Monitoring Health Concerns Related to Marijuana in Colorado: 2014

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

COLORADO

Department of Public Health & Environment

Presented to the Colorado State Board of Health, the Colorado Department of Revenue, and the Colorado General Assembly on Friday, January 30, 2015 by The Retail Marijuana Public Health Advisory Committee pursuant to C.R.S. 25-1.5-110 (2014).

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

25-1.5-110. 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. The department and panel are not required to perform the duties required by this section until the Marijuana Cash Fund, created in section 12-43.3-501, C.R.S., has received sufficient revenue to fully fund the appropriations made to the Department of Revenue related to articles 43.3 and 43.4 of title 12, C.R.S., and the appropriation to the division of criminal justice related to section 24-33.5-516, C.R.S., and the General Assembly has appropriated sufficient moneys from the fund to the department to pay for the monitoring required by this section.

HISTORY: Source: L. 2013: Entire section added, (SB 13-283), ch. 332, p. 1894, § 10, effective May 28.

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The Retail Marijuana Public Health Advisory Committee was established per Senate Bill 13-283, CRS 25-1.5-110. Duties of the Committee are to conduct a review of the scientific literature and data currently available on health effects of marijuana use. This document summarizes health topics and data reviewed in 2014. 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.

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Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Retail Marijuana Public Health Advisory Committee Members

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Introduction

As 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 impacts 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 impacts 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, or prescription drugs, misuse of marijuana can have serious health consequences. Standard public health approaches to alcohol, tobacco and prescription drugs is to monitor use patterns and behaviors, health care utilization and potential health impacts, and emerging scientific literature to guide the development of policies or consumer education strategies to prevent serious health consequences. This report presents initial efforts toward monitoring the changes in marijuana use patterns, potential health effects of marijuana use, and the most recent scientific findings associated with marijuana use to help facilitate evidence-based policy decisions and science-based public education campaigns.

In C.R.S. 25-1.5-110, 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 appointed a 13-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) consisted of individuals in the fields of public health, medicine, epidemiology, and medical toxicology who had demonstrated expertise related to marijuana through their work, training, or research. This committee was charged with the duties as outlined in C.R.S. 25-1.1-110 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 conducted nine public meetings between May 2014 and January 2015 to complete these duties. 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 of this committee are included in the Appendix, Retail Marijuana Public Health Advisory Committee By-laws.

Monitoring Changes in Marijuana Use Patterns

This report presents initial efforts toward monitoring the potential changes in marijuana use patterns in Colorado. Patterns of drug use are usually determined by using population-based surveys that ask specific questions about substance use. This report presents the most recent survey results from three major state or national surveys: 1) the Healthy Kids Colorado Survey of middle and high school kids; 2) the Influential Factors in Healthy Living (IFHL) survey of Colorado adults; and 3) the National Survey on Drug Use and Health (NSDUH) which is a national survey of individuals 12 and older. In addition, this report presents data from a one-time survey of Women, Infants, and Children (WIC) clients conducted by Tri-County Health Department in 2014 to assess marijuana-use and behaviors.

Unfortunately, prior to 2014, there was no funding source for adding questions about marijuana to Colorado's major public health surveys including the Behavioral Risk Factors Surveillance System (BRFSS) for adults, the Pregnancy Risk Assessment Monitoring System (PRAMS) for pregnant women and new mothers, and the Child Health Survey (CHS) for kids age 1 to 14. The new marijuana-related questions added to all of these surveys in 2014 are presented in this report. However, results from these surveys will not be available until the fall of 2015.

The data available at this time cannot answer all of the important questions about whether or not marijuana use patterns are changing as a result of legalization. However, the data presented here provide a snapshot that allows us to begin to measure the public health impact. The following are the general observations that can be supported by the available Colorado data on patterns of marijuana use from 2005 up to 2014.

- Fewer middle school students use marijuana than high school students (HKCS 2013).
- The data on marijuana use in Colorado middle schoolers supports prevention efforts aimed at children before they enter ninth grade (HKCS 2013).
- There are conflicting data on adolescent marijuana use in Colorado compared to national averages and other states.
    - NSDUH results (2012-2013) suggest that past thirty-day marijuana use among Colorado youth (ages 12-17) is 11% which is higher than the national average of 7%.
    - HKCS results (2013) suggest that past thirty-day marijuana use among Colorado high school students is 20% which is lower than the national average of 23%.
- There are significant racial, ethnic and sexual orientation disparities in the prevalence of use among adolescents in Colorado.
- Adult marijuana use is higher in Colorado than in most other states (NSDUH 2013).

- Based on limited data from Colorado adult marijuana users, it appears that, among those who report using marijuana, more than half (64%) use more than 8 times per month (IFHL 2014).

A more complete picture of marijuana use patterns in Colorado will emerge as data are compiled and analyzed from surveys that include more comprehensive questions about marijuana, collected after recreational marijuana was legalized and commercially available.

Literature Review on Marijuana Use and Health Effects

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 which indicates robust scientific findings that support the outcome and no credible opposing scientific evidence.
- Moderate evidence which indicates that scientific findings support the outcome, but these findings have some limitations.
- Limited evidence which indicates modest scientific findings that support the outcome, but these findings have significant limitations.
- Mixed evidence which indicates both supporting and opposing scientific findings for the outcome with neither direction dominating.
- Insufficient evidence which indicates that the outcome has not been sufficiently studied.

The committee also translated these evidence statements into lay language understandable by 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 of these were presented to the full committee during open public meetings that had opportunities for stakeholder input. Final statements, recommendations, and research gaps were formally approved by a vote of the committee.

The topics for review were chosen 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. Key findings for each topic are presented below.

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.

Marijuana Use During Pregnancy and Breastfeeding

The committee reviewed the literature for marijuana use during pregnancy and while breastfeeding. Outcomes reviewed included those apparent at birth as well as physical, neurocognitive, and mental health findings throughout childhood and adolescence. We found moderate evidence that maternal use of marijuana during pregnancy is associated with negative effects on exposed offspring, including decreased academic ability, cognitive function and attention. Importantly, these effects may not appear until adolescence. We also found moderate evidence that maternal use of marijuana during pregnancy is associated with decreased growth in exposed offspring.

Unintentional Marijuana Exposures in Children

The committee found moderate evidence that more unintentional marijuana exposures of children occur in states with increased legal access to marijuana; and the exposures can lead to significant clinical effects requiring medical attention. Additionally, we found moderate evidence that use of child resistant packaging reduces unintentional pediatric poisoning.

Marijuana Use Among Adolescents and Young Adults

The committee reviewed the literature on the potential effects of marijuana use among adolescents and young adults including effects on cognitive abilities, learning, memory, achievement, future use of substances such as marijuana and illicit drugs, and mental health issues. We found substantial evidence for associations between adolescent and young adult marijuana use and future addiction to illicit drugs in adulthood. We found an increased risk for developing psychotic symptoms or psychotic disorders in adulthood among adolescent and young adult regular-users. In addition, we found moderate evidence for associations between adolescent and young adult marijuana use and at least short-term impairment of cognitive and academic abilities. We also found moderate evidence indicating that adolescent marijuana users were less likely to graduate from high school and more likely to be addicted to marijuana, alcohol, and tobacco in adulthood. We found beneficial effects related to cessation of use, including moderate evidence that adolescent and young adult marijuana users who quit have lower risks of adverse cognitive and mental health outcomes than those who continue to use.

Marijuana Dose and Drug Interactions

This literature review focused on the dose-response of different methods of marijuana use with regard to THC blood levels and impairment. Additional review was performed to evaluate marijuana's interactions with other drugs and the possibility of a positive drug screen from passive marijuana exposure. In general, we found that, for occasional (less than weekly) marijuana users, smoking, eating, or drinking marijuana containing 10 milligrams or more of THC is likely to cause impairment that affects the ability to drive, bike, or perform other safety-sensitive activities. In addition, for these occasional users, waiting at least six hours after smoking marijuana (containing up to 35 milligrams of THC) will likely allow sufficient time for the impairment to resolve. The waiting time is longer for eating or drinking marijuana products. We found it is necessary for occasional users to wait at least eight hours for impairment to resolve after orally ingesting up to 18 milligrams of THC.

A substantial finding, regarding the use of edible marijuana products, is that it can take up to four hours after ingesting marijuana to reach the peak THC blood concentration and perhaps more time to feel the full effects. This has important implications for the time to wait between doses. Using alcohol and marijuana at the same time is likely to result in greater impairment than either one alone. Finally, typical passive exposure to marijuana smoke is unlikely to result in a failed workplace urine test or a failed driving impairment blood test.

Marijuana Use and Neurological, Cognitive and Mental Health

The committee reviewed the literature on the potential adverse effects of marijuana use among adults including effects on cognitive functioning, memory, and mental health issues such as anxiety, depression, and psychosis. We found substantial evidence for associations between marijuana use and memory impairments lasting at least seven days after last use, as well as the potential for acute psychotic symptoms immediately after use. We found moderate evidence that adults who use marijuana regularly are more likely than non-users to have symptoms or diagnosis of depression.

Marijuana Use and Respiratory Effects

The committee reviewed literature focused on marijuana use and effects to the respiratory tract. We found substantial evidence that marijuana smoke contains many of the same carcinogens found in tobacco smoke. We also found substantial evidence that acute use – (within the past hour) – results in immediate, short –term improvement in lung airflow. This finding includes use of both smoked and edible marijuana products. However, we found moderate evidence that heavy marijuana smoking is associated with mild airflow obstruction. In addition, we found substantial evidence heavy marijuana smoking is associated with chronic bronchitis, including chronic cough, sputum production, and wheezing. Finally, we found substantial evidence that heavy marijuana smoking is associated with pre-malignant lesions in the airway, but mixed evidence for whether or not marijuana smoking is associated with lung cancer.

Marijuana Use and Extrapulmonary Effects (non-respiratory body systems)

Unlike other literature reviews outlined in this document, there were relatively few literature reports of marijuana use related to myocardial infarction (heart attacks), ischemic stroke,

male infertility, testicular cancer, prostate cancer and bladder cancer. We found limited evidence that marijuana use may increase risk for both heart attack and some forms of stroke. These findings were most closely associated with recent, and in some cases heavy, marijuana use. Limited evidence also suggests an increased risk in both testicular (non-seminoma) and prostate cancers with marijuana use. Evidence was mixed for whether or not marijuana use increased the risk of male infertility.

Marijuana Use and Injury

Our literature review focused on the increased risk of injury with marijuana use in a variety of settings (occupational, motor vehicle, recreational). The committee found substantial evidence that risk of motor vehicle crash doubles among drivers with recent marijuana use. Additionally, we found substantial evidence for a positive relationship between THC blood level and motor vehicle crash risk –that is, substantial evidence that the higher the level of THC in blood, the higher the crash risk. Finally, the committee found that the combined use of marijuana and alcohol increases motor vehicle crash risk more than use of either substance alone. For non-traffic injuries, the evidence is limited, but data suggest that the risk of non-traffic workplace injuries may be higher with marijuana use.

Monitoring Possible Marijuana Related Health Effects

This report presents initial efforts toward monitoring the potential population-based health effects of legalized marijuana. We focused on analyses of two primary public health datasets: 1) exposure calls to the Rocky Mountain Poison and Drug Center (RMPDC); and 2) hospital and emergency department data provided by the Colorado Hospital Association (CHA). RMPDC call volume data are typically used as a surrogate data source to determine the potential for adverse health effects from exposure to chemicals and drugs. 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 up to 15 or 30 ICD-9-CM discharge diagnoses/billing codes and procedure codes. (ICD-9 CM, stands for the International Classification of Diseases, Ninth Revision, Clinical Modification, and is the current medical coding standard used in hospitals in the United States.)

The overall intent of these data analyses was to begin to assess the potential impact of legalized marijuana on Colorado health. It is unrealistic to expect that firm conclusions can be drawn from six months to a year of data. However, in reviewing the data, the following generalized observations can be made:

- There are increasing trends of poison center calls, hospitalizations, and emergency department visits possibly related to marijuana in Colorado.
- Though based on only six months of data with the limitations described, the three-fold increase in the hospitalization rates for children with possible marijuana exposures for January through June 2014 compared to 2010-2013 represents an important public health concern that merits further study.

- In general, there were large increases in poison center calls, hospitalizations, and emergency department visits observed after medical marijuana was commercialized in 2010 and additional increases after retail (recreational) marijuana was legalized in 2014.
- There were similar increasing trends in hospitalization rates following medical marijuana commercialization and retail marijuana legalization for all genders, age groups, and race/ethnicities.
- Rates of hospitalizations and emergency department visits were generally higher in more urban counties. However, we also observed increases in hospitalizations in more rural counties.

These data should be interpreted carefully, keeping in mind that observed increases have many potential explanations including: an increased availability of marijuana in Colorado, an overall increased awareness regarding marijuana, changes in physician care or reporting related to marijuana, increased patient honesty in reporting marijuana use to health care providers after legalization, or changes in coding practices by hospitals and emergency departments. In addition, for hospitalizations and emergency department visits, possible marijuana related cases account for 1% or less of the total Colorado hospitalizations or emergency department visits. 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. These recommendations loosely fall into several categories but almost all of the recommendations include some effort to standardize data quality (marijuana use frequency), standardize procedures (roadside THC testing) and improve monitoring of use patterns and health outcomes. Standardized data collection on method of marijuana use, amount and frequency should be encouraged across medical specialties and on survey tools used in Colorado to better characterize use patterns and dose among users. The committee also recommends data collection on the THC content of Colorado products to better characterize the THC dose of a typical user. In addition, improved information on blood THC levels of drivers is needed to effectively monitor the impact of driving under the influence of marijuana.

The committee recommends using (or continuing to use) current data sources – birth defects and cancer registries, Rocky Mountain Poison and Drug Center, Colorado Hospital Association data, and addiction treatment admissions information to monitor health outcomes of interest. In addition, the committee recommends small-scale public health studies to assess the severity and burden of health effects and injuries in specific populations such as pregnant women, children, and skiers. A high-priority recommendation by the committee was to continue to assessing the patterns of marijuana use on large Colorado-based surveys including the Pregnancy Risk Assessment Monitoring System (PRAMS), the Healthy Kids Colorado Survey (HKCS), and the Behavioral Risk Factor Surveillance System (BRFSS).

The committee recommended many educational interventions ranging from information on safe storage to protect the youngest Coloradans, to information for adult users, their families, and health care providers. 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 (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., defining impairment in frequent users). These research gaps provide an important framework for prioritizing 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.

Research gaps identified by the committee had five common themes: 1) additional research using marijuana with THC levels consistent with currently available products; 2) research on impairment in regular marijuana users who may have developed tolerance; 3) research to identify improved testing methods for impairment either through alternate biological testing methods or physical tests of impairment; 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 CBD; and 5) research to better characterize possible differences in health effects between heavy (daily or near daily), regular(weekly or more), and occasional (less than weekly) users.

Monitoring Changes in Marijuana Use Patterns in Colorado

Summary and Key Findings

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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Introduction

The Colorado Department of Public Health and Environment (CDPHE) was given statutory (C.R.S. 25-1.5-111) 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."

Medical marijuana has been legal in Colorado since 2000, and medical use was primarily viewed as an individual doctor/patient decision outside the scope of public health policy. Commercialization of medical marijuana in 2009 prompted a large increase in the number of individuals with active medical marijuana registration cards. The number of registration cards increased from 11,094 in July 2009 to 99,902 in July 2010. The number of active registration cards has hovered around 100,000 from July 2010 to the present (range 85,124 to 127,816). Legalization of retail (non-medical) marijuana and the potential for greater availability of marijuana in the general community of Colorado adults over 21 years of age (approximately 3.7 million) as well as tourists to the state, 21 years and older, prompted a closer look at marijuana use patterns in the population at large.

Patterns of drug use are usually 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, in conjunction with data gathered by a special one-time survey are compiled here to meet the reporting requirements set forth in C.R.S 25-1.1-111. These data also have been presented to the Retail Marijuana Public Health Advisory Committee (RMPHAC) which was charged with the duties outlined in C.R.S. 25-1.1-110 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." Reviewing marijuana use patterns in Colorado provides important insight to the RMPHAC members as they considered public health recommendations.

Survey data often are collected in populations of a specific age group or condition (e.g., pregnant women). Survey data are useful in generating general estimates of use patterns, including identifying trends over time. State-based surveys provide estimates of prevalence by geographic area, most often by county or Health Statistics Regions (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. Large surveys often require many months to complete, and may not be administered annually. Adding new questions to existing state-based surveys is a competitive process as there are many different important health or behavior questions and a strict limit on the amount of time that can be expected for each survey respondent. Each new question added to the survey has a cost. Prior to 2013, CDPHE was unable to provide funding for marijuana-related questions on the major adult surveys

including the Behavioral Risk Factor Surveillance System (BRFSS) and the Pregnancy Risk Assessment Monitoring System (PRAMS).

Methodology and population size sampled differs between surveys presented in this report, thus marijuana usage patterns may appear different in different surveys. The data presented in this report represents findings on marijuana use from 2005 to 2014, where 2014 data is available. In the event 2014 data is not yet complete for a survey, estimated date of availability is reported.

