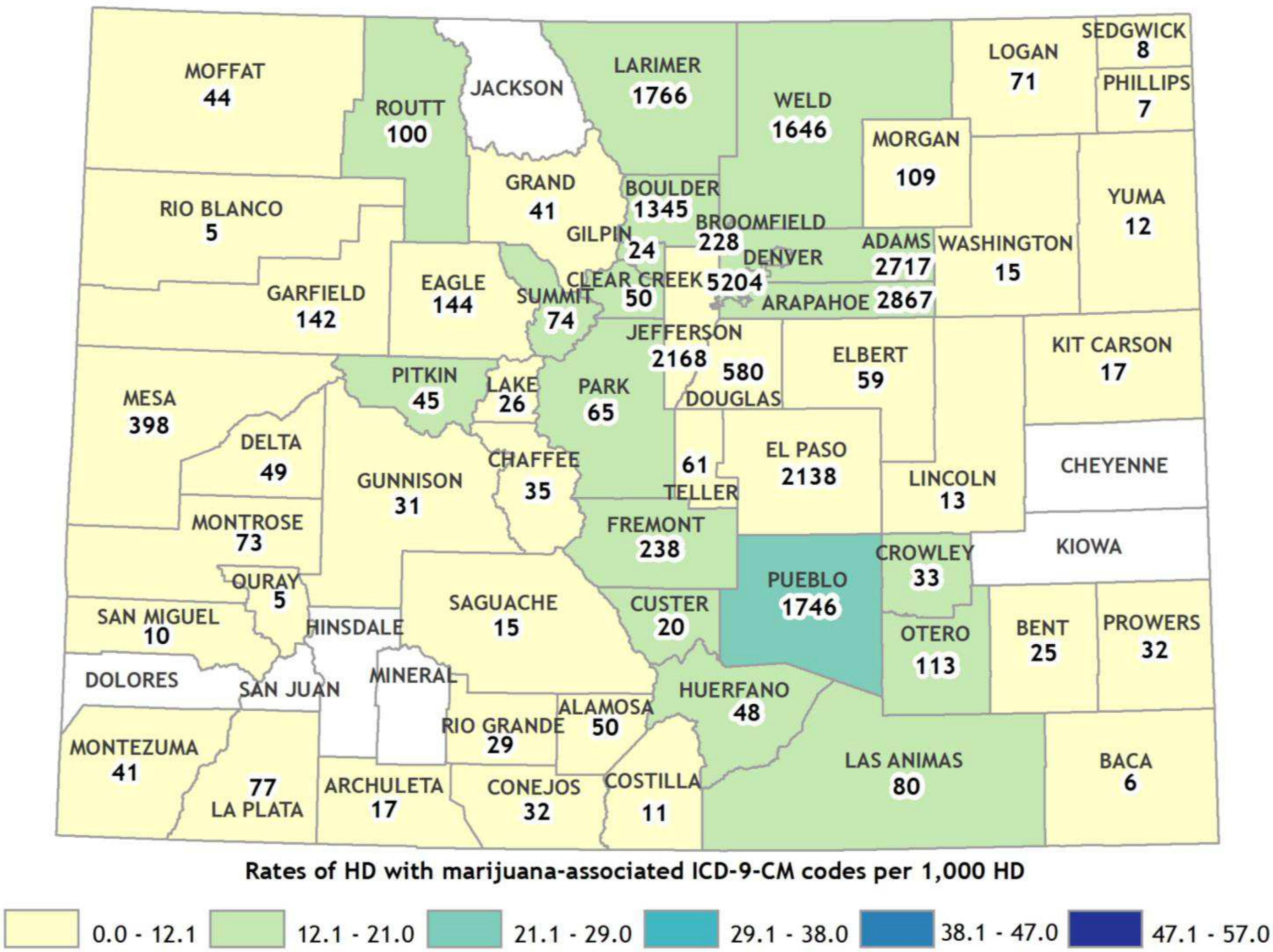


Produced by: EEOHT, CDPHE 2016
*Counties shown in white have no reported ED visits with marijuana-related billing codes.
†The number inside the counties was the total number of HD with marijuana-related billing codes in the specified county.
‡ICD-9-CM codes 305.20-305.23, 304.30-304.33, 969.6, and E854.1 were used to determine HD with marijuana-related billing codes.
§ Data Source: Colorado Hospital Association 2004-2009.

Major findings

- Rates and numbers of HD with marijuana-related billing codes were higher in urban areas compared to rural areas.
- The highest rates were in Pueblo (16 per 1,000 HD), Denver (13 per 1,000 HD), and Custer (12 per 1,000 HD) counties while the highest numbers of HD were in Denver (N=4,976 HD), Arapahoe (N=2,561 HD), and Adams (N=2,561 HD) counties.

Map 3. Rates and numbers of hospitalizations (HD) with marijuana-related billing codes per 1,000 hospitalizations in all ages in Colorado from 2010-2013.