Data Sources

Pregnancy Risk Assessment Monitoring System (PRAMS)

PRAMS is a Centers for Disease Control and Prevention (CDC) sponsored survey implemented by CDPHE in Colorado. PRAMS collects state-specific, population-based data on maternal attitudes and experiences before, during, and shortly after pregnancy. For the first time in 2014, the Colorado version of this survey included questions about marijuana use before, during and following pregnancy. This will allow us to assess the prevalence of marijuana use and identify subpopulations at risk for marijuana use. It is anticipated 2014 data will be available for analysis and review in the fall of 2015. (www.colorado.gov/pacific/cdphe/pregnancysurvey)

Women, Infants, and Children Survey: Tri-County Health Department

Women, Infants and Children is a Federal grant program administered by WIC state agencies. WIC provides services to low-income, nutritionally at-risk women and children up to 5 years of age. WIC provides nutritious foods, nutrition education, and screening and referrals to other health and social services as needed. In Colorado, Tri-County Health Department (TCHD) serves over 26% of the state's population (Adams, Arapahoe, and Douglas Counties), with an average WIC caseload of 25,000 clients per month. TCHD conducted a one-time survey of its Women, Infants, and Children (WIC) clients in 2014 to assess marijuana-use and behaviors. The study included a convenience sample of 1,749 individuals. Data from this survey are presented in this chapter. (www.tchd.org/291/4339/Women-Infants-Children-WIC)

Colorado Child Health Survey (CHS)

The CHS is an annual survey providing data on a wide range of health issues and risk factors affecting children and youth in Colorado and was developed to add to health data for children ages 1-14 years. In February 2014, topics relating to marijuana use and safe storage of marijuana products were added to the survey. Future collection of data on marijuana education and safe storage in the home will enable CDPHE and its partners to assess the number of children in Colorado who live in households with adult marijuana users. It is anticipated 2014 data will be available for analysis and review in the fall of 2015. (www.colorado.gov/pacific/cdphe/behaviorsurvey)

Healthy Kids Colorado Survey (HKCS)

The HKCS collects health information every odd calendar year from public school students in Colorado. HKCS is a collaboration of CDPHE, Colorado Department of Education and Colorado Department of Human Services. HKCS survey provides data on a wide range of health issues and risk factors affecting children and youth. Although representative for public high school students in Colorado, until 2013 these data were not representative of private school students. Since 1999, HKCS has asked questions about marijuana use including "ever use," "past 30 day use," and "age of first use." The 2013 survey included approximately 40,000 students (25,000 high school students, 15,000 middle school students). Data from the 2013 survey is presented in this chapter. See the Healthy Kids Colorado website for additional detail including a marijuana overview.
(www.ucdenver.edu/academics/colleges/PublicHealth/community/CEPEG/UnifYouth/Pages/HealthyKidsSurvey.aspx)

Behavioral Risk Factor Surveillance System (BRFSS)

The BRFSS is a CDC-sponsored population-based survey that collects data on adult behavioral health risk factors associated with leading causes of premature mortality and morbidity. CDPHE, in a cooperative agreement with CDC, manages and administers BRFSS in Colorado. Colorado added state-based questions on marijuana use to the 2014 survey. The 2015 survey will contain additional marijuana-use questions to further assess use type and frequency of use. It is anticipated 2014 data will be available in the fall of 2015.
(www.colorado.gov/pacific/cdphe/behaviorsurvey)

Influential Factors in Healthy living (IFHL)

IFHL is a call-back survey of The Attitudes and Behaviors Survey (TABS) on Health; a population-level survey of Colorado adults (18 years and older). IFHL addresses access to healthy food, health providers and workplace support of healthy living, as well as self-management of chronic health conditions. In 2013, marijuana use questions were added to the survey. A total of 3,974 participants completed the survey in 2013. Selected data collected from December 2013 to March 2014 are presented in this chapter.
(www.ucdenver.edu/academics/colleges/PublicHealth/community/CEPEG/WkProducts/Reports/Documents/120814%20IFHL%20Report%20Final.pdf)

National Survey on Drug Use and Health (NSDUH)

NSDUH provides national and state-level data on the use of tobacco, alcohol, marijuana, illicit drugs (including non-medical use of prescription drugs) and mental health in the United States. NSDUH is sponsored by the Substance Abuse and Mental Health Services Administration (SAMHSA), an agency of the U.S. Public Health Service in the U.S. Department of Health and Human Services (DHHS). State sample size in Colorado is approximately 1,000 individuals per year. (nsduhweb.rti.org/respweb/homepage.cfm)

Summary of Major Findings

Women, Infants, and Children Survey: Tri-County Health Department

The prevalence of WIC clients, low-income, nutritionally at-risk woman, reporting ever using marijuana was 29.1%, and 5.9% for current marijuana use. Marijuana users were younger and were more likely to be white and non-Hispanic. Among those who currently used marijuana, 35.8% reported use during their most recent pregnancy, 41.1% reported use after their most recent pregnancy, and 13.7% reported use while breastfeeding. WIC mothers reported the main reasons for using were depression, anxiety, stress, pain, nausea, and vomiting.

Healthy Kids Colorado Survey (HKCS)

Survey results from 2013 indicate approximately 37% of Colorado high school students reported ever using marijuana and nearly 20% report use in the past 30 days. Survey results find no statistically significant change in "ever use" and "past 30 day use" during the time period of 2005-2013, when comparing age-matched survey results to age-matched survey results in subsequent years. This also is true nationally. Marijuana use among younger students is lower than in older students. For Colorado middle school students, 5.1% report "past 30 day use" and 8.8% report having ever used marijuana. There are statistically significant differences in use and age of first use in students of different races and ethnicities. American Indian/Alaska Native, Black/African American, White Hispanic and Other Race high school students reported a higher prevalence of "ever use" and "past 30 day use" compared with White high school students. Sexual orientation was identified as another risk factor for higher prevalence of both marijuana use categories. Prevalence of "ever" and "past 30 day use" of marijuana is statistically significantly higher among gay, lesbian or bisexual (GLB) high school students compared to heterosexual students Marijuana use also varies significantly by Health Statistics Region (HSR). The highest prevalence of "past 30 day use" occurs in the Denver metro area, with similar prevalence estimates for the southwestern region of the state. These data are presented in detail in the chapter "Healthy Kids Colorado Survey."

Influential Factors in Healthy living (IFHL)

Survey results from data collection completed in March of 2014 indicate approximately 11% of Colorado adults (18 years of age and older) report "past 30 day use". Of those who reported use, 35% reported occasional use (1-7 times per month), 28% reported regular use (8-26 times per month), and 36% reported heavy use (27-30 times per month). When respondents who used marijuana were asked what forms of marijuana they used, the vast majority (95.8%) reported smoking marijuana. However, 45.9% reported ingesting marijuana products. Finally, when interviewees were asked whether their personal use of marijuana use had changed since retail legalization, 93.6% reported no change in use and 2.7% reported using more often. These data are presented in detail in the chapter "Influential Factors in Healthy Living Survey."

National Survey on Drug Use and Health (NSDUH)

NSDUH provides an additional, national source of adult use data. The most recent results available are from 2011-2013, which show reported marijuana use in the past month among those 18 years and older in Colorado was 13% compared to the U.S. national estimate of 7.4%. Marijuana use in the past 12 months in Colorado for those 18 years and older was 19% compared to a U.S. national estimate of 12.2%. NSDUH reports use by age groups, among every age group, marijuana use in the past 12 months in Colorado (12-17 years old: 19%, 18-25 years old: 41%, 26+ years old: 13%) was above the national average (12-17 years old: 14%, 18-25 years old: 31%, 26+ years old: 8%). Detailed data and methodology are presented in the chapter "National Survey on Drug Use and Health."

Discussion

The citizens of Colorado exhibit behaviors much more complex than any survey can capture. Data collected prior to January 2014 and the small amount of data available for 2014 cannot answer all of the important questions we have about whether or not marijuana use patterns are changing as a result of legalization. The data presented here present a snapshot that provides important information to allow us to begin to measure the public health impact in the future. In addition, these data provide important insights into marijuana use in vulnerable populations such as pregnant women, youth, and those with racial, ethnic, and sexual orientation disparities. This information can be used to target public health interventions. The following are the general observations that can be supported by the available Colorado data from 2005 up to 2014.

- Fewer middle school students use marijuana than high school students (HKCS 2013).
- The data on marijuana use among Colorado middle schoolers supports prevention efforts aimed at children before they enter ninth grade. (HKCS 2103)
- There are conflicting data on adolescent marijuana use in Colorado compared to national averages and other states, likely due to variations in the methods for how data are collected.
    - NSDUH results (2013) suggest that past 30-day marijuana use among Colorado youth (ages 12-17) is 11% which is higher than the national average of 7%, and also higher than surrounding states.
    - HKCS results (2013) suggest that past 30-day marijuana use among Colorado high school students is 20% which is lower than the national average of 23% (YRBS 2013).
- There are significant racial, ethnic and sexual orientation disparities in the prevalence of use among adolescents in Colorado (HKCS 2103).
- Adult marijuana use is higher in Colorado than in most other states (NSDUH 2013).
- Based on limited data from Colorado adult marijuana users, it appears that among those who use marijuana, more than half (64%) use more than eight times per month (IFHL 2014).

A more complete picture of marijuana use patterns in Colorado will emerge as data are compiled and analyzed from future surveys that include more comprehensive questions about marijuana use.

Recommendations & Future Directions

1. Continue assessing prevalence of marijuana use via large Colorado-based surveys including the Pregnancy Risk Assessment Monitoring System (PRAMS), Healthy Kids Colorado Survey (HKCS), and the Behavioral Risk Factor Surveillance System (BRFSS). 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 that marijuana policies and education campaigns are effective.
2. Add additional questions to existing surveys or conduct marijuana-specific surveys to gather details about patterns of use, method of use, amount used, frequency of use, and use concurrent with other substances.
3. Consider additional marijuana-specific surveys of adolescents in the 18 to 25 age group to further evaluate use patterns and risk factors in this high prevalence population.
4. More in-depth analyses of existing survey data should be performed to better assess risk and protective factors for marijuana use including changes in the perception of harm from marijuana use.
5. Collaborate 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.

Pregnancy Risk Assessment Monitoring System (PRAMS)

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Survey Coordinator:
Ricky Tolliver, MPH, Manager, Health Surveys and Analysis Program, Colorado Department of Public Health and Environment.

Background

PRAMS, the Pregnancy Risk Assessment Monitoring System, is a Centers for Disease Control and Prevention (CDC) sponsored survey. The information is collected in collaboration with state health departments. Surveillance provides data for state health official's use to improve the health of mothers and infants. PRAMS administrators collect state-specific, population-based data on maternal attitudes and experiences before, during, and shortly after pregnancy. It provides data not available from other sources about pregnancy and the first few months after birth. 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. It allows CDC and the states to monitor changes in maternal and child health indicators (e.g., unintended pregnancy, prenatal care, breastfeeding, infant health, smoking, drinking).

For the first time in 2014, PRAMS queried participants in Colorado about marijuana use before, during and following pregnancy. Future collection of data on marijuana use in the perinatal period will enable public health professionals to assess the prevalence of marijuana use and identify subpopulations at risk for marijuana use. This will permit targeted prevention and education efforts to reduce use in pregnant women. PRAMS administrators anticipate 2014 data will be available for analysis and review in the fall of 2015.

Survey Question

On January 1, 2014, Colorado became the first state in the nation to legalize the use and sale of recreational marijuana. The next questions are about marijuana.

85. 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.

1. During the 3 months before I got pregnant.
2. During the first 3 months of my pregnancy.
3. During the last 3 months of my pregnancy.
4. At any time during my most recent pregnancy.
5. Since my baby was born.

(Don't read)

8. Refused
7. Don't know/don't remember

Tri-County Health Department Women, Infant, and Children (WIC) Client Survey

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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Summary of Key Findings

Tri-County Health Department surveyed adults who participate in the Special Supplemental Nutrition Program for Women Infant and Children (WIC) in the fall of 2014 regarding marijuana use; 1,749 surveys were completed. Fifty-four percent of respondents were Hispanic, 29% were white, and 10% were black. Most respondents were mothers receiving WIC services for themselves and/or for one or more of their children. Overall, the prevalence of "ever use" of marijuana among WIC mothers was 29.1%. The prevalence of "current marijuana use" among WIC mothers was 5.9%. Those women who used marijuana tended to be younger (≤ 30 years) and white non-Hispanic. Current marijuana users reported use during pregnancy (35.8%), after pregnancy (41.1%), and while breastfeeding (13.7%). The most common reasons for using marijuana among WIC mothers who were current users were depression, anxiety, stress, pain, nausea, and vomiting. For the full report refer to Appendix, Monitoring Changes in Marijuana Use Patterns in Colorado: Tri-County Health Department Women, Infant, and Children (WIC) Client Survey.

Introduction

More than half of babies born in the United States participate in the Special Supplemental Nutrition Program for Women Infant and Children (WIC). Women, Infants and Children is a Federal grant program administered by WIC state agencies. WIC provides services to low-income, nutritionally at-risk woman and children up to 5 years of age. WIC provides nutritious foods, nutrition education, and screening and referrals to other health and social services as needed. Tri-County Health Department (TCHD), Colorado's largest local health department serving more than 26% of the state's population, has an average monthly caseload of approximately 25,000 WIC clients. Colorado was the first state to legalize marijuana in January 2014. Related to this new legislation, TCHD conducted a survey of WIC clients to assess marijuana use and to gain understanding regarding the educational needs around health effects of marijuana use.

Methods

TCHD, with assistance from the Colorado Department of Public Health and Environment, designed a voluntary, anonymous, in-person survey to learn about the needs and concerns WIC clients had regarding the health effects of marijuana and to measure usage rates. The survey was web-based and administered in English and Spanish to WIC clients at all 10 TCHD WIC offices between August and October 2014. The survey respondents represented a convenience sample of WIC clients who were endorsers on the WIC program, 18 years of age or older, and able to independently take the survey in English or Spanish using an iPad. A WIC endorser is a person who represent the WIC participant(s) in qualifying them for eligibility; the person must be the participant, a parent, legal guardian or caretaker.

Results

Survey respondents: During the 10-week administration of the survey, 3,137 clients had an on-site WIC appointment at the TCHD primary or satellite WIC clinics. Two hundred thirty-four clients (7.4%) were ineligible to take the survey based on criteria defined above. The remaining clients were asked to take the survey, and 1,749 were completed resulting in an overall 60.2% response rate. Among the 1,749 respondents, 1,308 (74.8%) surveys were completed in English and 441 (25.2%) were completed in Spanish.

Demographics: Table 1 shows the demographic characteristics of the WIC clients who participated in the survey. A high percentage of respondents were between the ages of 21 to 25 or 26 to 30 years. The majority of clients who took the survey identified as being the mother (87.6%) to the child or children on WIC.

Table 1. Demographic Profiles of survey respondents

Age Group	
18-20 years	10.1%
21-25 years	27.0%
26-30 years	25.4%
31-35 years	20.8%
36-40 years	11.7%
Over 40 years	5.0%
Gender	
Female	95.9%
Male	4.1%
Race/Ethnicity	
Non-Hispanic Origin	
White	29.4%
Black or African American	10.1%
Asian, Native Hawaiian or Other Pacific Islander	3.6%
Other Race or Multiracial	2.6%
Hispanic (of any race)	54.3%
Relationship to child on WIC	
Mother	87.6%
Pregnant and no other children on WIC	6.6%
Father	3.3%
Grandparent	0.9%
Guardian	0.5%
No children on WIC	0.3%
Other	0.8%

Marijuana use among WIC mothers

Since the vast majority of survey respondents were mothers or pregnant mothers receiving WIC services (N=1,616; 92%), the remainder of the marijuana use analysis focused just on those clients.

Ever, past and current marijuana users among WIC mothers

This subset of women was further classified into three use categories – ever, current, and past users. "Ever users" reported any previous use of marijuana. "Current users" reported having used marijuana at least once during the past 30 days. "Past users" were mothers who ever used marijuana, but had not used in the past 30 days. Among WIC mothers:

- 29.1% (470) ever used marijuana
- 5.9% (95) currently used marijuana
- 23.2% (375) used marijuana in the past

In this survey, among WIC mothers who reported using marijuana, about three-quarters were aged 30 years and younger, whether they were ever users (72.6%), current users (76.8%) or past users (71.5%). When comparing marijuana use among WIC mothers based on age, use was consistently higher among younger mothers 30 years of age and younger as compared to older mothers (Table 2).

Table 2. Proportion of WIC mothers by age who were ever, current, or past marijuana users

Survey respondents - WIC mothers	Ever users[¶ §]	Current users[¶]	Past users[¶ §]
WIC mothers ≤ 30 years	12.0%	7.4%	4.6%
WIC mothers > 30 years	5.7%	4.0%	1.7%

[¶] Percent of WIC mothers in the age group

[§] Statistically significant difference between older and younger WIC mothers

Timing of marijuana use

Among those WIC mothers who reported ever using marijuana, a question was asked regarding the timing of marijuana use relative to her most recent pregnancy. The time periods were: prior to being pregnant; during the pregnancy; since the baby was born; and while breastfeeding. Results are summarized in Table 3. Overall, WIC mothers who were current users reported substantially higher use of marijuana during any pregnancy-related time period compared to WIC mothers who were past users. Less marijuana use was reported while breastfeeding for all types of users.

Table 3. Timing of marijuana use during most recent pregnancy among ever, current, or past marijuana users

Survey respondents - WIC mothers	Ever users[¶]	Current users[¶]	Past users[¶]
Used marijuana during pregnancy	10.9%	35.8%	4.5%
Used marijuana since the baby was born	9.6%	41.1%	1.6%
Used marijuana while breastfeeding	3.0%	13.7%	<1%

[¶] Percent of WIC mothers in the marijuana user group

Reasons for using marijuana

WIC mothers who reported ever using marijuana also were asked the reason they used. The results are summarized in Table 4. Respondents could choose more than one response. Among current users, the most common reasons reported were to help with depression/anxiety/stress and to help with pain. However, ever and past users commonly reported using marijuana for fun/recreation.