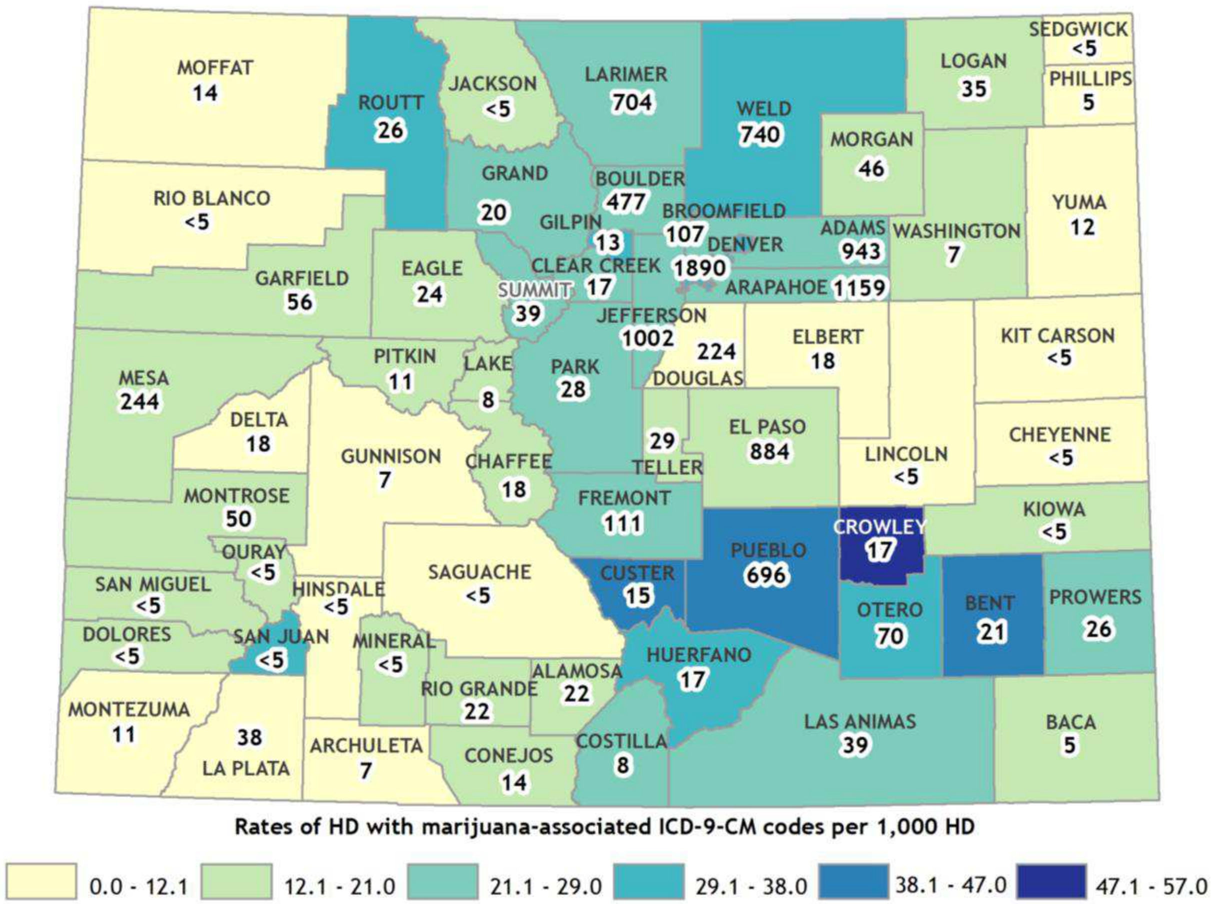


Produced by: EEOHT, CDPHE 2016
*Counties shown in white have no reported ED visits with marijuana-related billing codes.
†The number inside the county was the total number of HD with marijuana-related billing codes in the specified county.
‡ICD-9-CM codes 305.20-305.23, 304.30-304.33, 969.6, and E854.1 were used to determine HD with marijuana-related billing codes.
§ Data Source: Colorado Hospital Association 2010-2013.

Major findings

- Rates and numbers of HD with marijuana-related billing codes were higher in urban areas compared to rural areas.
- The highest rates were in Pueblo County (24 HD per 1,000 HD); however, the highest number of HD was in Denver County (N=5,204 HD).

Map 4. Rates and numbers of hospitalizations (HD) with marijuana-related billing codes per 1,000 hospitalizations in all ages in Colorado in 2014-September 2015.

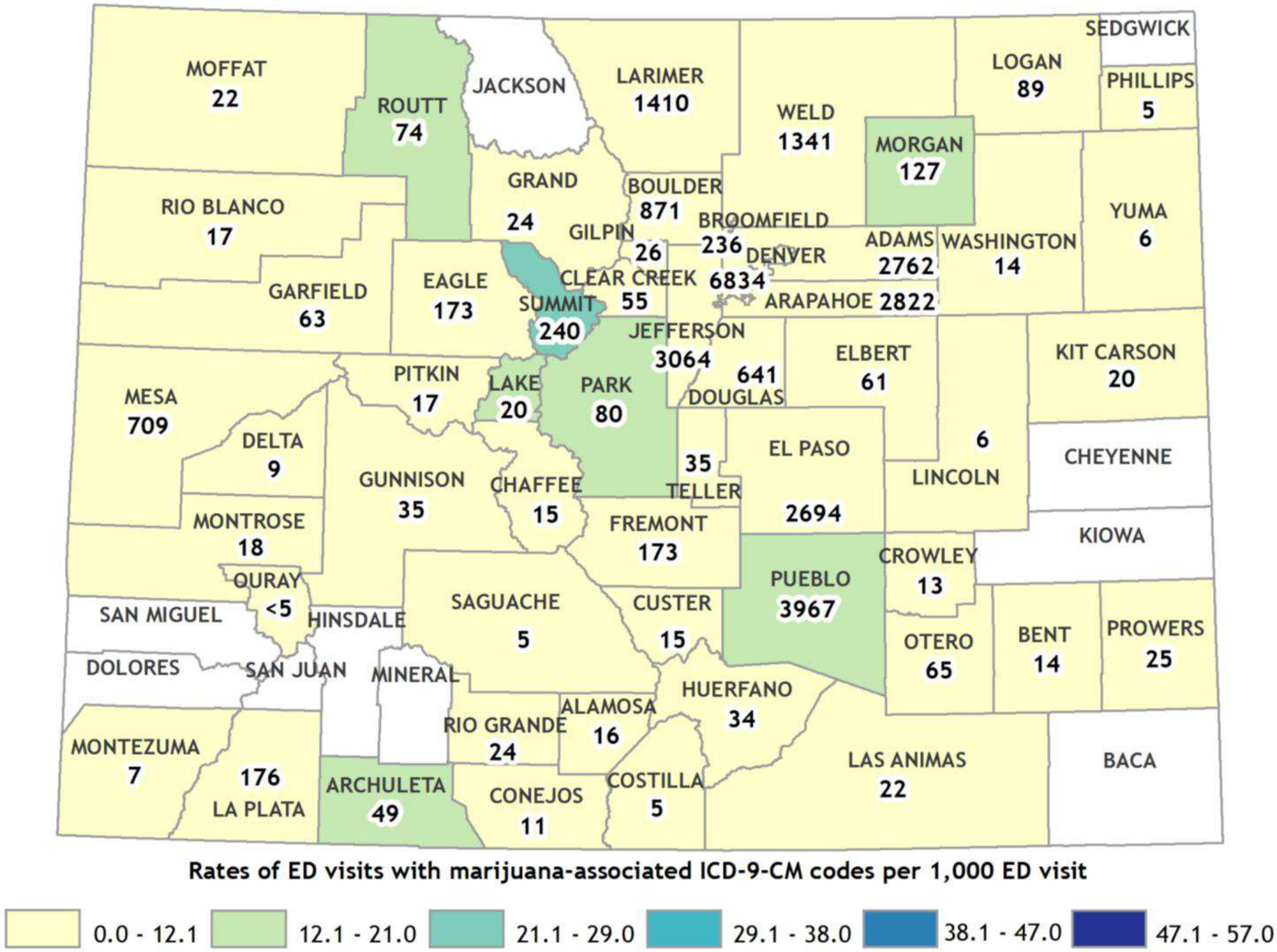


Produced by: EEOHT, CDPHE 2016
* Counties shown in white have no reported HD with marijuana-related billing codes.
†The number inside the county was the total number of HD marijuana-related billing codes in the specified county.
‡ICD-9-CM codes 305.20-305.23, 304.30-304.33, 969.6, and E854.1 were used to determine HD with marijuana-related billing codes.
§ Data Source: Colorado Hospital Association 2014-Sept 2015.

Major findings

- Numbers of HD with marijuana-related billing codes were higher in urban areas compared to rural areas.
- The highest rates of HD were in Crowley County (56 per 1,000 HD) while the highest numbers of HD were in Denver County (N=1,749 HD).

Map 5. Rates and numbers of emergency department (ED) Visits with marijuana-related billing codes per 1,000 ED visits in all ages in Colorado from 2011-2013.



Produced by: EEOHT, CDPHE 2016

* Counties shown in white have no reported ED visits with marijuana-related billing codes.

†The number inside the county was the total number of ED visits with possible marijuana-related billing codes in the specified county.

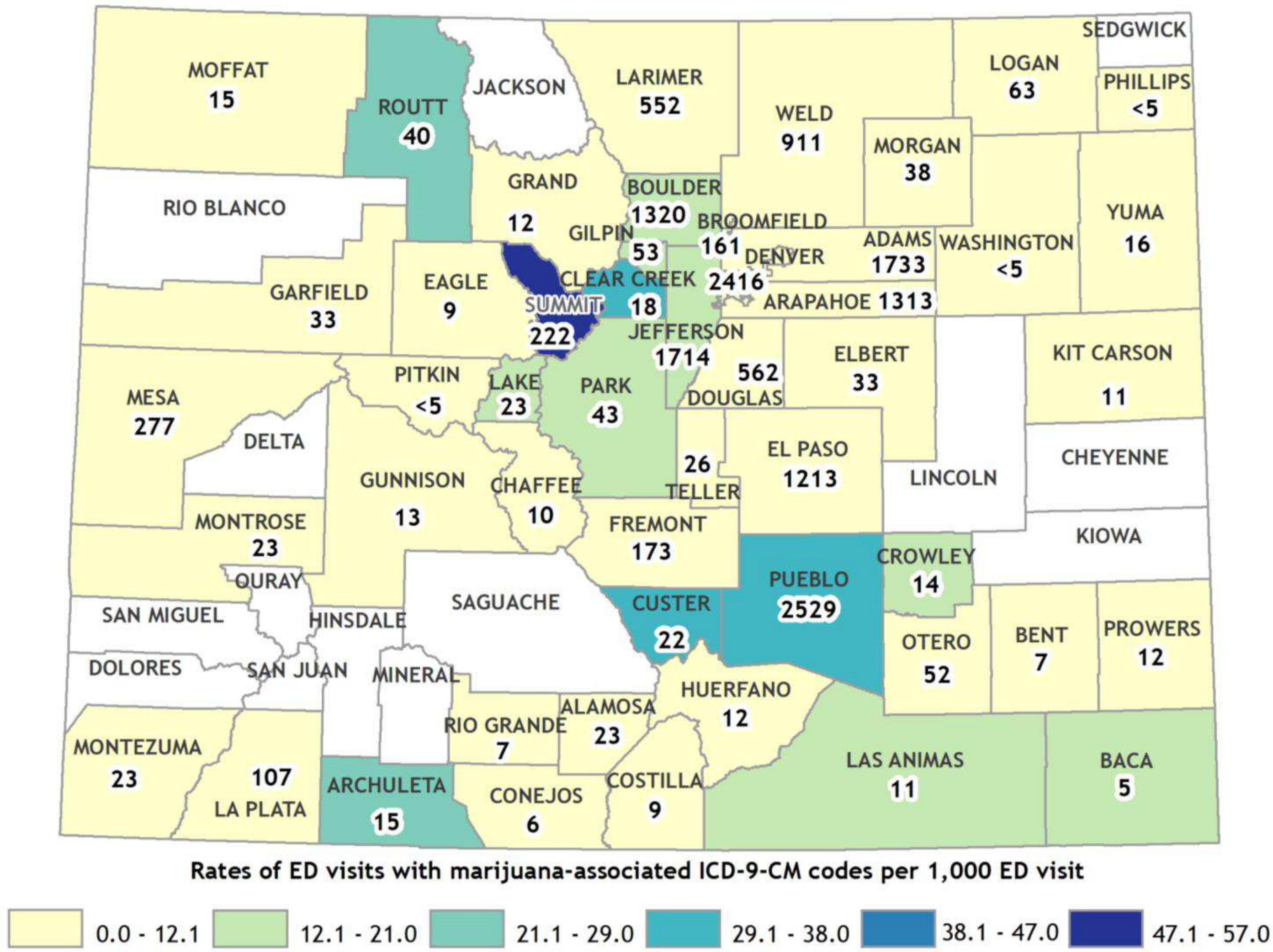
‡ICD-9-CM codes 305.20-305.23, 304.30-304.33, 969.6, and E854.1 were used to determine ED visits with marijuana-related billing codes.

§ Data Source: Colorado Hospital Association 2011-2013.

Major findings

- The rates of ED visits remained fairly constant from urban to rural counties; however, the numbers of ED visits were higher in urban counties compared to rural counties.
- The highest rates of ED visits were in Summit (21 per 1,000), Routt (17 per 1,000), Pueblo (17 per 1,000), Lake (13 per 1,000), Park (13 per 1,000) and Archuleta (13 per 1,000) counties, while the highest numbers of ED visits were in Denver (N=6,834) and Pueblo (N=3,967) counties.