Table 4. Reason for marijuana use [§]

Survey respondents - WIC mothers	Ever users	Current users	Past users
To help with depression/anxiety/stress	35%	63%	28%
To help with pain	29%	60%	21%
To help with nausea/vomiting	23%	48%	17%
For fun/recreation	59%	39%	65%
Other reason	16%	14%	16%

[§]Other reasons (write in response) included: sleep, cancer, seizures, migraines, and increase appetite. A couple of direct quotes from respondents were:

"To help with nausea and vomiting in first trimester of pregnancy"

"All the reasons above and plus when I was pregnant, it helped me want to eat

Marijuana Use During Pregnancy and the Method of Use

Fifty-one WIC mothers reported using marijuana during their most recent pregnancy. Among these 51 women, the manner in which marijuana was used included:

- 96% smoked
- 51% consumed via food or beverage
- 41% vaporized

Study Limitations

- Although overall survey response rate was high at 60.2%, the results are from a convenience sample of WIC clients visiting TCHD clinics over a several week period. Selection bias may have occurred among those women who agreed to participate in the study. Results may not be generalizable to the entire WIC population nor the general population.
- Recall bias may have occurred among women reporting past marijuana use, particularly for use related to a pregnancy. Behavior around current use may be more accurate than reported behavior from past use.
- Marijuana use may have been underreported by WIC women who had concerns about disclosing such behavior, even in an anonymous survey.

- The study did not specifically identify all WIC women who were currently pregnant (only those who were receiving WIC services because of pregnancy, and not for other children). Estimates of marijuana use during pregnancy may be over or underestimated.

Child Health Survey (CHS)

Survey Coordinator:

Ricky Tolliver, MPH, Manager, Health Surveys and Analysis Program, Colorado Department of Public Health and Environment.

Background

In 2004, the Colorado Department of Public Health and Environment, along with other community partners, launched the Child Health Survey. This annual survey provides data on a wide range of health issues and risk factors affecting children and youth in Colorado, and was developed to add to health data for children ages 1-14 years. Through a screening process, surveyors identify Behavioral Risk Factor Surveillance Survey (BRFSS) participating households with children ages 1-14 years. Households are contacted shortly after completion of the BRFSS to conduct the CHS survey. If agreed, the parent completes the survey on different indicators of health (physical activity, nutrition, access to health and dental care, behavioral health, school health, sun safety, injury).

In February 2014, topics relating to marijuana use and safe storage of marijuana products (if an adult in the home consumes marijuana products) were added to the survey. Future collection of data on marijuana education and safe storage in the home will enable CDPHE and its partners to assess the number of children in Colorado who live in households with adult marijuana users. Based on responses, resources may be developed to assist parents in initiating discussion with their children regarding safe and legal use of marijuana products. CHS administrators estimate 2014 data will be available for analysis and review in the fall of 2015.

Survey Questions

1a Have you begun to talk to your child about the risks of using marijuana? (Children ages 10 and older) (1) Yes (2) No DO NOT READ (7) don't know (9) refused
1b When (child's name) is older do you plan to talk to him/her about the risks of using Marijuana? (Children ages 1-9 years) (1) Yes (2) No DO NOT READ (3) Already having/had the conversation (9) refused
2 Is there any marijuana or marijuana product in or around your home right now? (1) Yes (2) No (skip to CHSMJ4) DO NOT READ (7) don't know (9) refused

3 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. (1) In a childproof container or packaging (2) In a locked container such as a cabinet, drawer or safe (3) In a location your child cannot access (such as out of reach) (4) Someplace else? (specify)
4 During the past 30 days, has anyone- including yourself, used marijuana or hashish inside your home? (1) Yes (2) No (End of Survey) DO NOT READ (7) don't know (9) refused
5 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. (1) It was Vaporized (e-cigarette-like vaporizer) (2) It was Smoked (in a joint, bong, pipe, blunt) (3) It was eaten in food (in brownies, cakes, cookies, candy) (4) It was consumed in a beverage (tea, cola, alcohol) (5) It was used in some other way (specify)

Healthy Kids Colorado Survey (HKCS)

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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Bruce Mendelson, MPA, Substance Abuse Epidemiology and Data Consultant, Denver Office of Drug Strategy, Drug Strategy Commission, University of Colorado Denver.

Introduction

The Healthy Kids Colorado Survey (HKCS) collects health information every odd calendar year from public school students. HKCS is a collaboration of CDPHE, Colorado Department of Education and 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 fulfills Colorado's reporting requirement for the CDC-sponsored Youth Risk Behavioral Surveillance Survey (YRBSS) and ensures Colorado data can be compared to both national data and data from other states. HKCS survey provides data on a wide range of health issues and risk factors affecting children and youth including; access to healthy food, access to recreation, safety, depression, alcohol, tobacco and other substance use, and sexual behaviors.

Methods

In 2013, because of the new collaborative structure of the survey, the survey population was expanded to approximately 40,000 public school students (25,000 high school students, 15,000 middle school students).

Patterns of marijuana use were evaluated using affirmative responses to three questions:

- Ever use: "During your life, how many times have you used marijuana?" (1+ vs none)
- Past 30 day use: "During the past 30 days, how many times did you use marijuana?" (1+ vs none)
- Age of first use: "How old were you when you tried marijuana for the first time?"

Results regarding marijuana use were analyzed by CDPHE and included below.

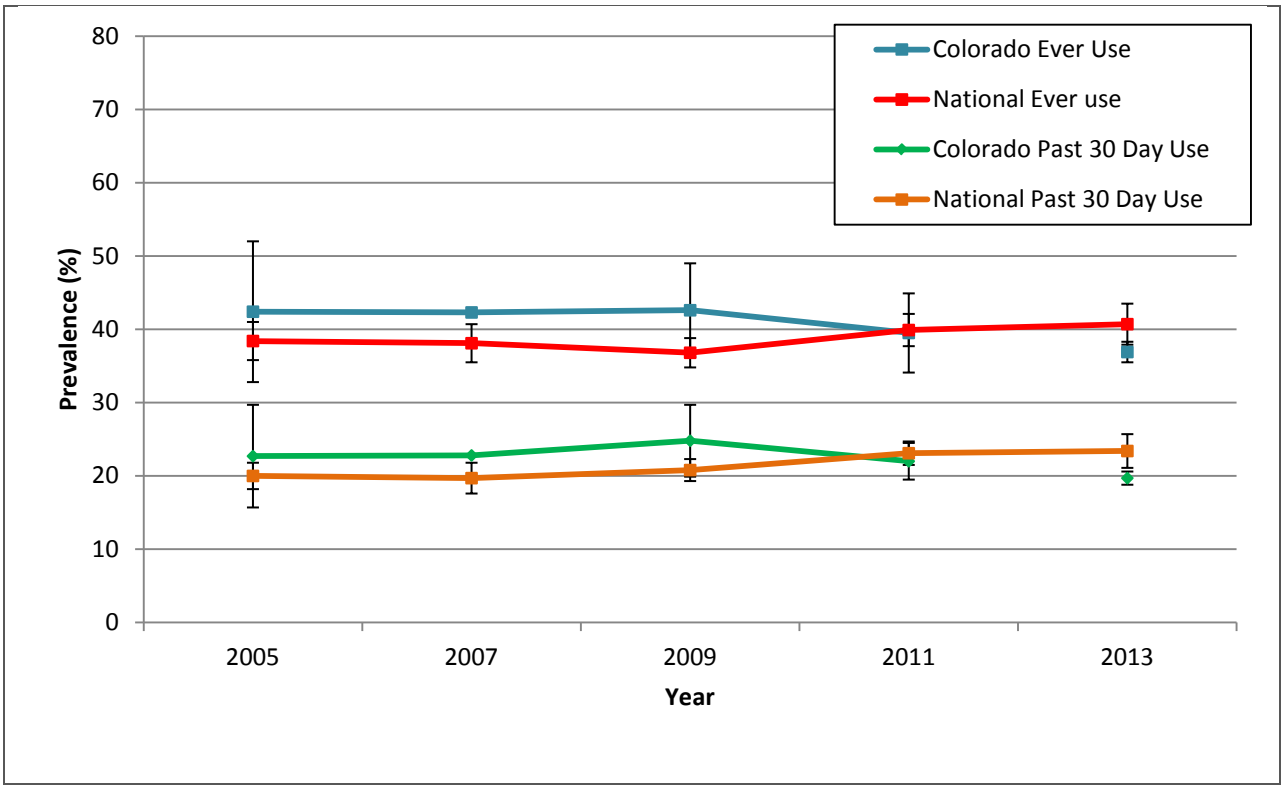
Results

Survey results from 2013 indicate approximately 37% of Colorado high school students reported ever using marijuana and nearly 20% report use in the past 30 days. Nationally, approximately 44% of high school students reported ever using marijuana and approximately 23% report use in the past 30 days. Survey results find no significant change in "ever use" and "past 30 day use" during the time period of 2005-2013. Marijuana use among younger students in Colorado is lower; with 5.1% of Colorado middle school students reporting "past 30 day use" and 8.8% having ever used marijuana. Marijuana use increases as children age, both "ever use" and "past 30 day use" increased significantly between grades 6-12 (except "past 30 day use" between grades 11 and 12). Male students had a significantly higher prevalence of "past 30 day use" compared to female students, and male students started using marijuana earlier than female students. When twelfth grade students were asked about age of first use of marijuana: the majority reported first use between ages 13 and 16.

There are significant differences in use and age of first use in students of different races and ethnicities. American Indian/Alaska Native, Black/African American, White Hispanic and other race high school students reported a higher prevalence of "ever use" and "past 30 day use" compared with White high school students. When White students are compared to Asian students, prevalence of use (both "ever use" and "past 30 day use") were significantly higher in White students. Sexual orientation was identified as another risk factor for higher prevalence of both marijuana use categories. Prevalence of "ever" and "past 30 day" use of marijuana is significantly higher among gay, lesbian or bisexual (GLB) high school students compared to heterosexual students A statistically significantly greater percentage of GLB (19.9%) high school students reported trying marijuana before age 13 compared with heterosexual (6.4%) high school students.

Marijuana use also varies significantly 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. The highest prevalence of "past 30 day use" in high school students occurs in the Denver metro area, with similar prevalence estimates for the southwestern region of the state. The Colorado state average prevalence estimate for "past 30 day use" is 19.7% and the range of prevalence estimates in HSRs is 9.4% to 14.8% in HSRs with the lowest prevalence, and estimates of 23.2% to 32.1% in the HSRs with the highest prevalence estimates.

Figure 1. Marijuana Use among High School Students — U.S.* and Colorado**, 2005-2013

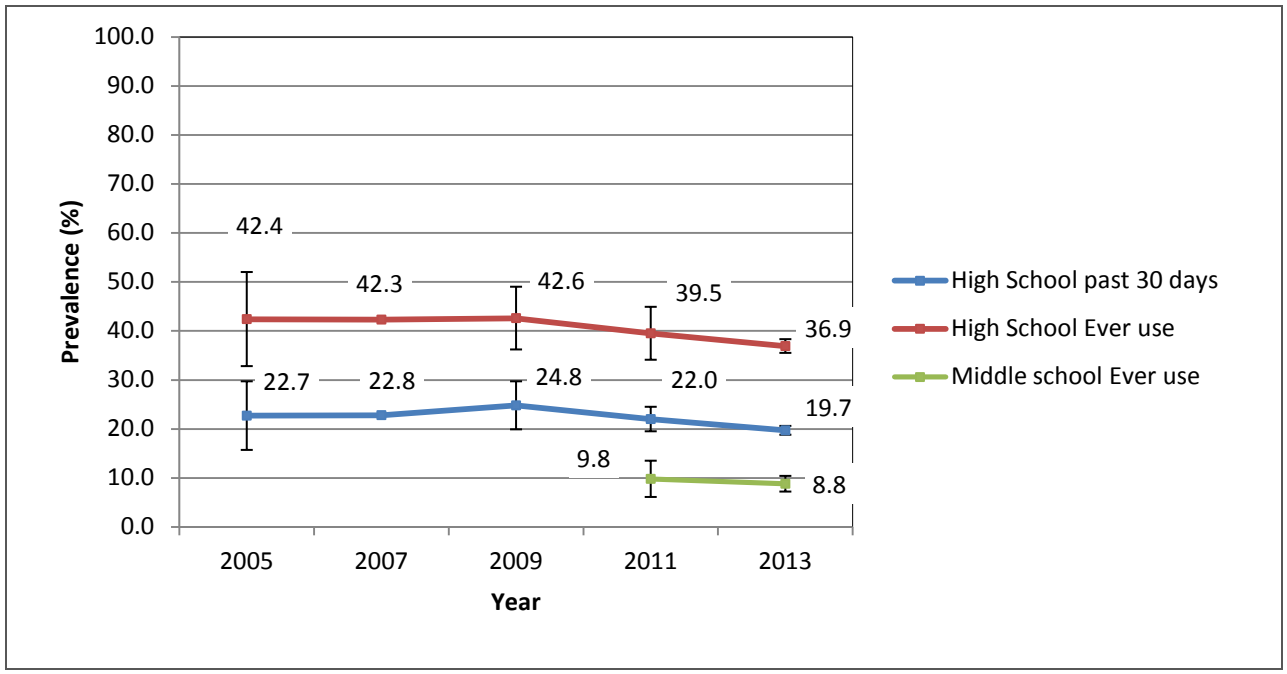


*Data source: Youth Risk Behavioral Survey prevalence estimates.
** Data source: Healthy Kids Colorado Survey prevalence estimates.
***The 2007 estimates are unweighted and therefore no confidence intervals are calculated.

Major Findings

- In 2013 40.7% (37.9, 43.5) of U.S. high school students reported ever using marijuana while 36.9% (35.4, 38.3) of Colorado high school students reported "ever use" of marijuana.
- Similarly, 23.4% (21.3, 25.7) of U.S. high school students had used marijuana in the past 30 days compared to 19.7% (18.7, 20.6) of Colorado high school students.
- In a trend analysis of historical data, there was not a significant trend (increase or decrease) or change between 2009 and 2011 for the three marijuana use indicators.

Figure 2. Marijuana Use among Students in Colorado 2005-2013

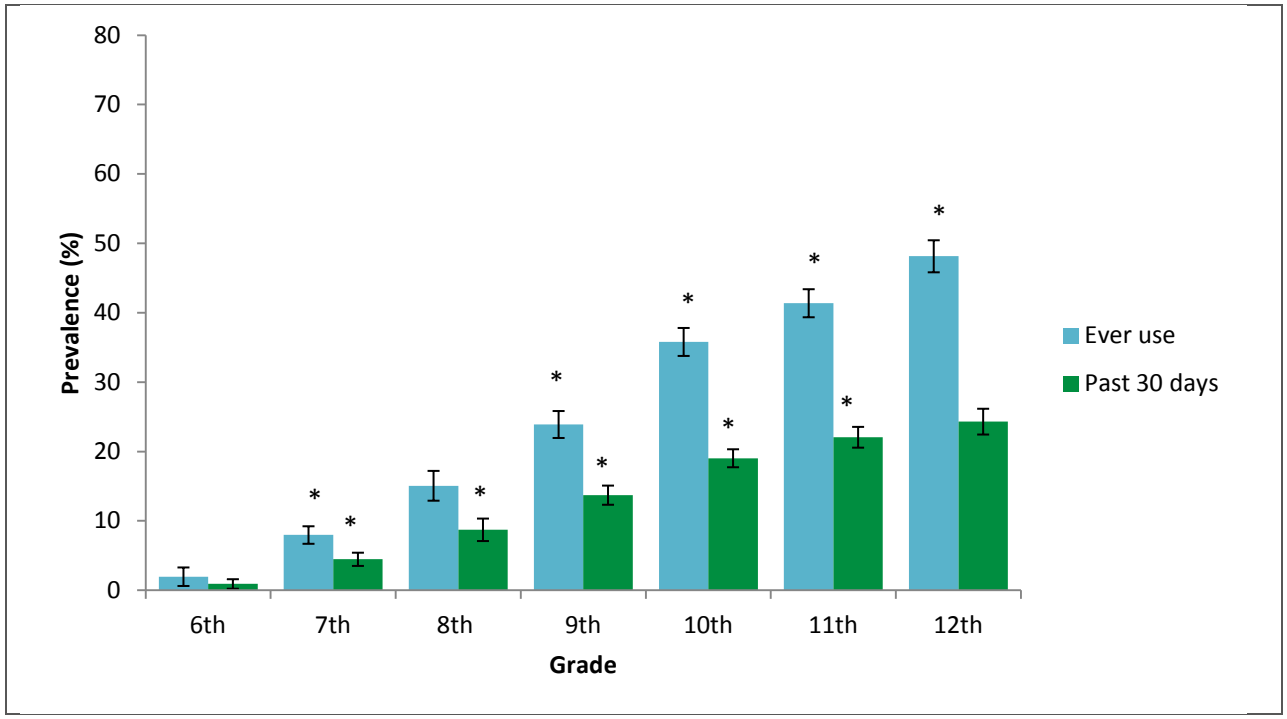


*Middle School current use only 2013. The 2007 estimates are unweighted and therefore no confidence intervals are available. Data source: YRBS data 2005 to 2009, HCKS data 2011,2013

Major Findings

- For 2013 in Colorado, approximately 37% of high school students reported ever using marijuana and nearly 20% used in the past 30 days.
- The YRBS/HKCS survey was expanded to include a sample of middle school students in 2011.
- Marijuana use among these younger students is low; with 5.1% of Colorado middle school students reporting past 30 day use (data not shown) and 8.8% having ever used marijuana.
- There was no statistically significant change in "ever use" among middle school students between 2011 and 2013.