Map 6. Rates and numbers of emergency department (ED) visits with marijuana-related billing codes[b] per 1,000 hospitalizations in all ages in Colorado in 2014-September 2015.

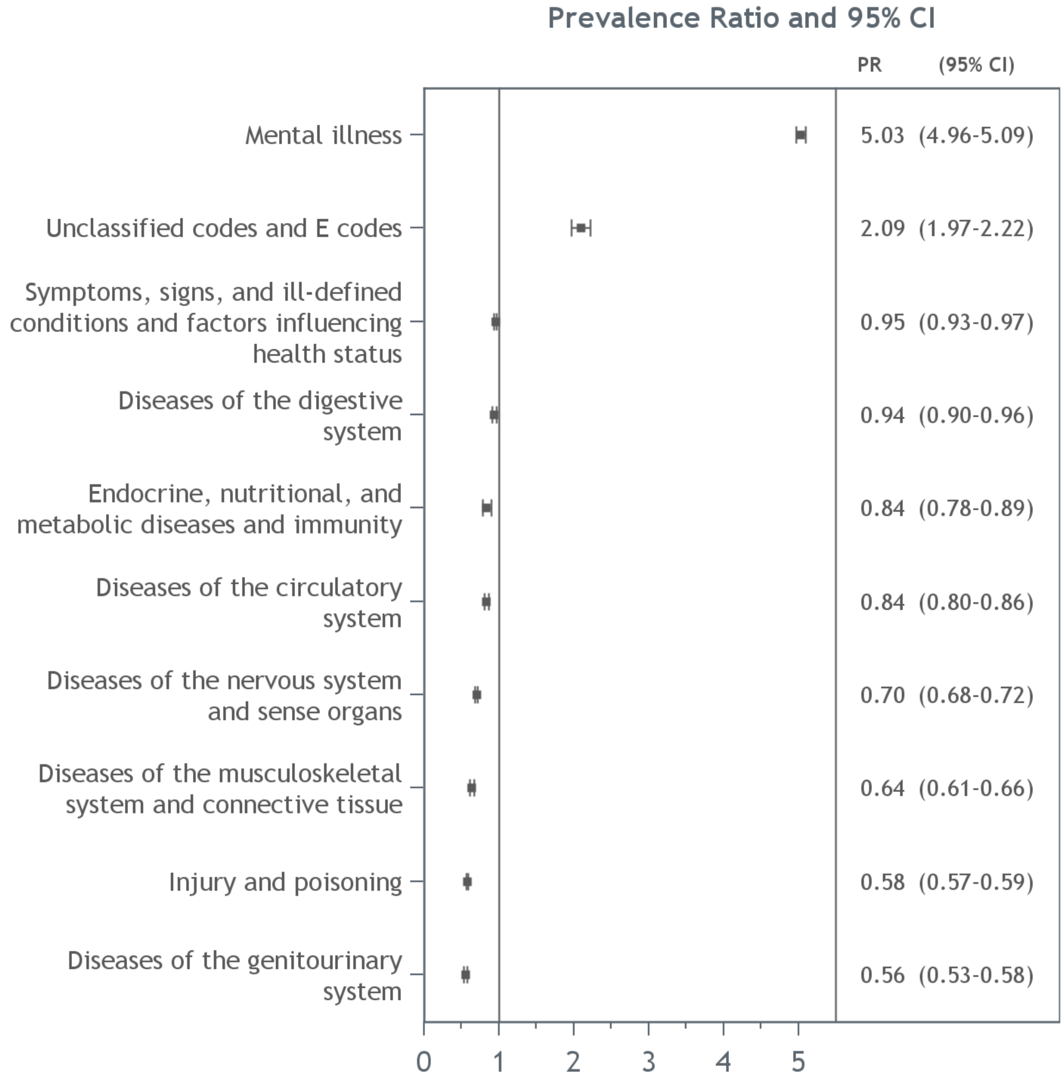


Produced by: EEOHT, CDPHE 2016
* Counties shown in white have no reported ED visits with marijuana-related billing codes.
†The number inside the county was the total number of ED visits with marijuana-related billing codes in the specified county.
‡ICD-9-CM codes 305.20-305.23, 304.30-304.33, 969.6, and E854.1 were used to determine ED visits with marijuana-related billing codes.
§ Data Source: Colorado Hospital Association 2014-Sept 2015.

Major findings

- The rate of ED visits increased in Adams, Alamosa, Arapahoe, Archuleta, Baca, Boulder, Broomfield, Chaffee, Clear Creek, Costilla, Crowley, Custer, Dolores, Douglas, El Paso, Elbert, Fremont, Garfield, Gilpin, Grand, Jefferson, Kit Carson, La Plata, Lake, Las Animas, Logan, Mesa, Moffat, Montezuma, Montrose, Morgan, Otero, Park, Phillips, Pueblo, Routt, Summit, Teller, Washington, Weld, and Yuma counties from 2011-2013.
- The highest rates of ED visits were in Summit County (56 per 1,000), while the highest numbers of ED visits were in Pueblo County (N=2,529).

Figure 7. Top ten primary diagnosis categories among emergency department (ED) visits with marijuana-related billing codes compared to those without in Colorado from 2011 through September 2015.