Figure 3. Ever and Past 30 Day Use of Marijuana among High School and Middle School Students by Grade — Colorado, 2013

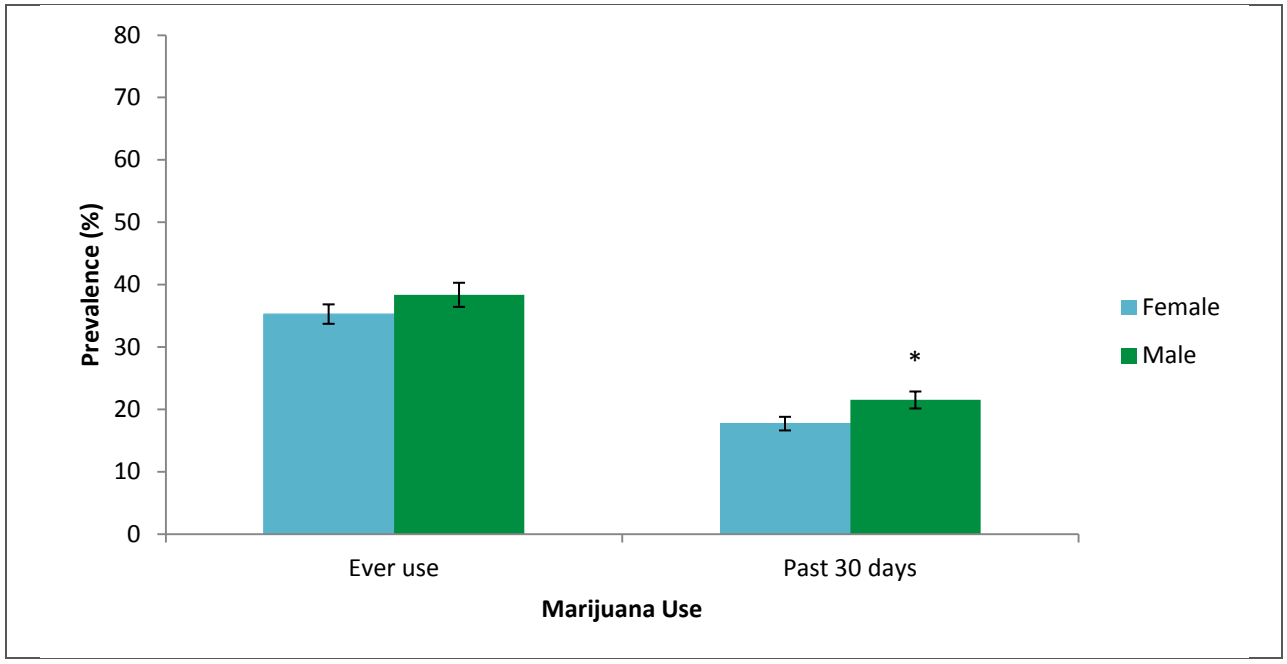


Data source: HKCS 2013,
*indicates significant increase in prevalence of marijuana use between grades.

Major Findings

- The prevalence of high school and middle school students ever using marijuana increased significantly with each advance in grade.
- The same pattern was observed in these populations for past 30 day use.

Figure 4: Ever and Past 30 Day Use of Marijuana among High School Students by Sex — Colorado, 2013

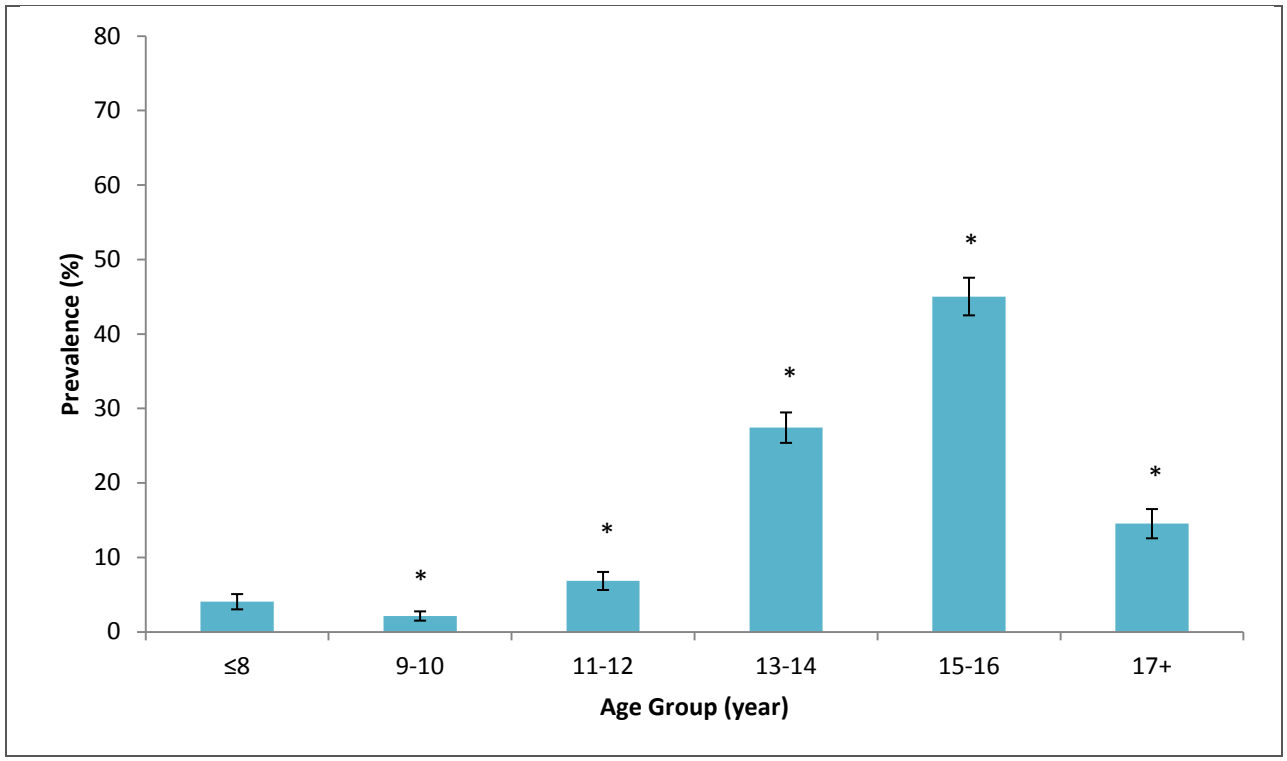


Data source: HKCS 2013
*indicates significantly higher than comparison group.

Major Findings

- Male high school students had a significantly higher prevalence of current marijuana use compared to female students.
- There were no significant differences in "ever use" of marijuana between males and females.

Figure 5. Age of First Marijuana Use— Colorado, High School Seniors, 2013

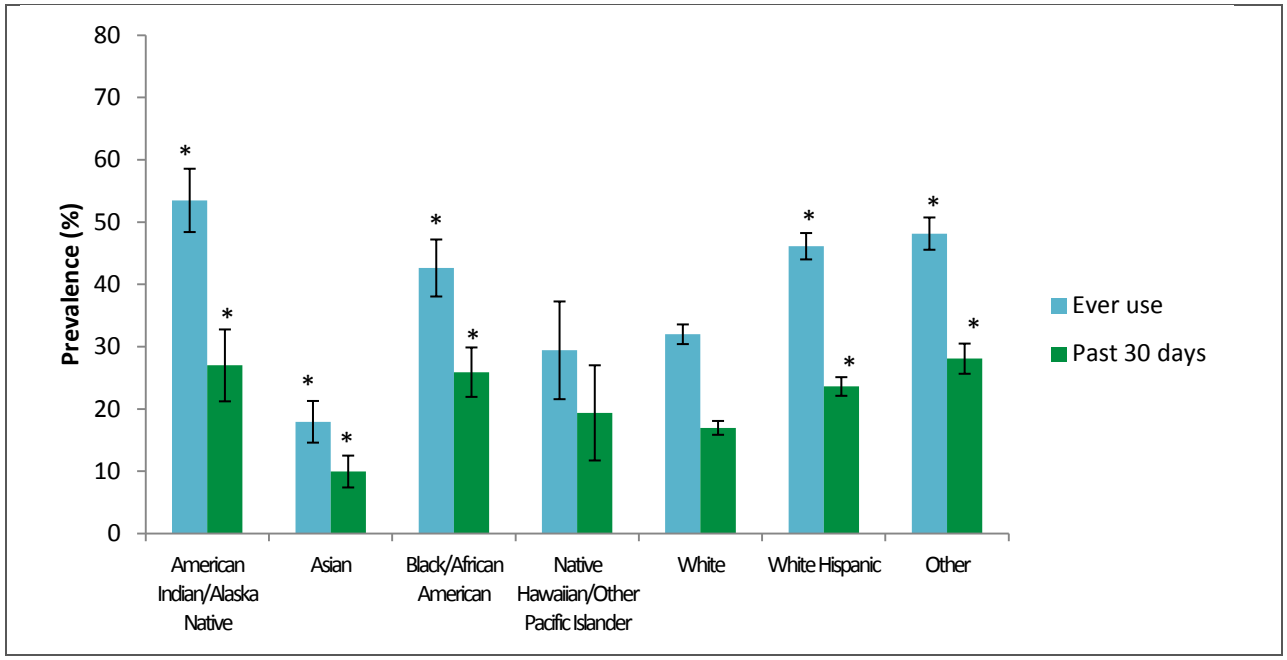


Data Source: HKCS 2013
*indicates a significant increase/decrease between age groups.

Major Findings

- When twelfth grade students were asked about age of first use of marijuana, the majority reported first use between ages 13 and 16.

Figure 6. Ever and Past 30 Day Use of Marijuana among High School Students by race/ethnicity — Colorado, 2013

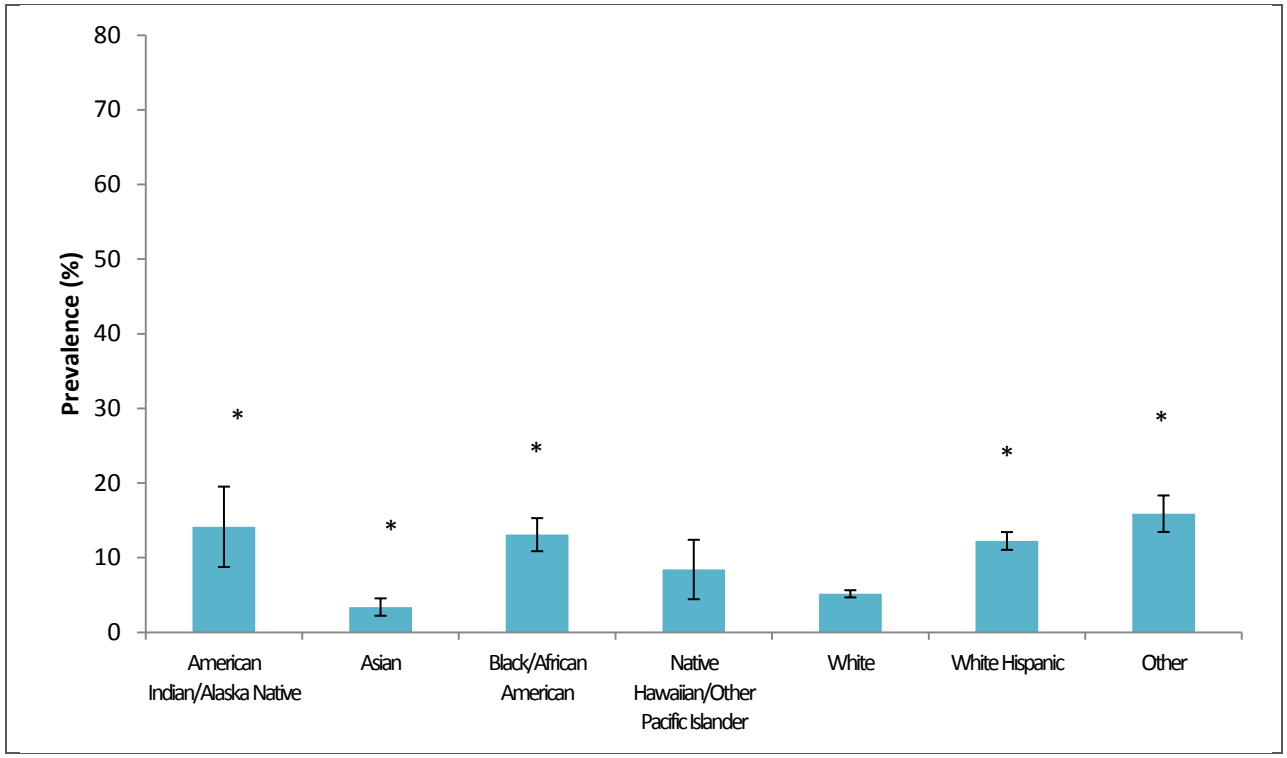


Data source: HKCS 2013
*indicates significantly higher/lower than White high school students.

Major Findings

- American Indian/Alaska Native, Black/African American, White Hispanic and other race high school students reported a higher prevalence of "ever use" and "past 30 day use" compared with White high school students.
- Use was statistically significantly lower among Asian high school students compared with White high school students.

Figure 7. Tried Marijuana before age 13 by Race/ethnicity— Colorado, High school students, 2013

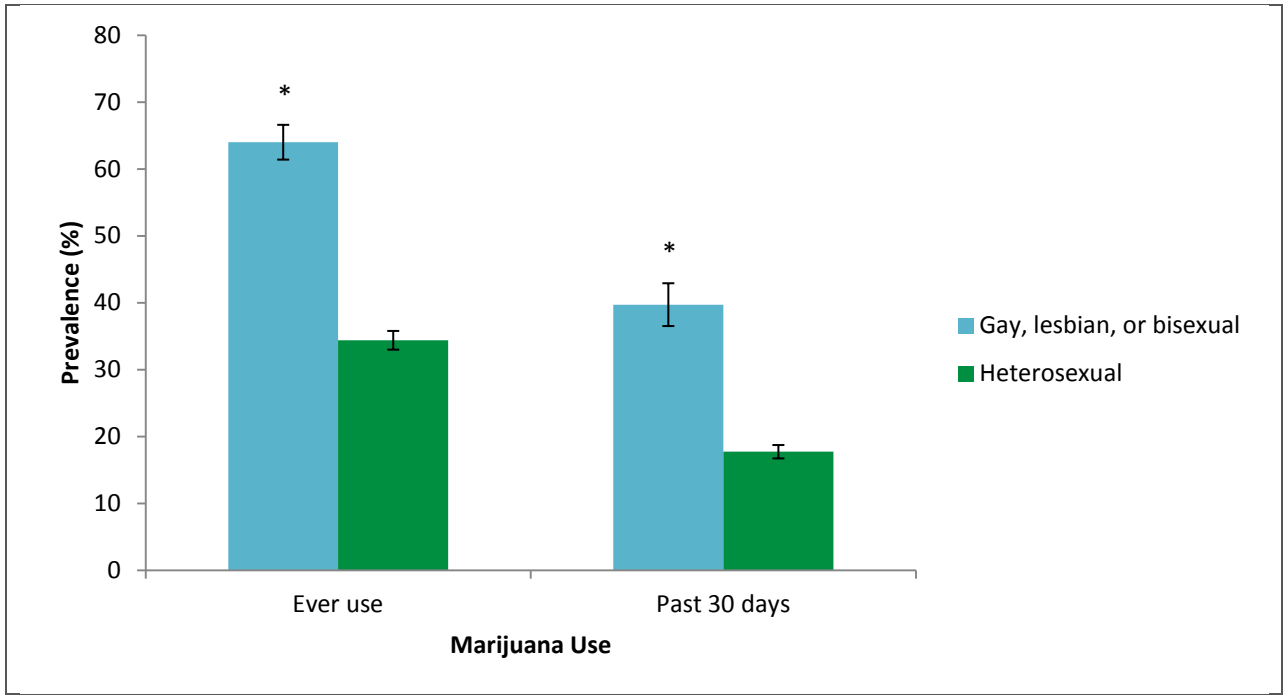


Data source: HKCS 2013
*indicates significantly higher/lower than White high school students.

Major Findings

- There is a statistically significantly higher percentage of American Indian/Alaska Native, Black/African American, White Hispanic and other high school students reporting they tried marijuana before age 13 compared with White high school students.
- Statistically significantly fewer Asian high school students reported they tried marijuana before age 13 compared with White high school students.

Figure 8. Tried Marijuana before age 13 by Sexual Orientation— Colorado, High school students, 2013

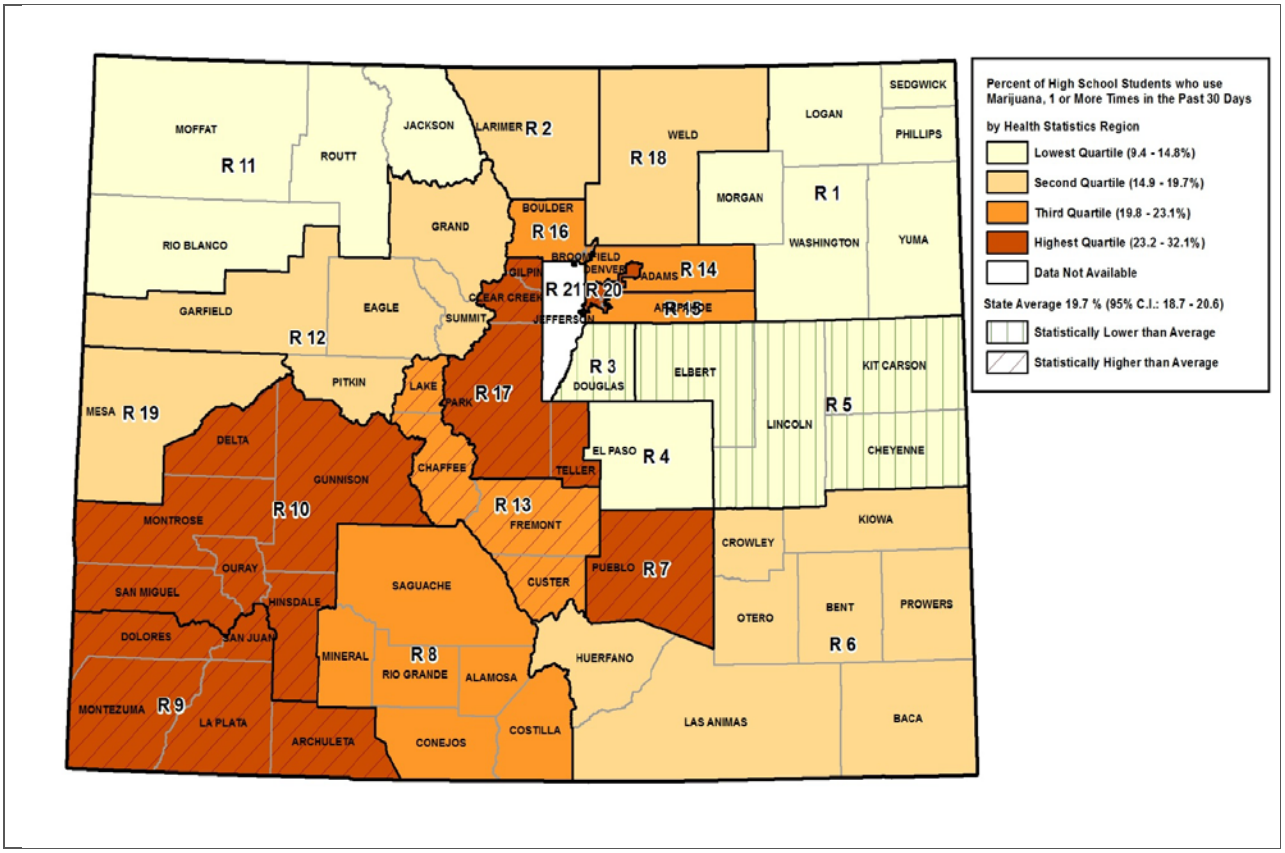


Data source: HKCS 2013
*indicates significantly higher than comparison group.