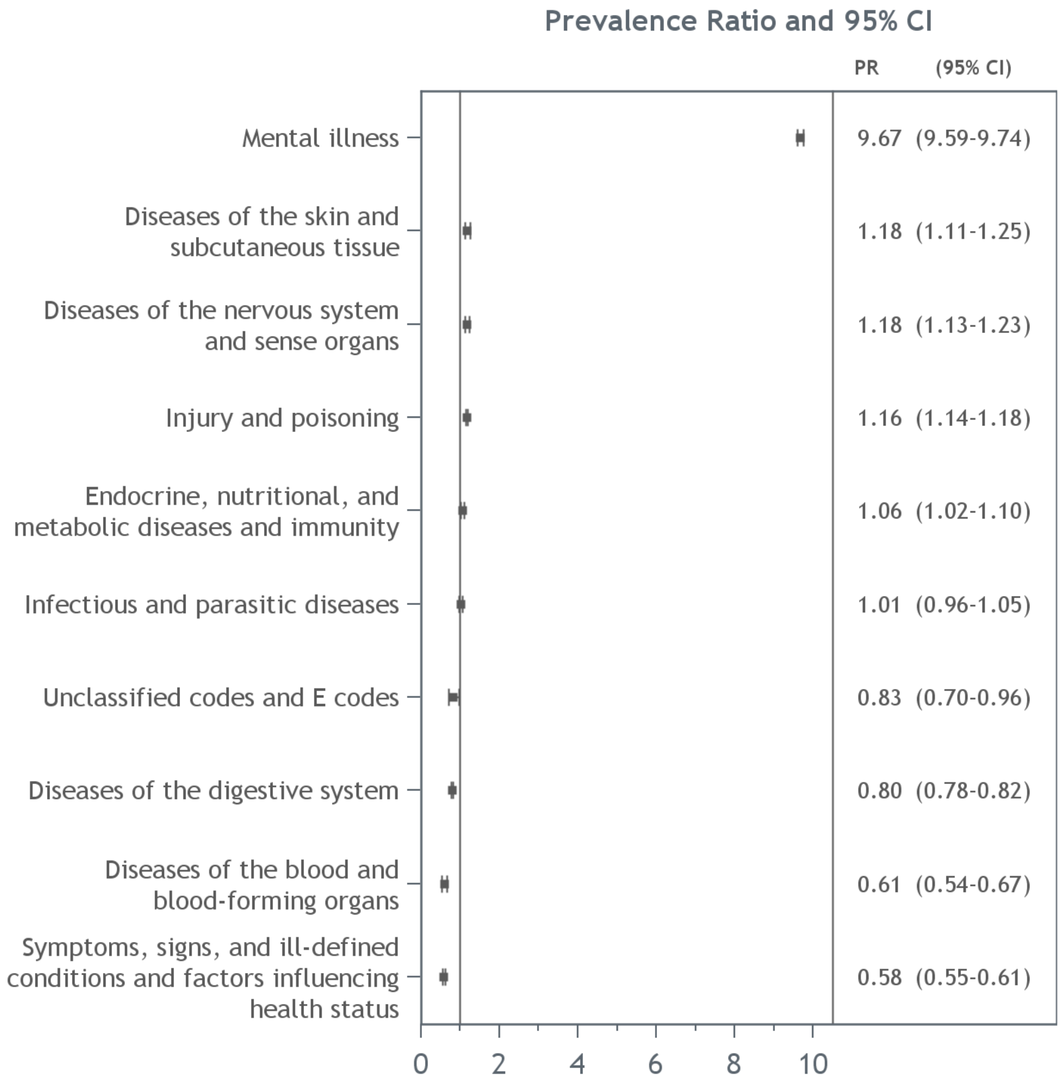


Produced by: EEOHT, CDPHE 2016
*ED visits with marijuana-related billing codes included 304.30-304.33, 305.20-305.23, 969.6, and E854.1 in any of the listed 30 diagnosis codes.
†PR=Prevalence Ratio, CI=Confidence Interval
‡Data Source: Colorado Hospital Association 2011-Sept 2015.

Major findings

- The prevalence of the primary diagnosis category *mental illness* was five-fold higher and the category of *unclassified codes and E codes* was two-fold higher among ED visits with marijuana-related billing codes compared to ED visits without marijuana-related billing codes.

Figure 8. Top ten primary diagnosis categories among hospitalizations (HD) with marijuana-related billing codes compared to those without in Colorado from 2000 through September 2015.



Produced by: EEOHT, CDPHE 2016
*Hospitalizations with marijuana-related billing codes included 304.30-304.33, 305.20-305.23, 969.6, and E854.1 in any of the listed 30 diagnosis codes.
†PR=Prevalence Ratio, CI=Confidence Interval
‡Data Source: Colorado Hospital Association 2000-Sept 2015

Major findings

- The prevalence of the primary diagnosis category *mental illness* among HD with marijuana-related billing codes was nine-fold higher compared to HD without marijuana-related billing codes.

References

1. Centers for Disease Control and Prevention. Scientific Data Documentation: International Classificaiton of Diseases-9-CM, (1979). 2014; http://wonder.cdc.gov/wonder/sci_data/codes/icd9/type_txt/icd9cm.asp. Accessed November 3, 2015.
2. Practice Management Information Corporation [PMIC]. *International Classification of Diseases 9th Revision Clinical Modification*. Vol 1, 2, & 3. Sixth ed. Los Angeles, California 2015.
3. Thomas K, Johnson R. *State Injury Indicators Report: Instruction for Preparing 2013 Data*. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control;2015.
4. Safe States. *Consensus Recommendations for National and State Poisoning Surveillance: Report from the Injury Surveillance Work-group (ISW7)*. Atlanta: Safe States; 2012 2012.
5. CO Const. amend. 20 art. XVIII §14 http://www.lexisnexis.com/hottopics/colorado/?app=00075&view=full&interface=1&docinfo=off&searchtype=lt&search=Colo.+Const.+Art.+XVIII%2C+Section+14.
6. H.B. 10-1284 (CO 2010).
7. Ogden DW. "Memorandum to All United States Attorneys on Investigations and Prosecutions in States Authorizing the Medical Use of Marijuana" 19, October 2009. In: U.S. Department of Justice, ed, https://www.justice.gov/opa/blog/memorandum-selected-united-state-attorneys-investigations-and-prosecutions-states. Washington, DC.
8. CO Const. amend. 64 art. XVIII §16.

Retail Marijuana Public Health Advisory Committee

Membership Roster 2015-2016

Mike Van Dyke, PhD, CIH

CDPHE Marijuana Health Monitoring & Research Program Representative,
Chairman

Dr. Van Dyke is the Chief of the Environmental Epidemiology, Occupational Health, and Toxicology Branch at the Colorado Department of Public Health and Environment. Dr. Van Dyke is trained in the evaluation and control of occupational and environmental chemical exposures. He has spent the last 20 years working in public and occupational health focusing on chemical exposures, environmental and occupational epidemiology, and risk communication.

Shireen Banerji, PharmD, DABAT

Poison Center Representative

Dr. Banerji is the Clinical Manager of the Rocky Mountain Poison Center (RMPC). RMPC, a division of Denver Health, serves as the poison center for 5 states. She holds faculty appointments in four schools of pharmacy including University of Colorado School of Pharmacy. She is responsible for managing the clinical operations of RMPC which includes training, teaching, research, quality control, and continuing education of the poison center hotline staff. She has select administrative roles and also serves as clinical toxicologist and resource to staff. She works in conjunction with EPA, CDC and local and state health departments when toxicological emergencies with potential threat to public health arise, to provide clinical management and real-time and historical surveillance. Areas of interest include pediatric toxicology, medication safety, and poison prevention.

Laura Borgelt, PharmD

Pharmacologist/Clinical Pharmacy Specialist

Dr. Laura Borgelt is an Associate Dean and Professor at the University of Colorado Anschutz Medical Campus in the Departments of Clinical Pharmacy and Family Medicine. Dr. Borgelt's teaching, practice, and research focus on patient safety and women's health. Her initial interest in educating providers and patients about medical marijuana started about seven years ago when she was asked clinical questions about its use in pregnant and lactating women. Since that time, she has investigated the potential effectiveness and risks of marijuana in a comprehensive manner and has provided evidence-based presentations to various organizations at the state and national level. She has served on five different working groups regarding rulemaking in the state of Colorado involving consumer safety and social issues. Through her training, research, and experience, Dr. Borgelt has extensive knowledge of marijuana with regards to its pharmacology, pharmacokinetics, pharmacodynamics, therapeutic effectiveness, and potential risks.

Ashley Brooks-Russell, PhD, MPH

Colorado School of Public Health Representative

Dr. Brooks-Russell is an assistant professor at the Colorado School of Public Health and a member of the Injury Prevention, Education and Research Program. She completed her doctoral training in Health Behavior at the University of North Carolina at Chapel Hill and completed a postdoctoral fellowship at the Prevention Research Branch at the Eunice Kennedy Shriver National Institute of Child Health and Human Development. Her current research focuses on the areas of adolescent substance use and impaired driving.

Russell Bowler, MD, PhD

Pulmonologist

Dr. Bowler is Professor of Medicine at National Jewish Health in Denver and University of Colorado in Aurora, Colorado. He has multiple NIH and foundation grants to study the effects of tobacco and marijuana on lung health. There is a strong emphasis on generation and integration of genetics, genomics, proteomics and metabolomics data. Complementary animal and laboratory exposure models are used to demonstrate proof of concept using discoveries from human Omics work. He runs on of the country's largest clinical databases and biobanks of smokers with over 3000 well-characterized subjects.

Ken Gershman, MD, MPH

CDPHE, Medical Marijuana Representative

Dr. Gershman is Manager of the Marijuana Research Grants Program at the Colorado Department of Public Health and Environment (CDPHE). He has worked as a public health practitioner at CDPHE for 24 years in the areas of communicable disease control and chronic disease prevention, including managing the Cancer, Cardiovascular Disease and Chronic Pulmonary Disease (CCPD) Amendment 35 grant program.

Heath Harmon, MPH

Local Public Health Representative

Heath Harmon is the Director of Health Divisions at Boulder County Public Health (BCPH). He has more than 20 years of public health experience spanning communicable disease epidemiology, environmental health, emergency preparedness and response, adolescent health, maternal and child health, health communications, health planning, and health policy. Mr. Harmon completed his Master of Public Health from the University of South Florida in 2000 and currently devotes his time at BCPH to health policy, health equity, and organizational leadership initiatives.

Rebecca Helfand, PhD

Substance Abuse and Mental Health Epidemiologist

Dr. Helfand is the Director of Data and Evaluation at the Colorado Department of Human Services' Office of Behavioral Health. She completed her doctoral training at Baylor University and completed a postdoctoral fellowship at the Institute for Behavioral Genetics and the University of Colorado, Boulder. Dr. Helfand's current work focuses on analysis of mental health and substance abuse treatment data for the state of Colorado.

Sharon Langendoerfer, MD

Neonatology and Pregnancy

Dr. Langendoerfer is a retired Pediatrician and Neonatologist from Denver Health
Medical Center. For many years she has cared for high risk infants and children, including those exposed before birth to alcohol and other drugs.

Andrew Monte, MD

Medical Toxicologist

Dr. Monte is an emergency medicine physician and medical toxicologist at University of Colorado and the Rocky Mountain Poison and Drug Center. Dr. Monte is an active researcher studying human exposures to a variety of poisons, toxins, and drugs.

Kristina T. Phillips, PhD

Psychologist

Dr. Phillips is a licensed Clinical Psychologist and Professor in the School of Psychological Sciences at the University of Northern Colorado (UNC). She completed her doctoral work at Bowling Green State University and her post-doctoral training at the Center for Alcohol and Addiction Studies at Brown University. Her primary research interests focus on consequences associated with illicit substance use (e.g., academic problems related to marijuana use, health consequences of injection drug use), treatment development and efficacy, and ecological momentary assessment. Dr. Phillips has been the principal investigator or co-investigator on several NIH grants, including projects testing the efficacy of a brief intervention for people who inject drugs and a new study that examines academic outcomes associated with heavy marijuana use in college students.

Judith Shlay, MD, MSPH

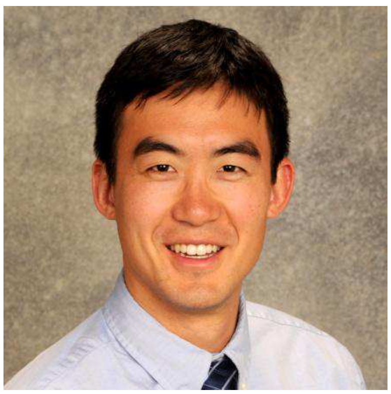
Surveillance Epidemiologist/Local Public Health Representative

Dr. Shlay is the Interim Director of Denver Public Health (DPH) and a Professor of Family Medicine at the University of Colorado, School of Medicine. She has been working on various programs at DPH for the past 27 years. Dr. Shlay has been the principal investigator for a number of projects focusing on health promotion and disease prevention, HIV-related metabolic and neurologic disorders, immunization delivery, reproductive health, sexually transmitted infections, substance abuse, teen pregnancy prevention, and tobacco prevention. In addition to her public health work, Dr. Shlay is a primary care provider through Denver Health's Community Health Services Department.

Christian Thurstone, MD

Addiction Psychiatrist

Dr. Thurstone is a child psychiatrist, general psychiatrist, and addiction psychiatrist. He is an Associate Professor of Psychiatry at the University of Colorado and the Medical Director of Addiction Services at Denver Health. His research focuses on clinical studies related to adolescent substance use disorders.