Major Findings

- Prevalence of "ever" and "past 30 day" use of marijuana is statistically significantly higher among gay, lesbian or bisexual (GLB) high school students compared to heterosexual students.
- A statistically significantly greater number of GLB (19.9%) high school students reported trying marijuana before age 13 compared with heterosexual (6.4%) high school students (data not shown).

Map 1: **Past Thirty Day Marijuana Use by Region, Colorado High School Students, 2013**



Data Source: HKCS

Major Findings

- The prevalence of marijuana use in the past 30 days among high school students varied significantly across Health Statistics Regions (HSR's) in Colorado.
- The highest prevalence of "past 30 day use" in high school students occurs in the Denver metro area, with similar prevalence estimates for the southwestern region of the state. T
- The Colorado state average prevalence estimate for "past 30 day use" is 19.7% and the range of prevalence estimates in HSRs is 9.4% to 14.8% in HSRs with the lowest prevalence estimates, and 23.2% to 32.1% in the HSRs with the highest prevalence estimates.

Behavioral Risk Factor Surveillance System (BRFSS)

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Survey Coordinator
Ricky Tolliver, MPH, Manager, Health Surveys and Analysis Program, Colorado Department of Public Health and Environment.

Background

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. Colorado participates in BRFSS, using core and optional modules, as well as state-added questions, to customize data collection to topics most relevant to Coloradans.

Colorado added state-based questions on marijuana use to both the 2014 and the 2015 surveys. Continued collection of data regarding marijuana use in adults over time will provide insight into the changing use patterns in adult populations. This data will be analyzed by age, race/ethnicity, and when possible, county of residence. BRFSS administrators anticipate 2014 data will be available in the fall of 2015.

Survey Questions

Have you ever used marijuana or hashish? 1. Yes 2. No 7. Don't Know/Not Sure 9 Refused	2014/2015
How old were you the first time you used marijuana or hashish? AGE:_____ [RANGE: 1 - 110] 7 Don't Know/Not Sure 9 Refused	2014/2015
During the past 30 days on how many days did you use marijuana or hashish? ___ Number of Days 88. None 7. Don't Know/Not Sure 9. Refused	2014/2015
During the past 30 days, how many times did you drive a car or other vehicle when you had been using marijuana or hashish? __ __ Number of days [1-30] 7. Don't Know/Not Sure 9. Refused	2014/2015

On the days that you did use marijuana, how many times per day did you use it on average? __ __ Number of times 88 None 77 Don't know/Not sure 99 Refused	2015
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. (1 Yes; 2 No; 7 Don't know/Not sure; 9 Refused) 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? Other _____ (specify)	2015

Influential Factors in Healthy Living Survey (IFHL)

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Primary Authors:

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Survey Administrator:

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

Primary Reviewers:

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

Bruce Mendelson, MPA, Substance Abuse Epidemiology and Data Consultant, Denver Office of Drug Strategy, Drug Strategy Commission, University of Colorado Denver.

Introduction

Influential Factors in Healthy Living (IFHL) is a "call back" survey of The Attitudes and Behaviors Survey (TABS) on Health, a population-level survey of Colorado adults (18 years and older). TABS data allow understanding of influential factors that public health programs can address to improve the health of Colorado. This population-level survey supports planning, implementation and evaluation of Colorado state and local programs to address health risks and chronic disease. Findings have been used to identify priority needs and gaps in the reach of evidence-based strategies; to inform strategic program planning; to explore possible mechanisms that underlie health risk and chronic disease behaviors; and to inform policy choices. The call back survey, IFHL, addresses access to healthy food, health providers and workplace support of healthy living, as well as self-management of chronic health conditions. The full methods and results of the IFHL survey may be accessed at: (http://www.ucdenver.edu/academics/colleges/PublicHealth/community/CEPEG/WkProducts/Reports/Documents/120814%20IFHL%20Report%20Final.pdf)

Methods

In 2013, marijuana use questions were added to the IFHL survey. Interviews were attempted with 5,819 randomly selected adults who had previously agreed to be called during the TABS calls. A total of 3,974 participants completed interviews. Data are weighted to provide unbiased estimates of Colorado's adult population. Data collected from December 2013 to March 2014 are presented.

Results

Survey results from data collection completed in March of 2014 indicate approximately 11% of Colorado adults (18 years of age and older) report "past 30 day use". Of those who reported use, 35% reported occasional use (1-7 times per month), 28% reported regular use (8-26 times per month), and 36% reported heavy use (27-30 times per month). Among adults who used marijuana in the past 30 days, 72% did not drive a car while using marijuana; however, 18% drove a car more than five times while using marijuana in the past 30 days and 7% drove a car everyday while using marijuana.

When respondents who used marijuana were asked what forms of marijuana they used, the vast majority (96%) reported smoking marijuana. However, 46% reported ingesting marijuana products. Finally, when interviewees were asked whether their personal marijuana use had changed since retail legalization, 94% reported no change in use and 3% reported using more often.

Table 1. Marijuana Use Patterns in Colorado Adults (IFHL 2014)

(n=3974)	percent	95% CI
Ever Used Marijuana	48.5%	(45.8,51.2)
Ever Used Synthetic Marijuana	1.8%	(1.0,2.6)
Have a Medical Marijuana License	3.6%	(2.5,4.7)
(n=1914) Among those who ever used		
Median Age at First Use (years)	16.7	(16.3,17.0)
How Recently Used		
in the past 30 days	21.2%	(17.8,24.6)
30 days to 12 months	10.6%	(8.1,13.1)
more than12 months ago	67.3%	(63.5,71.2)
(n=406)		
How Consumed, among past 30 day users		
smoked	95.8%	(92.4,99.3)
ingested	45.9%	(35.6,56.2)

Table 2. Current Use Colorado adults 2014 (IFHL 2014)

	percent	95% CI
current marijuana user	10.4%	(8.6,12.1)
not current user	89.6%	(87.9,91.4)

Table 3. Frequency of Use (times per month) among Current Users (IFHL 2014)

	percent	95% CI
0	1.0%	(0, 2.9)
1-7	34.8%	(26.1, 43.4)
8-26	27.8%	(19.4%, 36.3)
27-30	36.4%	(27.2, 45.3)

National Survey on Drug Use and Health (NSDUH)

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Primary Author:

Dara Burris, MPH, Applied Epidemiology Fellow, Centers for Disease Control and Prevention (CDC), Council of State and Territorial Epidemiologists.

Survey Administrator

Substance Abuse and Mental Health Services Administration (SAMHSA), an agency of the U.S. Public Health Service in the U.S. Department of Health and Human Services (DHHS).

Primary Reviewers:

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

Bruce Mendelson, MPA, Substance Abuse Epidemiology and Data Consultant, Denver Office of Drug Strategy, Drug Strategy Commission, University of Colorado Denver.

Introduction

The National Survey on Drug Use and Health (NSDUH) provides national- and state-level data on the use of tobacco, alcohol, illicit drugs (including non-medical use of prescription drugs) and mental health in the United States. NSDUH is sponsored by the Substance Abuse and Mental Health Services Administration (SAMHSA), an agency of the U.S. Public Health Service in the U.S. Department of Health and Human Services (DHHS).

Methods

Randomly selected individuals aged 12 and older participate in the survey. Interviews are administered in person, in private and take about one hour. Interviewers read the questions, and enter the participant's response into a program on a laptop computer. Full names are never recorded and data only is used in aggregate for statistical analysis. State sample size in Colorado is approximately 1,000 individuals per year

Results

Reported use in the past 12 months (Map 1)

Among those 18 years of age or older in the U.S. in 2013, about 12% reported using marijuana in the past 12 months. In Colorado, about 19% reported using marijuana in the past 12 months which is significantly above the national average of 12%. Other surrounding states above the national average, although not significantly, include New Mexico (15%) and Arizona (13%). In Wyoming, Oklahoma, and Nebraska, about 10% of the population used marijuana in the past 12 months. Among Colorado's neighbors, Utah (9%) and Kansas (8%) had the lowest prevalence estimates of marijuana use in the past 12 months.

Reported marijuana use in the past 12 months was highest among 18 to 25 year olds. Between 2011 and 2013, the prevalence among 18-25 year olds was about 19% nationally, compared to about 7% in 12-17 year olds and about 5% in those 26 years of age and older. Among every age group, marijuana use in Colorado (12-17 years old: 19%, 18-25 years old: 41%, 26+ years old: 13%) and New Mexico (19%, 33%, 10%) was above the national average (14%, 31%, 8%), and significantly below the national average in Utah (10%, 19%, 5%).

Reported use in the past month (Map 2)

About 7% of U.S. adults 18 years of age and older reported using marijuana in the past month in 2013. Colorado's prevalence of marijuana use in the past month (13%) was significantly above the national average. Estimates of marijuana use in the past month in New Mexico (9%) and Arizona (8%) were also above the national average, although not significantly. Oklahoma (6%), Nebraska (5%), Utah (5%), and Kansas (4%) estimates were significantly below the national average.

The prevalence of reported marijuana use in the past month follows the same time and age trends as reported marijuana use in the past 12 months. Among 12-17 year olds in Colorado, prevalence of use in the past 30 days (11%) is about half the prevalence of use in the past 12

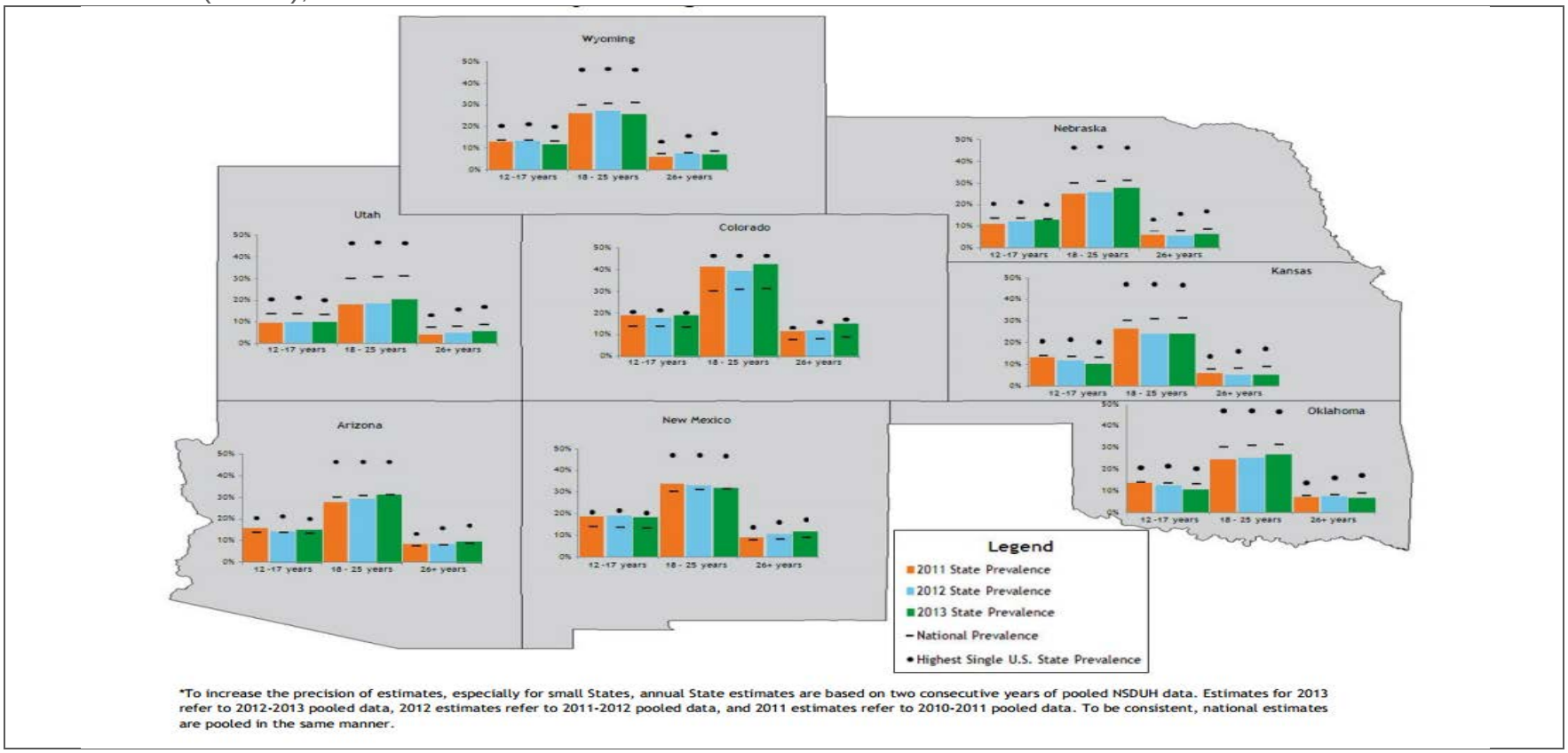
months (19%). This trend among 12-17 year olds is the same in neighboring states. For example, in Utah, about 5% used marijuana in the past month compared to about 10% that used in the past 12 months.

Table 1 - Marijuana Use in the Past 12 Months and Past Month among Adults (18+), National Survey on Drug Use and Health (NSDUH), 2013

	Use in the Past 12 Months		Use in the Past Month	
	Estimate	95% CI*	Estimate	95% CI*
U.S.	12.22	11.89-12.55	7.43	7.17-7.69
Colorado	18.94	16.50-21.65	12.86	10.90-15.10
New Mexico	14.73	12.51-17.27	9.02	7.38-10.99
Arizona	12.71	10.75-14.97	7.84	6.34-9.66
Wyoming	9.95	8.37-11.78	5.81	4.59-7.34
Oklahoma	9.91	8.31-11.79	5.61	4.39-7.13
Nebraska	9.66	8.22-11.32	5.38	4.34-6.67
Utah	8.59	7.17-10.25	5.03	3.95-6.40
Kansas	8.01	6.69-9.56	4.33	3.38-5.53

*Confidence Interval

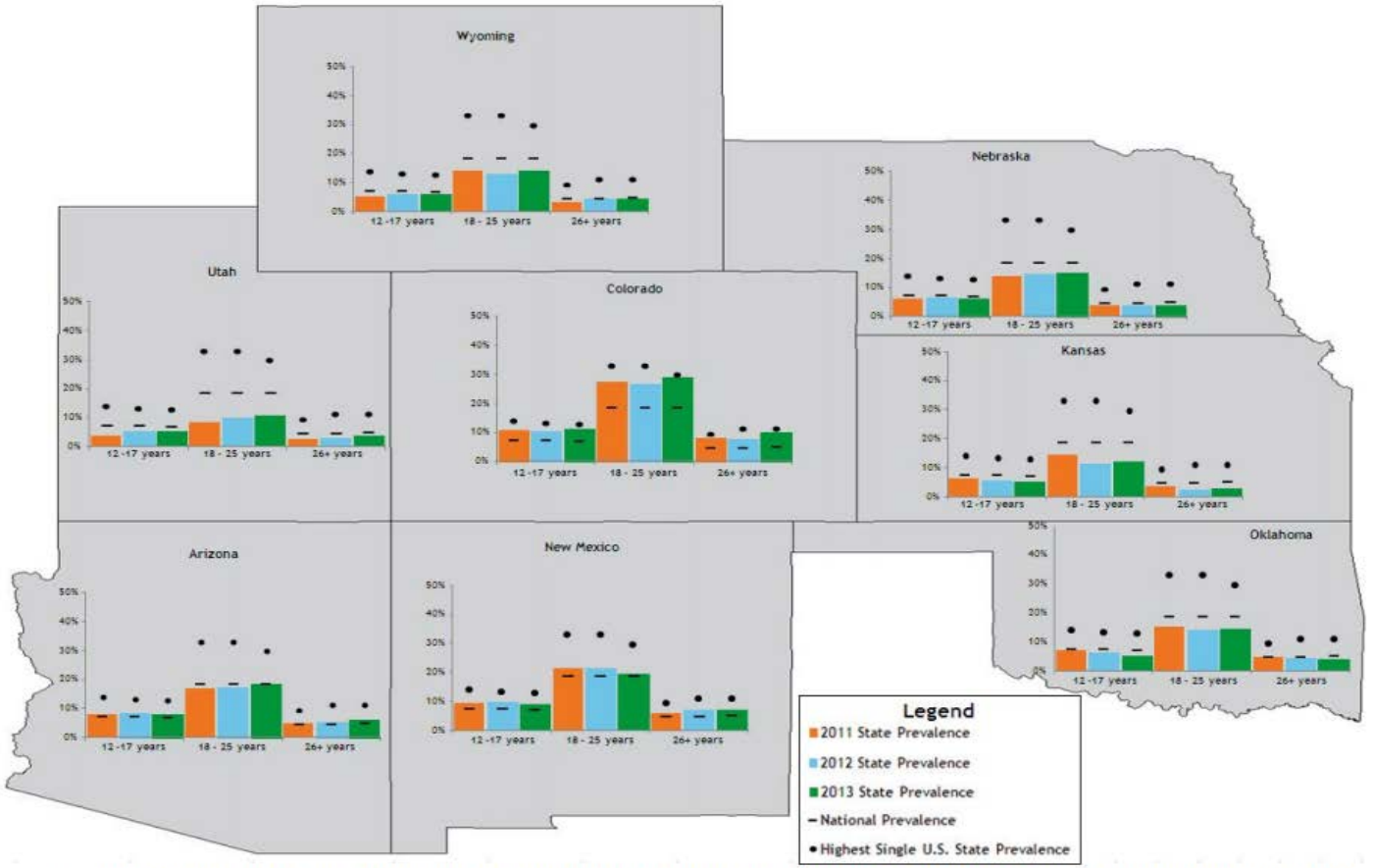
Map 1. Prevalence of Reported Marijuana Use in the Past 12 Months in Colorado and Neighboring States, National Survey on Drug Use and Health (NSDUH), 2011-2013*



Major Findings

- Among those 18 years of age or older in the U.S. in 2013, about 12% reported using marijuana in the past 12 months.
- In Colorado among those 18 years of age or older, about 19% reported using marijuana in the past 12 months.
- Reported marijuana use in the past 12 months in the U.S. was highest among 18-25 year olds. Between 2011 and 2013, the prevalence among 18-25 year olds was about 19% nationally, compared to about 7% in 12-17 year olds and about 5% in those 26 years of age and older.
- Marijuana use in Colorado for all age groups (12-17 years old: 19%, 18-25 years old: 41%, 26+ years old: 13%) was above the national averages (14%, 31%, 8%).

Map 2. Prevalence of Reported Marijuana Use in the Last Month in Colorado and Neighboring States, National Survey on Drug Use and Health (NSDUH), 2011-2013*



*To increase the precision of estimates, especially for small States, annual State estimates are based on two consecutive years of pooled NSDUH data. Estimates for 2013 refer to 2012-2013 pooled data, 2012 estimates refer to 2011-2012 pooled data, and 2011 estimates refer to 2010-2011 pooled data. To be consistent, national estimates are pooled in the same manner.

Major Findings

- About 7% of U.S. adults 18 years of age and older reported using marijuana in the past month in 2013.
- Colorado's prevalence of marijuana use in the past month (13%) was significantly above the national average.
- Among 12-17 year olds in Colorado, prevalence of use in the past 30 days was 11%.

Literature Review on Marijuana Use and Health Effects

Summary and Key Findings

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Introduction

In C.R.S. 25-1.5-110, 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."

Based on this charge, CDPHE appointed a 13-member committee, the Retail Marijuana Public Health Advisory Committee (RMPHAC), to review scientific literature on the health effects of marijuana. Members of this committee (see Appendix, Retail Marijuana Public Health Advisory Committee Membership Roster) consisted of individuals in the fields of public health, medicine, epidemiology, and medical toxicology who had demonstrated expertise related to marijuana through their work, training, or research. This committee was charged with the duties as outlined in C.R.S. 25-1.1-110 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 conducted nine public meetings between May 2014 and January 2015 to complete these duties. 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 of this committee are included in the Appendix, 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 supporting scientific evidence. These evidence statements were classified as follows:

- Substantial evidence which indicates robust scientific findings that support the outcome and no credible opposing scientific evidence.
- Moderate evidence which indicates that scientific findings support the outcome, but these findings have some limitations.
- Limited evidence which indicates modest scientific findings that support the outcome, but these findings have significant limitations.
- Mixed evidence which indicates both supporting and opposing scientific findings for the outcome with neither direction dominating.
- Insufficient evidence which indicates that the outcome has not been sufficiently studied.

The committee also translated these evidence statements into lay language understandable by 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 of 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 vote of the committee.

The topics for review were chosen 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. Key findings for each topic are presented below.

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.

Marijuana Use During Pregnancy and Breastfeeding

The committee reviewed the literature for marijuana use during pregnancy and while breastfeeding. Outcomes reviewed included those apparent at birth as well as physical, neurocognitive, and mental health findings throughout childhood and adolescence. We found moderate evidence that maternal use of marijuana during pregnancy is associated with negative effects on exposed offspring, including decreased academic ability, cognitive function and attention. Importantly, these effects may not appear until adolescence. We also found moderate evidence that maternal use of marijuana during pregnancy is associated with decreased growth in exposed offspring.

Unintentional Marijuana Exposures in Children

The committee found moderate evidence that more unintentional marijuana exposures of children occur in states with increased legal access to marijuana; and the exposures can lead to significant clinical effects requiring medical attention. Additionally, we found moderate evidence that use of child resistant packaging reduces unintentional pediatric poisoning.

Marijuana Use Among Adolescents and Young Adults

The committee reviewed the literature on the potential effects of marijuana use among adolescents and young adults including effects on cognitive abilities, learning, memory,

achievement, future use of substances such as marijuana and illicit drugs, and mental health issues. We found substantial evidence for associations between adolescent and young adult marijuana use and future addiction to illicit drugs in adulthood. We found an increased risk for developing psychotic symptoms or psychotic disorders in adulthood among regular adolescent and young adult users. In addition, we found moderate evidence for associations between adolescent and young adult marijuana use and at least short-term impairment of cognitive and academic abilities. We also found moderate evidence indicating that adolescent marijuana users were less likely to graduate from high school and more likely to be addicted to marijuana, alcohol, and tobacco in adulthood. We found beneficial effects related to cessation of use including moderate evidence that adolescent and young adult marijuana users who quit have lower risks of adverse cognitive and mental health outcomes than those who continue to use.

Marijuana Dose and Drug Interactions

This literature review focused on the dose-response of different methods of marijuana use with regard to THC blood levels and impairment. Additional review was performed to evaluate marijuana's interactions with other drugs and the possibility of a positive drug screen from passive marijuana exposure. In general, we found that substantial evidence that for occasional (less than weekly) marijuana users, smoking, eating, or drinking marijuana containing 10 milligrams or more of THC is likely to cause impairment that affects the ability to drive, bike, or perform other safety sensitive activities. In addition, for these occasional users, waiting at least six hours after smoking marijuana (containing up to 35 milligrams of THC) will likely allow sufficient time for the impairment to resolve. The waiting time is longer for eating or drinking marijuana products. We found it is necessary for occasional users to wait at least eight hours for impairment to resolve after orally ingesting up to 18 milligrams of THC.

A substantial finding, regarding the use of edible marijuana products, is that it can take up to four hours after ingesting marijuana to reach the peak THC blood concentration and perhaps more time to feel the full effects. This has important implications for the time to wait between doses. Using alcohol and marijuana at the same time is likely to result in greater impairment than either one alone. Finally, typical passive exposure to marijuana smoke is unlikely to result in a failed workplace urine test or a failed driving impairment blood test.

Marijuana Use and Neurological, Cognitive and Mental Health

The committee reviewed the literature on the potential adverse effects of marijuana use among adults including effects on cognitive functioning, memory, and mental health issues such as anxiety, depression, and psychosis. We found substantial evidence for associations between marijuana use and memory impairments lasting at least seven days after last use, as well as the potential for acute psychotic symptoms immediately after use. We found moderate evidence that adults who use marijuana regularly are more likely than non-users to have symptoms or diagnosis of depression.

Marijuana Use and Respiratory Effects

The committee reviewed literature focused on marijuana use and effects to the respiratory tract. We found substantial evidence that marijuana smoke contains many of the same carcinogens found in tobacco smoke. We also found substantial evidence that acute use – (within the past hour) – results in immediate, short–term improvement in lung airflow. This finding includes use of both smoked and edible marijuana products. However, we found moderate evidence that heavy marijuana smoking is associated with mild airflow obstruction. In addition, we found substantial evidence heavy marijuana smoking is associated with chronic bronchitis, including chronic cough, sputum production, and wheezing. Finally, we found substantial evidence that heavy marijuana smoking is associated with pre-malignant lesions in the airway, but mixed evidence for whether or not marijuana smoking is associated with lung cancer.

Marijuana Use and Extrapulmonary Effects (non-respiratory body systems)

Unlike other literature reviews outlined in this document, there were relatively few literature reports of marijuana use related to myocardial infarction (heart attacks), ischemic stroke, male infertility, testicular cancer, prostate cancer and bladder cancer. We found limited evidence that marijuana use may increase risk for both heart attack and some forms of stroke. These findings were most closely associated with recent, and in some cases heavy, marijuana use. Limited evidence also suggests an increased risk in both testicular (non-seminoma) and prostate cancers with marijuana use. Evidence was mixed for whether or not marijuana use increased the risk of male infertility.

Marijuana Use and Injury

Our literature review focused on the increased risk of injury with marijuana use in a variety of settings (occupational, motor vehicle, recreational). The committee found substantial evidence that risk of motor vehicle crash doubles among drivers with recent marijuana use. Additionally, we found substantial evidence for a positive relationship between THC blood level and motor vehicle crash risk – that is, substantial evidence that the higher the level of THC in blood, the higher the crash risk. Finally, the committee found the combined use of marijuana and alcohol increases motor vehicle crash risk more than use of either substance alone. For non-traffic injuries, the evidence is limited, but data suggest the risk of non-traffic workplace injuries may be higher with marijuana use.

Public Health Recommendations

The committee made a number of public health recommendations interspersed throughout this report. These recommendations loosely fall into several categories but almost all of the recommendations include some effort to standardize data quality (marijuana use frequency), standardize procedures (roadside THC testing) and improve monitoring of use patterns and health outcomes. Standardized data collection on method of marijuana use, amount and frequency should be encouraged across medical specialties and on survey tools used in Colorado to better characterize use patterns and dose among users. The committee also

recommends data collection on the THC content of Colorado products to better characterize the THC dose of a typical user. In addition, improved information on blood THC levels of drivers is needed to effectively monitor the impact of driving under the influence of marijuana.

The committee recommended many educational interventions ranging from information on safe storage to protect the youngest Coloradans, to information for adult users, their families, and health care providers. 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 (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., defining impairment in frequent users). These research gaps provide an important framework for prioritizing 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.

Research gaps identified by the committee had five common themes: 1) Additional research using marijuana with THC levels consistent with currently available products; 2) Research on impairment in regular marijuana users who may have developed tolerance; 3) Research to identify improved testing methods for impairment either through alternate biological testing methods or physical tests of impairment; 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 CBD; and 5) Research to better characterize possible differences in health effects between heavy (daily or near daily), regular(weekly or more), and occasional (less than weekly) users.

Table 1.
Substantial and Moderate Findings from Systematic Literature Review

	Substantial	Moderate
Marijuana Use During Pregnancy & Breastfeeding (p.75)		Decreased IQ scores Attention problems Decreased growth Decreased cognitive function Decreased academic ability
Unintentional Marijuana Exposures in Children (p.87)		Legal marijuana access increases unintentional marijuana exposures in children Child resistant packaging reduces unintentional pediatric poisonings
Marijuana Use Among Adolescents and Young Adults (p.94)	Other illicit drug use and addiction after adolescence Psychotic symptoms or disorders like schizophrenia	Impaired cognitive abilities and academic performance after 28 days abstinence Less high school graduation Increased MJ use and addiction after adolescence Alcohol or tobacco use and addiction after adolescence Quitting lowers risks
Marijuana Dose and Drug Interactions (p.103)	Increased risk of driving impairment at blood [THC] 2-5 ng/mL Smoking > 10 mg THC leads to blood [THC] near or > 5 ng/mL within 10 minutes Smoking > 10 mg THC leads to driving impairment	Ingesting ≥15mg THC may lead to blood [THC] > 5 ng/mL Inhaling vaporized THC leads to blood [THC] similar to smoking same dose Higher blood [THC] in impaired drivers now than in past

Table 1 (Continued).
Substantial and Moderate Findings from Systematic Literature Review

	Substantial	Moderate
Marijuana Dose and Drug Interactions (p.103)	Ingesting > 10 mg THC leads to driving impairment Waiting at least 6 hrs after smoking < 18 mg resolves/nearly resolves driving impairment Waiting at least 8 hrs after ingesting < 18 mg resolves/nearly resolves driving impairment Time to peak blood [THC] up to four hours post oral ingestion Passive exposure does not lead to positive screen by urine or blood	Waiting at least 6 hrs after smoking < 35 mg resolves/nearly resolves driving impairment
Marijuana Use and Neurological, Cognitive, and Mental Health Effects (p.116)	Impaired memory to at least 7 days abstinence (heavy users) Acute psychotic symptoms during intoxication	Depression [symptoms or diagnosis], (regular users)
Marijuana Use and Respiratory Effects (p.125)	Same carcinogens in marijuana smoke as tobacco smoke Chronic bronchitis with cough/wheeze/sputum Precancerous lesions in airways Acute use improves airflow	Heavy use increases airflow obstruction
Marijuana Use and Injury (p.142)	Increased MV crash risk THC level and MV crash risk Combined use with alcohol increases MV crash risk	

Systematic Literature Review Process

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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

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

* Dr. Vigil'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

Through C.R.S. 25-1.5-110, 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."

Based on this charge, CDPHE appointed a 13-member expert committee, the Retail Marijuana Public Health Advisory Committee (RMPHAC), to review the known and potential health effects of marijuana use. Members of this committee (see Retail Marijuana Public Health Advisory Committee Membership Roster) consisted of individuals in the fields of public health, medicine, epidemiology, and toxicology who had demonstrated expertise related to marijuana through their work, training, or research. This committee was charged with the duties as outlined in C.R.S. 25-1.1-110 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 RMPHAC was appointed in April 2014, had its first organizational meeting in May 2014, and began the scientific review process in June 2014. At the organizational meeting, the committee established its 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 established a series of topics for review 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, 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 the committee meeting.

Overview of Systematic Review Process

The committee utilized a PRISMA framework to ensure 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 a modified GRADE system which is a well-accepted method for systematic literature review[2].

4. Group related findings: Each finding is categorized based on population, exposure, or outcome.

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. 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.” Animal experimentation searches were excluded in the advanced search function using NOT: "animal experimentation [mesh] OR rat OR rats OR mouse OR mice OR rodent OR rodents OR monkey OR monkeys OR rabbit OR rabbits OR pigeon OR pigeons OR dog OR dogs OR cat OR cats.”

Rating the Findings

Findings were rated based on a modified GRADE system as high, medium, or low quality defined as outlined below. 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 significant 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. The primary considerations for 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.)
- Full vs. selective outcome reporting

- Effect size and width of confidence intervals
- Temporal relationship between exposure and effect
- Completeness of follow-up

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. 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 sub-grouping of findings:

Levels of Marijuana Use

- Heavy marijuana use: daily or near daily (5-7 days/week)
- Regular marijuana use: weekly (1-4 days/week)
- Occasional marijuana use: less than weekly
- Recent Use: use within the past hour
- Any Level of Use: evidence for all of the above
-

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 indicates robust scientific findings that support the outcome and no credible opposing scientific evidence. Substantial was defined as any of the following:

- At least one high quality finding, plus supporting findings, with no opposing findings
- At least three medium quality findings, with no opposing findings
- Many high quality findings that heavily outnumber opposing findings
- At least two high quality findings from systematic reviews or meta-analyses published within the past 10 years

Moderate evidence indicates that scientific findings support the outcome, but these findings have some limitations. Moderate was defined as any of the following:

- A single high quality finding only, with no opposing findings
- At least one medium quality finding, plus supporting findings with no opposing findings; supporting findings can include animal studies
- Mixed findings, heavily favoring one conclusion (opposing findings must be low quality)
- Many medium quality findings that heavily outnumber opposing findings
- A single high quality finding from a systematic review or meta-analysis published within the past 10 years

Limited evidence indicates modest scientific findings that support the outcome, but these findings have significant limitations. Limited was defined as any of the following:

- A single medium quality finding only
- Two or more low quality findings in agreement
- One low quality finding supported by animal studies
- Mixed findings, most favoring one conclusion

Mixed evidence indicates both supporting and opposing scientific findings for the outcome with neither direction dominating. Mixed was defined as any of the following:

- Mixed findings, with neither direction dominating
- Mixed findings, with a medium or high quality study on each side

Insufficient evidence indicates that the outcome has not been sufficiently studied. Insufficient was defined as the following

- A single low quality finding or less
- The relevant parameters to be examined have not been adequately defined or established

Evidence 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.

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 evidence becomes "is strongly associated"
- Moderate evidence becomes "is associated"
- Limited evidence becomes "may be associated"
- Mixed evidence becomes "There is conflicting research 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 2015 and 2016. 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 information becomes available or public health needs change.

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Marijuana Use During Pregnancy and Breastfeeding

Systematic Literature Review

Retail Marijuana Public Health Advisory Committee
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Introduction

Marijuana use in pregnant and breastfeeding mothers is a public health concern due to the potential harmful effects of tetrahydrocannabinol (THC) on the developing fetus – with specific focus on the potential risk for birth defects, abnormal growth and physical development, and perhaps most critically, sub-normal brain development. Adverse effects of alcohol and tobacco consumption during pregnancy are well-documented. While research on fetal health outcomes related to marijuana exposure is limited, there is no known "safe" amount of marijuana use for women during pregnancy. Additionally, biological evidence demonstrates that THC is present in the breast milk of women who use marijuana during the months they are breastfeeding, and there is evidence that infants who drink breast milk containing THC absorb and metabolize THC.