George Sam Wang, MD

Pediatrician

Dr. Wang is board certified in general pediatrics, pediatric emergency medicine and medical toxicology. He is an Assistant Professor of Pediatrics, Department of Pediatrics, Section of Emergency Medicine and Medical Toxicology at University of Colorado Anschutz Medical Campus and Children's Hospital Colorado and a volunteer faculty member with the Rocky Mountain Poison and Drug Center. Dr. Wang's focus or research is ingestions and exposures in the pediatric population, and a major has been prevention of unintentional marijuana exposures among children and also the use of cannabidiol in pediatric epilepsy.

Tista Ghosh, MD, MPH

CDPHE, Alternate Member

Dr. Ghosh is a physician trained in both internal medicine and preventive medicine, with a master's degree in public health from Yale University. She also has had specialized training in applied epidemiology and public health practice through the Centers for Disease Control and Prevention's Epidemic Intelligence Service Program. Dr. Ghosh has experience in both communicable and non-communicable disease epidemiology and public health research, as well as over a decade of experience in public health at the local, state, federal and international levels. She serves as both the deputy chief medical officer of the Colorado Department of Public Health and Environment and the director of Public Health Programs.

Glossary

Abnormal female reproductive function
Abnormal ovulation, implantation, placenta formation, or reproductive hormone levels.

Abnormal male reproductive function
Abnormal sperm count, concentration, motility or structure, or abnormal reproductive hormone levels.

Acute marijuana use
Marijuana used within the past few hours, such that the short-term effects or symptoms are still being experienced.

Adolescent
Individual 9 to 17 years of age.

Adult
Individual 25 years or older.

Analgesic
A medication used to relieve pain.

Anencephaly
A neural tube defect that results in underdevelopment or the absence of portions of the brain, skull, and scalp.

Bullous lung disease
Destruction of lung tissue causing pockets of air to replace lung tissue, diagnosed by imaging.

Cancer-causing chemicals
Chemicals known to cause cancer in humans, including polycyclic aromatic hydrocarbons.

Cannabidiol (CBD)
A non-psychoactive cannabinoid that is a component of marijuana.

Cannabinoid hyperemesis syndrome
A term currently used by some medical professionals to describe cyclic vomiting occurring in long-time marijuana users. A formal medical definition, including clinical diagnostic criteria, has not yet been established.

Cannabis use disorder
A formal diagnosis indicating two or more of these factors: hazardous use, social/interpersonal problems related to use, neglects major roles in order to use, legal problems, withdrawal, tolerance, uses more or longer than planned, repeated attempts to quit or reduce use, much time is spent using, physical or psychological problems related to use, and/or gives up activities in order to use; commonly called addiction.

Cardiovascular disease
A disease of the heart and/or blood vessels, including both heart disease and stroke.

Child
Individual up to 9 years of age.

Chronic bronchitis
A long term cough with sputum production that is diagnosed by symptoms.

Chronic obstructive pulmonary disease (COPD)
A severe form of small airway obstruction characterized by long-term poor airflow from the lungs, with common symptoms including of shortness of breath and cough with sputum production, diagnosed by pulmonary function tests.

Cognitive abilities
Brain-based skills we need to carry out any task from the simplest to the most complex, which include retrieving information from memory, using logic to solve problems, communicating through language, mentally visualizing a concept and focusing attention when distractions are present.

Combustion by-products
Chemicals produced when a material is burned. These chemicals including carbon monoxide and polycyclic aromatic hydrocarbons.

Cyclic vomiting
Eepisodes of severe, repeated vomiting.

Dabbing
A method of marijuana use where a "dab" (small amount) of marijuana concentrate is placed on a pre-heated surface, creating concentrated marijuana vapor to be inhaled.

Daily or near-daily use
Marijuana use on 5 to 7 days per week.

Driving impairment
A reduced ability to perform the various elements of driving.

Drug-drug interaction
A potentially dangerous interaction that occurs when the effects of one medication are changed by the use of another medication or drug. An example is when a person taking a blood thinner starts a new medication or drug that causes an increase in the blood thinner, leading to bleeding. Similar interactions can occur with many medications.

Electronic smoking device (vaporizer or e-cigarette)
A vaporizing device, with a rechargeable battery, that heats material such as marijuana flower (bud) or liquids containing THC or nicotine to produce vapor for inhalation. Used as an alternative to smoking marijuana or tobacco.

mphysema
The breakdown of lung tissue, typically causing air trapping, poor airflow and shortness of breath, diagnosed by imaging.

Executive function
an umbrella term for the management (regulation, control) of cognitive processes, including working memory, reasoning, task flexibility, organization, time and space management, and problem solving as well as planning and execution.

Gastroschisis
A birth defect where the abdominal (belly) wall has failed to close properly. The resulting hole allows the intestines to protrude outside the fetus.

Hash oil extraction
A technique that removes THC (the psychoactive component of marijuana) from the plant material in a concentrated form. This concentrate can then be smoked, vaporized, mixed into food or drink, or used on the skin. A very common method of extraction uses butane, which is highly flammable.

Heart disease
Encompasses several conditions that affect the heart, including coronary heart disease, myocardial infarction (heart attack), heart failure, arrhythmias and heart valve problems.

Injury
Physical damage to the body resulting from acute exposure to thermal, mechanical, electrical, or chemical energy.

Illicit drugs
Fall into two categories: 1) Those drugs that are illegal to process, sell, and consume; includes cocaine, methamphetamine, ecstasy and heroin. 2) Those drugs that are legal to process, sell, and consume when prescribed by a physician, but are then misused or used without a prescription; includes prescription pain medication and prescription sedatives.

Intelligence quotient (IQ)
a number used to express the apparent relative intelligence of a person, determined by one's performance on a standardized intelligence test relative to the average performance of others of the same age.

Ischemic stroke
Occurs as a result of an obstruction within a blood vessel supplying blood to the brain.

Joint
See **Marijuana cigarette**

Less-than-weekly use - marijuana use on less than 1 day/week.

Levels of marijuana use
• Daily or near daily use - 5-7 days/week.
• Weekly use - 1-4 days/week.
• Less-than-weekly use: less than 1 day/week.
• Acute use: Used within the last few hours, such that the short-term effects or symptoms are still being experienced.

Low birth weight
Baby who weighs less than 5.5 pounds at birth, regardless of the gestational age.