U.S. and international prevalence estimates exist for marijuana use among pregnant women. The National Survey on Drug Use and Health (NSDUH) in 2012-2013 reported 4.9% of pregnant 15-44 year old women used marijuana in the past month.[1] Schauberger and colleagues reported in 2014 on the prevalence of marijuana use in pregnant women in a private practice in Wisconsin. Two hundred women had urine tests at intake; seven tested positive for marijuana (3.5%).[2] Both Australia and the U.K. report use in pregnant women of 1 to 4%[3, 4]. These estimates provide some quantification of both the at-risk population of children born to woman who use during pregnancy and/or while breastfeeding, and also the population of women on which prevention and education messaging should be targeted.

Marijuana use during pregnancy to reduce symptoms of "nausea during pregnancy" recently has been documented by the Pregnancy Risk Assessment and Monitoring System (PRAMS) data from 2009-2011 by the state of Hawaii and published by Roberson[5]. Of the 2.6% of pregnant women who reported use during pregnancy, 21.2% reported severe nausea. Local research by the Tri County Health Department (TCHD) in Colorado in 2014 supports the findings reported by Hawaii regarding marijuana use for symptom relief of nausea, and also for pain, depression, anxiety and stress. [See Monitoring Changes in Marijuana Use Patterns: Women, Infants, and Children, for more information.]

Key Findings

The potential for adverse outcomes in exposed offspring of marijuana-using mothers prompted the committee to review the available literature on physical, developmental and mental health outcomes. We reviewed the literature for marijuana use during pregnancy and while breastfeeding. Outcomes reviewed included those apparent at birth as well as physical, neurocognitive, and mental health findings throughout childhood and adolescence. We found moderate evidence that maternal use of marijuana during pregnancy is associated with negative effects on exposed offspring, including decreased academic ability, cognitive function and attention. Importantly, these effects may not appear until adolescence. We also found moderate evidence that maternal use of marijuana during pregnancy is associated with decreased growth in exposed offspring.

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 amount, frequency, and method of use is limited. Adequate assessment of the link between marijuana use during pregnancy and adverse health outcomes, for both pregnant women and their exposed offspring, must begin with consistent, standardized data collection about marijuana use from pregnant women at all their pregnancy-related medical appointments and be followed by collection of accurate birth outcome data. The committee recommended public health monitoring to help clarify the possible contribution of marijuana use to major birth defects.

Educational programs for pregnant women, their families, and health care providers who care for pregnant women are needed to ensure more information is shared about the known health effects, and also about what is unknown at present. Reducing the stigma associated with admitted marijuana use during pregnancy would improve the ability of 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 should be available and distributed at marijuana dispensaries.

The committee identified several research gaps, including the need for more research 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. More research also is needed regarding the possible association between the use of marijuana and increased risk of miscarriage, as well as infant health risks from use by breastfeeding moms.

Table 1:
Findings Summary: Effects on exposed offspring of maternal marijuana use during pregnancy and breastfeeding

Substantial	Moderate	Limited	Insufficient	Mixed
	Decreased growth	Stillbirth	Psychosis symptoms	Preterm delivery
	Decreased IQ scores in young children	SIDS (evidence of no association)	Breastfeeding and SIDS	Low birth weight
	Decreased cognitive function	Increased depression symptoms	Initiation of future marijuana use	Small for gestational age
	Decreased academic ability	Delinquent behavior		Decreased birth weight
	Attention problems	Isolated simple ventricular septal defects		Newborn behavior issues
				Breastfeeding and infant motor development
				Birth defects including NTD, gastroschisis
				Frequency of use during adolescence

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.

Birth Outcome Risks of Marijuana Use During Pregnancy

Birth Defects -

1. We found MIXED evidence for whether or not maternal use of marijuana during pregnancy is associated with birth defects.[6-8]

2. We found MIXED evidence for whether or not maternal use of marijuana during pregnancy is associated with neural tube defects such as anencephaly.[9-11]

3. We found MIXED evidence for whether or not maternal use of marijuana during pregnancy is associated with gastroschisis.[9, 12]

4. We found LIMITED evidence that maternal use of marijuana during pregnancy is associated with isolated, simple ventricular septal defects (heart defects).[13]

Preterm Delivery

5. We found MIXED evidence for whether or not maternal use of marijuana during pregnancy is associated with preterm delivery.[3, 7, 14-18]

SIDS

6. Based on LIMITED evidence, there does not appear to be an association between maternal use of cannabis during and after pregnancy and SIDS.[19-21]

Stillbirth

7. We found LIMITED evidence that maternal use of marijuana during pregnancy is associated with an increased risk of stillbirth.[22]

Decreased Birth Weight

8. We found MIXED evidence for whether or not maternal use of marijuana during pregnancy is associated with decreased birth weight.[6, 7, 14, 24-29]

Low Birth Weight (birth weight <2,500g regardless of gestational age)

9. We found MIXED evidence for whether or not maternal use of marijuana during pregnancy is associated with low-birth weight infants.[3, 16, 17, 23]

Small for Gestational Age (birth weight less than 10th percentile for gestational age)

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.[3, 7, 18]

Effects of Prenatal Marijuana Use on Exposed Offspring

11. We found INSUFFICIENT evidence that maternal marijuana use during pregnancy is associated with initiation of marijuana use by the exposed offspring during adolescence.[30]

12. 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.[30, 31]

13. We found MIXED evidence for whether or not maternal use of marijuana during pregnancy is associated with newborn behavior issues.[32-35]

14. We found MODERATE evidence that maternal use of marijuana during pregnancy is associated with decreased growth in exposed offspring.[36, 37]

15. We found MODERATE evidence that maternal use of marijuana during pregnancy is associated with attention problems in exposed offspring. [38-41]

16. We found MODERATE evidence that maternal use of marijuana during pregnancy is associated with decreased IQ scores in exposed offspring. [42, 43]

17. We found MODERATE evidence that maternal use of marijuana during pregnancy is associated with reduced cognitive function in exposed offspring.[44-46]

18. We found MODERATE evidence that maternal marijuana use during pregnancy is associated with decreased academic ability of exposed offspring.[47-49]

19. We found LIMITED evidence that maternal use of marijuana during pregnancy is associated with increased depression symptoms in exposed offspring.[50]

20. We found INSUFFICIENT evidence to suggest that maternal marijuana use during pregnancy is associated with psychosis symptoms in exposed adolescent offspring.[51]

21. We found LIMITED evidence that maternal marijuana use during pregnancy is associated with delinquent behaviors in exposed offspring. [52]

Marijuana Use and Breastfeeding

22. Biological evidence shows that THC is present in the breast milk of women who use marijuana.[53]

23. Biological evidence shows that infants who drink breast milk containing THC absorb and metabolize the THC.[53]

24. We found MIXED evidence for whether or not an association exists between maternal use of marijuana while breastfeeding and motor development in exposed infants.[54, 55]

25. 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.[20]

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.

4. Maternal use of marijuana during pregnancy is associated with negative effects on exposed offspring, including decreased academic ability, cognitive function and attention. These effects may not appear until adolescence.

5. Marijuana use during pregnancy may be associated with an increased risk of heart defects (isolated simple ventricular septal defects) in exposed offspring.

6. Marijuana use during pregnancy may be associated with an increased risk of stillbirth.

7. There is conflicting research for whether or not marijuana use during pregnancy is associated with increased marijuana use in exposed offspring.

8. Marijuana use during pregnancy may be associated with increased depression symptoms and delinquent behaviors in exposed offspring.

9. There are negative effects of marijuana use during pregnancy regardless of when it is used during pregnancy.

10. 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, 2) developing and targeting public health education and prevention strategies for high-risk sub-populations.

Data Quality Issues

- Need for standardization of data collection on dose, amount, frequency and method of marijuana use
- Need to separate and account for other drug use

Surveillance

- Better data on prevalence of marijuana use in pregnant and breastfeeding women
- Enhanced surveillance for birth outcomes
- Collection of reported marijuana use in electronic health records
- Data collection to identify specific populations for public health intervention (geography, income, race, etc.)

Education

- Education of health care providers
- Education of pregnant women
- Public education
- Educational materials provided at dispensaries

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.

- Effect of cannabidiol (CBD) and other cannabinoids
- Effect of consumption of edibles or by vaping
- Contribution of smoking marijuana to its health effects
- Effect on miscarriage
- Marijuana use and breastfeeding;
    - Effect on growth and weight gain in infants
    - Length of time THC remains in breast milk
    - Replication of presence of THC in breast milk, including comparison of amount of THC in breast milk to maternal blood THC levels
- Studies to correlate urine THC levels with presence of THC in breast milk

- Pair self-report with biomarker testing in Colorado
- Impact of potency on health effects
- Reasons for use of marijuana during pregnancy/breastfeeding

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Unintentional Marijuana Exposures in Children

Systematic Literature Review

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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* Dr. Vigil'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

In the years following the commercialization of medical marijuana (2010 and later) Dr. Wang, an assistant professor of pediatric emergency medicine, identified an increasing trend in unintentional marijuana poisonings at the hospital where he was employed. He subsequently published confirmation of his findings in 2013 in the Journal of the American Medical Association – Pediatrics. In 2014 he and his colleagues, having previously identified this trend in Colorado, expanded their review to include unintentional pediatric exposures reported to poison control centers in both Colorado and other states where medical marijuana is legal. Their findings, published in 2014 in the Annals of Emergency Medicine, demonstrate a statistically significant increase in calls to poison control centers for unintentional ingestion of marijuana by children in states that have legalized medical marijuana. This literature review provided the committee with insight on best practices for safer storage of marijuana products using child-resistant packaging.

Key Findings

The committee found moderate evidence that more unintentional marijuana exposures of children occur in states with increased legal access to marijuana, and the exposures can lead to significant clinical effects requiring medical attention. Additionally, we found moderate evidence that use of child-resistant packaging reduces unintentional pediatric poisonings.

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

As in many other medical specialties, there is a critical need to collect complete data on amount and type of marijuana product ingested. For pediatric exposures, this data is critical for clinical management if emergency medical services or hospitalization is needed. Continued monitoring of RMPDC and CHA data for 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 care providers about safe adult use and safe storage. Further research is needed on marijuana exposures and outcomes

in Colorado, including comparisons with other states, both those with similar legal environments for marijuana and those with no legal access. Additional research is needed on harm reduction associated with child-resistant packaging.

Table 1:
Findings Summary: Unintentional Marijuana Exposures in Children

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 CDPHE staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee.

1. We found MODERATE evidence that more unintentional marijuana exposures of children occur in states with increased legal access to marijuana; and the exposures can lead to significant clinical effects requiring medical attention.[1, 2]

2. We found MODERATE evidence that use of child-resistant packaging reduces unintentional pediatric poisonings from a wide range of hazardous household products including pharmaceutical products.[3-5]

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 associated with increased numbers of unintentional exposures in children which can lead to hospitalizations.

2. While little data are available for marijuana, evidence indicates that child resistant packaging prevents exposure to children from potentially harmful substances.

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 sub-populations.

Data Quality Issues

- Standardization of data collection on dose, amount, frequency and method of marijuana use in medical records and other surveillance data sources.

Surveillance

- Monitor pediatric accidental marijuana exposure emergency department visits.

Education

- Parental education about safe use and safe storage.

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 compare the factors associated with unintentional poisonings, for example between states with different legal status. These studies should include specific factors such as parental influences, marijuana marketing and marijuana packaging requirements.

Definitions

- Children: 0 to 8 years of age
- Adolescents: 9 through 17 years of age

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Marijuana Use Among Adolescents and Young Adults

Systematic Literature Review

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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* Dr. Vigil'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 most recent statistics indicate that approximately 20% of Colorado high school students have used marijuana within the last month and 37% have tried marijuana at some point.[1] Other surveys have indicated past month marijuana use in Colorado at 11% among 12 to 17 year olds and 29% among 18 to 25 year-olds; compared with 7% and 19%, respectively, for the United States.[2] With one in 10 adolescents and young adults using marijuana at least monthly, the importance of potential adverse health effects is a significant public health concern.

Adolescence through young adulthood is a critical window for social and emotional development and for neurocognitive functioning. It is also a time period with an increased risk of developing mental health disorders including depression and anxiety. A growing body of literature suggests parts of the brain continue to develop well into a person's twenties and that adolescent use of substances, including alcohol, may have lasting effects on functions such as memory and learning. Because of the relatively high prevalence of marijuana use among adolescents and young adults, combined with the sensitive time period of development for neurocognitive and mental health issues, it is of critical importance to systematically review the literature on this topic.

Key Findings

This literature review focused on the potential adverse effects of marijuana use among adolescents and young adults including effects on cognitive abilities, learning, memory, academic achievement, future use of substances such as marijuana and illicit drugs, and mental health issues. Our findings are outlined in the table below. We found substantial evidence for associations between adolescent and young adult marijuana use and future addiction to illicit drugs in adulthood. We found an increased risk for developing psychotic symptoms or psychotic disorders in adulthood among regular adolescent and young adult users. In addition, we found moderate evidence for associations between adolescent and young adult marijuana use and at least short-term impairment of cognitive and academic abilities. We also found moderate evidence indicating that adolescent marijuana users were less likely to graduate from high school and more likely to be addicted to marijuana, alcohol, and tobacco in adulthood. We found beneficial effects related to cessation of use including moderate evidence that adolescent and young adult marijuana users who quit have lower risks of cognitive and mental health disorders compared with those who continue to 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

A number of important public health recommendations were identified. There were significant limitations in the reviewed literature regarding the characterization of marijuana use. In order to facilitate future study on the effects of marijuana, it is important to improve data quality by systematically collecting information on the amount (dose), frequency, and method of marijuana use in the clinical setting as well as public health surveillance data sources. 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) and the Healthy Kids Colorado Survey (HKCS). 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. There also were a number of potential educational interventions identified including education regarding the potential adverse effects of marijuana for parents and school campuses.

Our review identified a number of important research gaps. A common theme among the research gaps was the need for longer-term studies with better defined marijuana-use histories. A particular need was identified for a larger study to evaluate the dose effects separately for occasional versus heavy users. Finally, studies using longer periods of abstinence are needed to evaluate the potential long-term cognitive effects.

Table 1.
Findings Summary: Marijuana Use and Potential Youth Health Effects

Substantial	Moderate	Limited	Insufficient	Mixed
Other illicit drug use and addiction after adolescence	Impaired cognitive abilities and academic performance after 28 days abstinence	Lower IQ after short abstinence		Anxiety after adolescence
Psychotic symptoms or disorders like schizophrenia	Less high school graduation	Less likely to earn college degree		Depression after adolescence
	Increased MJ use and addiction after adolescence			Suicidal thoughts or attempts
	Alcohol or tobacco use and addiction after adolescence			
	Quitting lowers risk of cognitive and mental health effects			

Evidence Statements

Evidence statements are based on systematic scientific literature reviews performed by CDPHE staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee.

1. We found MODERATE evidence that adolescents and young adults who regularly use marijuana are more likely than non-users to have ongoing impairment of cognitive and academic abilities for at least 28 days after last use.[3-6]

2. We found LIMITED evidence that adolescents who regularly use marijuana are more likely than non-users to score lower on IQ tests 12 hours or more after last use.[7-9]

3. We found MODERATE evidence that adolescents who regularly use marijuana are less likely than non-users to graduate from high school.[10-12]

4. We found LIMITED evidence that adolescents who regularly use marijuana are less likely than adolescent non-users to attain a college degree.[13-15]

5. We found MODERATE evidence that adolescent and young adult marijuana users are more likely than non-users to increase their use and to become addicted to marijuana in adulthood.[11, 12, 16]

6. 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.[11, 12, 17]

7. 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.[11, 15, 17-22]

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.[23, 24]

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.[23-28]

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.[28-31]

11. We found SUBSTANTIAL evidence that adolescents and young adults who regularly use marijuana are more likely than non-users to develop psychotic symptoms or psychotic disorders like schizophrenia in adulthood.[26, 32-36]

12. 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.[7, 9, 17, 27]

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. Regular 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. Regular marijuana use by adolescents and young adults is strongly associated with developing psychotic symptoms and disorders such as schizophrenia in adulthood.
    a. This risk is higher among those who start using marijuana at a younger age.
    b. This risk is higher with more frequent marijuana use.

3. Marijuana use by adolescents and young adults - even occasional use - is associated with future high-risk use of alcohol, tobacco, and other drugs like cocaine, ecstasy, opioids and methamphetamine.

4. Starting marijuana use during adolescence or young adulthood is associated with future marijuana addiction.

5. Marijuana use by adolescents may be associated with low academic achievement, such as not graduating from high school or attaining a university degree, lower income, and more unemployment.

6. There is conflicting research for whether or not marijuana use by adolescents and young adults is associated with depression, anxiety or suicidal thoughts.

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 sub-populations.

Data Quality Issues

- Standardization of data collection on dose, 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.

Surveillance

- Monitor adolescent use and the factors associated with adolescents initiating use, through surveys such as the Healthy Kids Colorado Survey.

- Monitor young adult use and the factors associated with initiation of use, through surveys such as the Behavioral Risk Factor Surveillance Survey and data from college campuses.
- Monitor adolescent and young adult marijuana related hospitalizations (both psychiatric and non-psychiatric) and emergency department visits.
- Monitor adolescent and young adult marijuana addiction treatment rates.

Education

- Public education.
- Educational materials at schools and colleges.
- Educational materials at dispensaries.
- Parental education.

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 occasional users, separate from regular or heavy users.
- 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.
- More studies are needed to assess the risk of increasing use or becoming addicted for occasional users, based on age of onset.
- 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 reported association, which may be confounded by other factors.