Mainstream smoke
Also known as firsthand smoke, it is the smoke that a smoker inhales from a lit cigarette, pipe, or joint and then exhales.

Marijuana addiction
An informal term which is more commonly used than cannabis use disorder, but the two are considered equivalent by the committee and many mental health professionals.

Marijuana cigarette
“Currently available” marijuana cigarette contains approximately 0.5 gm total weight and 12-23%% THC (potency); also called a “joint”.

Marijuana combustion
The heating of marijuana flower or concentrate by applying a direct heat source of 230 degrees Celsius or above in order to produce smoke for inhalation. Combustion methods include burning a joint, blunt, pipe, or bong bowl.

Miscarriage
A baby born before reaching 20 weeks of pregnancy and therefore unable to survive.

Myocardial infarction
The medical term for a 'heart attack,' which occurs when blood flow to the heart is blocked, causing injury to part of the heart muscle. This can cause a life-threatening change in heart rhythm (arrhythmia).

Neural tube defects (NTD)
Birth defects of the brain, spinal cord or spine. The defects occur in the embryo during the first few weeks of pregnancy.

Newborn behavior issues
May include fussiness and sleep difficulties occurring during the first 28 days after birth.

Nonseminoma
The more common type of testicular cancer which tends to grow more quickly than seminomas and are often made up of more than one type of cell.

Nulliparous
A woman who has never carried a pregnancy beyond 20 weeks.

Opioid
One of many medications or street drugs including heroin, opium and prescription pain medications such as morphine, hydrocodone (Vicodin, Norco, Lortab), oxycodone (Percocet, OxyContin), hydromorphone (Dilaudid), fentanyl and methadone.

Older adult
Individual 65 years of age or older

Pharmacokinetic / pharmacodynamic
The absorption, distribution, metabolism and excretion of a drug and the effect the drug has on the body.

Physical dating violence
Physically aggressive behavior among current or former romantic, sexual/intimate, or dating partners, including hitting, kicking, choking, slapping, etc. Psychological, emotional, verbal or sexual violence were not included, nor were threats of violence.

Physical dating violence perpetration (PDVP)
To commit physical violence against a partner.

Physical dating violence victimization (PDVV)
To be harmed by physical violence committed by a partner.

Pneumothorax
The collapse of a lung caused by air or fluid filling up the space around the lung, an emergency condition diagnosed by physical exam and/or imaging.

Polycyclic aromatic hydrocarbons
A group of more than 100 different chemicals released from burning coal, oil, gasoline, trash, tobacco, wood, or other organic substances.

Preterm delivery
A birth that occurs more than three weeks before the baby is due — in other words, after less than 37 weeks of pregnancy.

PRISMA
Evidence-based minimum set of items for reporting in systematic reviews and meta-analyses to help authors improve reporting.

Psychotic disorders
These include schizophrenia, schizoaffective, schizophreniform, schizotypal, and delusional disorders. These formal diagnoses are made when a combination of psychotic symptoms are present (possibly combined with other mental health symptoms), the symptoms cause significant problems with work, relationships or self-care, and they have been present for six months or longer.

Psychotic symptoms
These include auditory or visual hallucinations, difficulty separating real from imagined, perception that self or others can read minds, perceived ability to predict the future, feeling that an outside force is controlling thoughts or actions, fear that someone intends to harm them, belief they have supernatural gifts, apathy, social withdrawal, absent or blunted emotions, occurrences of unclear speech or inability to speak, or difficulty organizing thoughts to complete activities.

Pulmonary function (tests)
Measurements that show how well the lungs move air in and out and how well they exchange oxygen and carbon dioxide with the blood.

Recreational injury
Any injury outside the workplace and not classified as a motor vehicle (MV) crash.

Route of Exposure
The physical passageway which the marijuana product takes to enter the body; (for example) oral/ingested, smoked, or topical.

Secondhand marijuana smoke exposure
The smoke that is inhaled by non-smokers when near to a person smoking marijuana, also known as passive exposure.
• Typical conditions: exposure at or below the level of smoke present in a small ventilated room (such as with open windows or an exhaust fan) with multiple people smoking marijuana.
• Extreme conditions: exposure at or above the level of smoke present in an small room (or a vehicle) without ventilation and with multiple people smoking marijuana.

Sidestream smoke
The smoke that wafts off the end of a lit cigarette, pipe or joint into the surrounding air.

SIDS
See **Sudden infant death syndrome**

Small airway obstruction
A condition causing air to be trapped in the lungs, making it difficult to breathe the air out to make room for the next breath, diagnosed by pulmonary function tests.

Small for gestational age (SGA)
A baby that is born smaller than 90 percent of babies of the same gestational age (number of weeks of pregnancy).

Smoked dose
Dependent on the potency and dry weight of cannabis flower, a.k.a. marijuana bud. It is approximately equal to the product of potency (%THC) and weight (mg).

Smoking topography
How a person smokes a substance, including measures of the number of puffs and puff volume, duration, and velocity.

Stillbirth
The birth of an baby that has died in the womb after having reached at least 20 weeks of pregnancy (earlier instances being regarded as abortion or miscarriage).

Stroke
An event that blocks blood flow to part of the brain or causes bleeding into the brain, causing permanent damage.

Sudden infant death syndrome (SIDS)
The sudden and unexplained death of a seemingly healthy baby less than a year old.

Tetrahydrocannabinol (THC)
The main psychoactive component of marijuana.

Thirdhand marijuana smoke exposure
Residual contamination left in rooms and on clothes after marijuana smoking.

Unintentional marijuana exposures
Ingesting a substance without knowing that it contains THC or other cannabinoids, more commonly observed with edible marijuana products.

Vaporization of marijuana (vaping)
A method of marijuana use in which marijuana vapor, rather than smoke, is inhaled. Marijuana flower or concentrate is heated in a vaporizing device (vaporizer) to a temperature below the point of combustion, to produce vapor.

Ventricular septal defect
A congenital heart defect also known as a "hole in the heart." The defect occurs when the wall (septum) that separates the right and left ventricles of the heart does not form properly.

Water pipe
A pipe for smoking tobacco, marijuana, etc., that draws the smoke through water to cool it. Examples are a hookah and a bong.

Weekly use
Marijuana use on 1 to 4 days/week.

Young adult
Individual 18 to 24 years of age.