Definitions

Age Groups

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

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Marijuana Dose and Drug Interactions

Systematic Literature Review

Retail Marijuana Public Health Advisory Committee
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Introduction

Marijuana is second to alcohol as the most commonly detected drug among drivers. Nationally about 3% of adults (26 years of age and older) and 11% of 18 to 25 year olds reported driving under the influence of illicit drugs in the past year [1]. A 2007 National Highway Traffic Safety Administration (NHTSA) study found approximately 9% of weekend, nighttime drivers tested positive for marijuana.[2] In Colorado, 2013 data from the Colorado Department of Transportation indicated about 12% of the drivers tested for drugs were positive for THC only. These statistics suggest driving while under the influence of marijuana is a significant public health issue. Unfortunately, we know much less about the doses that lead to driving impairment and the necessary time to wait for impairment to resolve for marijuana as compared to alcohol. Complicating matters further are the different methods of marijuana use such as edibles and vaporizing, which may have different doses that cause impairment and different wait times to allow the impairment to resolve. In addition, information is needed in clinical settings regarding the potential for marijuana interactions with prescription drugs and in workplaces regarding the possibility of a positive drug screen from passive marijuana exposure.

Key Findings

This literature review focused on the dose-response of different methods of marijuana use with regard to THC blood levels and impairment. Additional review was performed to evaluate marijuana's interactions with other drugs and the possibility of a positive drug screen from passive marijuana exposure. Findings are outlined in Table 1: Findings Summary, Marijuana Dose and Drug Interaction. In general, we found, for occasional marijuana users, smoking, eating, or drinking marijuana containing 10 milligrams or more of THC is likely to cause impairment that affects the ability to drive, bike, or perform other safety sensitive activities. In addition, for these occasional users, 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.

The waiting time is longer for eating or drinking marijuana products, we found it is necessary for occasional users to wait at least eight hours for impairment to resolve after ingesting less than 18 milligrams of THC. A substantial finding regarding the use of edible marijuana products, was that it can take up to four hours after ingesting marijuana to reach the peak THC blood concentration and perhaps longer to feel the full effects. This has important implications for the time to wait between doses. Using alcohol and marijuana at the same time is likely to result in greater impairment than using either one alone. Finally, typical passive exposure to marijuana smoke is unlikely to result in a failed workplace urine test or a failed driving impairment blood test.

Clinical and pharmacokinetic data about marijuana's interactions with other drugs are limited at this time 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, clozapine, CNS depressants, disulfiram, hexobarbital, hydrocortisone, indinavir, ketoconazole, MAO inhibitors, phenytoin, theophylline, 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.

An important note, 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 data collection efforts to assess marijuana use patterns among Colorado users and the THC content of Colorado products to better characterize the THC dose of a typical user. In addition, improved information on blood THC levels of drivers is needed to effectively monitor the impact of driving under the influence of marijuana. Data collection efforts should be focused on blood THC levels with standardized timing of testing after accidents, especially for fatally-injured drivers and at-fault drivers. For improved public health monitoring, there is a definite need for centralized reporting of actual blood THC levels to effectively assess the increased risk of marijuana-related accidents. There are significant intervention opportunities for public education on marijuana-related impairment. However, in order to measure the impact of these educational interventions over time, there is a need for adding questions to 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.

Research gaps identified by the committee had four common themes: 1) Additional research using doses with THC levels consistent with currently available products; 2) Research on impairment in regular marijuana users who 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, and impairment related to newer methods of marijuana use such as edibles and vaporizing.

Table 1.
Findings Summary: Marijuana Dose and Drug Interaction

(Note: All statements apply only to occasional users, → = yields/produces)

Substantial	Moderate	Insufficient
Increased risk of driving impairment at blood [THC] 2-5 ng/mL	Ingesting ≥15 mg THC may → blood [THC] > 5 ng/mL	Passive MJ exposure → positive drug screen by oral fluid
Smoking >10 mg THC produces blood [THC] near or > 5 ng/mL within 10 minutes	Inhaling vaporized THC→ blood [THC] similar to smoking same dose	How long to wait after other methods (vaporizing, dermal or mucosal applications)
Smoking >10 mg THC→ driving impairment	Higher blood THC in impaired drivers now than in past	How long to wait after smoking ≥ 35 mg for impairment to resolve
Orally Ingesting >10 mg THC → driving impairment	Waiting ≥ 6 hrs after smoking < 35 mg → driving impairment resolves/nearly resolves	How long to wait after smoking, vaporizing, or oral use
Waiting ≥ 6 hrs after smoking < 18 mg → driving impairment resolves/nearly resolves		
Time to peak blood [THC] up to four hours post ingestion		
Passive exposure → NO positive drug screen by urine or blood		
Waiting ≥ 8 hrs after orally ingesting < 18 mg → driving impairment resolves/nearly resolves		

Evidence Statements

Evidence statements are based on systematic scientific literature reviews performed by CDPHE staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee.

1. We found SUBSTANTIAL evidence for meaningful driving impairment in occasional users with whole blood THC of 2-5 ng/mL.[3-6]

2. 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.[4, 7-9]

3. We found SUBSTANTIAL evidence that, for occasional users, smoking more than about 10 mg THC (or part of a currently available marijuana cigarette) is likely to meaningfully impair driving ability.[3, 4, 8, 10-20]

4. 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.[12, 21-25]

5. We found SUBSTANTIAL evidence that, for occasional users, ingesting 10 mg or more of THC is likely to meaningfully impair driving ability.[4, 12, 21, 24]

6. We found MODERATE evidence that inhaling vaporized marijuana yields blood THC levels that are similar to those produced by smoking the same dose.[26, 27]

7. We found MODERATE evidence that blood THC levels of marijuana-impaired drivers are higher now than in the past.[28]

8. We found SUBSTANTIAL evidence that delaying driving at least 6 hours after smoking less than 18 mg THC allows THC-induced impairment to resolve or nearly resolve for occasional users.[3, 4]

9. 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 occasional users.[10, 11, 13]

10. 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 occasional users.[4, 13]

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 occasional users.[4, 12, 22, 24]

12. 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 regular or heavy users after smoking, vaporizing, or oral ingestion of marijuana.[6, 10, 17, 19, 29, 30]

13. We found INSUFFICIENT evidence to determine the amount of time to delay driving after other methods of marijuana use (vaporizing and application of dermal and mucosal preparations) for occasional, regular, or heavy users.

14. We found SUBSTANTIAL evidence that an individual passively exposed to marijuana smoke (up to approximately 10% THC) under usual passive exposure conditions would NOT test positive for marijuana on a urine screening test or a blood test, given the current federal screening cutoff (50 ng/mL for urine cannabinoid metabolites) and the current Colorado limit for driving (5 ng/mL whole blood THC).[31-42]

15. We found INSUFFICIENT evidence to determine whether individuals passively exposed to marijuana smoke would screen positive by oral fluid testing because it has not yet been established which analyte or analytes to measure and which cutoff(s) to use.[32, 33, 43-45].

16. We found SUBSTANTIAL evidence that it takes up to 4 hours after ingesting marijuana to reach peak blood THC concentrations.[12, 21, 23, 24]

17. Biological evidence shows the combination of marijuana and alcohol or another sedating drug will cause greater impairment than that caused by marijuana, alcohol or the other drug used separately.[6, 30, 46-49]

18. Clinical and pharmacokinetic data about marijuana's interactions with other drugs are limited at this time 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, clozapine, CNS depressants, disulfiram, hexobarbital, hydrocortisone, indinavir, ketoconazole, MAO inhibitors, phenytoin, theophylline, 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.[27, 46, 50-63]

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. 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 occasional 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 smoking 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 eating or drinking 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.

2. It is important to delay consuming another THC-containing product until the effects from the first edible serving are known. For new or occasional users, it takes up to 4 hours to reach maximum blood levels of THC and potentially longer to feel the full effects of consuming a marijuana edible product.

3. Using alcohol and marijuana at the same time is likely to result in greater impairment than either one alone.

4. Typical passive exposure to marijuana smoke is unlikely to result in a failed workplace urine test or a failed driving impairment blood test.

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

6. Use caution when driving, biking, or performing other safety-sensitive activities after use of any form of marijuana including vaporized, tinctures, or topical products.

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 sub populations.

Data Quality Issues

- Monitor data on THC content of marijuana products in Colorado.
- Monitor data on marijuana use habits of Coloradans.
- Standardize timing of THC blood testing relevant to motor vehicle crashes and driving under the influence of drugs (DUID).
- Use better quality exposure measures of marijuana use, for example, blood THC levels instead of self-reported cannabis use for studies of impairment and accidents.
- Increase testing of drivers, especially fatally-injured drivers and at-fault drivers.

Surveillance

- Centralize reporting of blood THC levels (not just presence/absence of THC) for driving under the influence of drugs (DUID).
- Monitor self-reported impaired driving behaviors and perceptions of risk associated with impaired driving.
- Monitor formulation 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.
- Educate the public on using marijuana with other drugs and 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.

- 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.
- More research to address interactions between marijuana and prescription drugs.
- 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).

Definitions

Levels of Marijuana Use

- Heavy marijuana use: daily or near daily (5-7 days/week)
- Regular marijuana use: weekly (1-4 days/week)
- Occasional marijuana use: less than weekly

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	Reference
Chlorpromazine	Marijuana smoking increased clearance of chlorpromazine, as did tobacco smoking	N				P	[50]
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	N			P	P	[52]
CNS depressants	Additive drowsiness and CNS depression Includes: alcohol, opioids, sedative-hypnotics, barbiturates, benzodiazepine, buspirone, antihistamines, muscles relaxants, and many more	N		Y			[27, 46, 51]
Disulfiram	Possible hypomanic/psychotic reaction	N	P				[46, 51]
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	N					[54]
Hexobarbital	May enhance CNS depressant effect. CBD decreased metabolism of hexabarbital but did not change its clinical effects.	N		Y	P		[53]
Hydrocortisone	THC increased serum cortisol, but effect is blunted in frequent users. Theoretical possibility of cushingoid syndrome	N			P		[55]
Indinavir	Statistically significant decrease in peak concentration of indinavir with THC use	N				P	[56]
Ketoconazole	Peak THC concentration was increased by 27%	N	P	P			[62]
MAO Inhibitors	Possible enhancement of orthostatic hypotension	N					[46]
Nelfinavir*	No change in kinetic parameters.	N					[56]
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.	N		Y	P	P	[46, 57, 60]
Theophylline	Smoked marijuana lowers theophylline concentrations, similar to tobacco. Unclear if only a smoking-related effect. No studies of oral marijuana/THC.	N				P	[58, 61]
Warfarin	Possible enhanced anticoagulant effect	N			P		[46, 59, 63]

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Marijuana Use and Neurological, Cognitive and Mental Health Effects

Systematic Literature Review

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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Introduction

The most recent statistics from the U.S. Substance Abuse and Mental Health Service Administration (SAMHSA):National Survey on Drug Use and Health (NSDUH, 2013 survey) indicate approximately 10% of Colorado adults (ages 26+) used marijuana within the last month and 15% used marijuana within the past year[1]. With at least one in 10 adults using marijuana monthly, potential adverse health effects in this population are of significant public health concern.

Based on 2013 data from the National Survey on Drug Use and Health, Mental Health Findings, approximately 18.5% of American adults have a diagnosable mental, behavioral, or emotional disorder[1]. While the impact of these disorders can range from mild impairment to disability, all have a serious personal cost. In addition, these disorders place a considerable financial burden on our health care system. Some researchers have suggested marijuana use can cause mental health issues such as anxiety, depression, and psychosis. The relatively high prevalence of marijuana use among adults, combined with the large economic and public health burden of mental health disorders, necessitates systematic review of the literature on this topic.

Key Findings

This literature review focused on potential adverse effects of marijuana use among adults including effects on cognitive functioning; memory; and mental health issues such as anxiety, depression, and psychosis. Our findings are outlined in the table below. We found substantial evidence for associations between marijuana use and memory impairments lasting at least seven days after last use, as well as the potential for acute psychotic symptoms immediately after use. We found moderate evidence that adults who use marijuana regularly are more likely than non-users to have symptoms or diagnosis of depression.

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. There were significant limitations in the reviewed literature regarding the characterization of marijuana use. To facilitate future study on the effects of marijuana, it is important to improve data quality by systematically collecting information in clinical settings, as well as with public health surveillance data sources on the amount, frequency, and method of marijuana use. To better assess potential adverse outcomes, adult hospitalizations and emergency department visits related to marijuana use and mental health outcomes 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. Data on the prevalence of mental health disorders in combination with marijuana use also should be monitored using population-based surveys such as the Behavioral Risk Factor Surveillance System (BRFSS). Importantly the committee recommended the development and distribution of high-quality education materials on the potential mental health effects of marijuana use.

Our review identified a number of important research gaps. A common theme among the research gaps was the need for longer-term studies with better defined marijuana-use histories. Finally, studies using longer periods of abstinence are needed to evaluate the potential long-term cognitive 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).

Table 1.

Findings Summary: Marijuana Use and Neurological, Cognitive, and Mental Health Effects

Substantial	Moderate	Limited	Insufficient	Mixed
Impaired memory to at least 7 days abstinence (heavy users)	Depression (symptoms or diagnosis), (regular users)	Impaired decision-making up to 2 days after last use, (regular users)		Impaired executive functioning after short abstinence
Acute psychotic symptoms during intoxication		Anxiety (symptoms or diagnosis)		Cognitive impairment for at least 28 days after last use, (heavy users)
		Psychosis (symptoms or diagnosis)		

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.

1. We found SUBSTANTIAL evidence that adults who use marijuana heavily are more likely than non-users to have memory impairments for at least seven days after last use.[2-9]

2. We found SUBSTANTIAL evidence that THC intoxication can cause acute psychotic symptoms, which are worse with higher doses.[10-12]

3. We found MODERATE evidence that adults who use marijuana regularly are more likely than non-users to have symptoms or diagnosis of depression.[13, 14]

4. We found LIMITED evidence that adults who use marijuana regularly are more likely than non-users to have impaired decision-making for up to two days without use. [9, 15]

5. We found LIMITED evidence that adults who use marijuana are more likely than non-users to have symptoms or diagnosis of anxiety.[16]

6. We found LIMITED evidence that adults who use marijuana are more likely than non-users to have symptoms or diagnosis of psychosis, and increasing likelihood with greater marijuana use.[17]

7. 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.[3, 4, 6, 7]

8. We found MIXED evidence for whether or not adults who use marijuana heavily are more likely than non-users to have impairment of memory or other cognitive functions for at least 28 days after last use.[2, 4, 6, 18]

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. Heavy use of marijuana is associated with impaired memory, persisting a week or more after quitting.

2. Use of THC, a component of marijuana, can cause acute psychotic symptoms during intoxication.

3. Regular use of marijuana is associated with depression and may be associated with other mental health disorders such as anxiety and psychosis.

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 Issues

- Standardize data collection on dose, 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.

Surveillance

- Population-based monitoring of mental health conditions through surveys such as the Behavioral Risk Factor Surveillance System (BRFSS)
- Monitoring marijuana-related hospitalizations and emergency department (ED) visits.
- Monitoring marijuana addiction treatment rates.

Education

- Public education.

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 incorporating number of times used, rather than number of days used.
- More on duration of impact (after various lengths of abstinence).
- Effects of higher potency marijuana, especially dabbing (high-dose rate).
- Effects of different methods of use.
- Effects of other cannabinoids, especially cannabidiol (CBD).

Definitions

Levels of Marijuana Use

- Heavy marijuana use: daily or near daily (5-7 days/week)
- Regular marijuana use: weekly (1-4 days/week)
- Occasional marijuana use: less than weekly
- Acute marijuana use: Used within the last hour.
- Any level of use: evidence for all of the above

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Marijuana Use and Respiratory Effects

Systematic Literature Review

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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Introduction

The risks to lung health related to cigarette smoking are well-defined. This is not the case for marijuana smoking, and all types of marijuana use. Smoking lung topography differs greatly among the two substances. Marijuana smokers typically inhale a greater volume of smoke into their lungs and tend to hold the particulate-filled smoke in the lungs much longer.[1] Thus, while some commonalities exist between tobacco and cigarette smoke, there is a great deal we don't yet know about marijuana use and the potential for adverse health effects to the respiratory system, including the mucosal surfaces of the mouth, tongue, and throat and into the lungs.

Key Findings

This literature review focuses on marijuana use and potential adverse effects to the respiratory tract. Findings are outlined in Table 1: Findings Summary, Marijuana Use and Respiratory Effects. We found substantial evidence that marijuana smoke contains many of the same carcinogens found in tobacco smoke. We also found substantial evidence that acute use, in the preceding hour, results in immediate, short –term improvement in lung airflow. This finding includes use of both smoked and edible marijuana products. However, we found moderate evidence that heavy marijuana smoking is associated with mild airflow obstruction. In addition, we found substantial evidence that heavy marijuana smoking is associated with chronic bronchitis, including chronic cough, sputum production, and wheezing. We found substantial evidence heavy marijuana smoking is associated with pre-malignant lesions in the airway, but mixed evidence for whether or not marijuana smoking is associated with lung cancer.

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 standardization of data collection mentioned in many previous chapters. Improvements are needed in consistent collection of information on amount, frequency, and method of marijuana use in both clinical settings and

for public health surveillance data collection methodologies. Current methods for marijuana exposure assessment need improvement in both testing methodology and reporting requirements (i.e., blood THC levels instead of self-reports of use). Public health monitoring should include the assessment of new cases of lung cancer possibly related to marijuana use using data available in the Colorado Central Cancer Registry. 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 Center for Improving Value in Health Care (CIVHC) claims data systems. Educational opportunities exist with both primary and more 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 chronic obstructive pulmonary disease (COPD), lung function and lung cancer using older subjects with better defined marijuana-use histories. Prospective studies of groups of marijuana users' lung function and symptoms over long time periods are needed to address the long-term risk of marijuana use on respiratory diseases such as chronic bronchitis, asthma, and lung and oropharyngeal cancers. Additional research on the potential respiratory effects of newer 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

Substantial	Moderate	Limited	Insufficient	Mixed
Same carcinogens in marijuana smoke as tobacco smoke	Heavy use increases airflow obstruction	Increased particulate matter deposits compared to tobacco	Emphysema	COPD
Chronic bronchitis with cough/wheeze/ sputum		Bullous lung disease	Respiratory infections	Lung cancer
Pre-malignant lesions in airways		Smoke from water pipes or bongs contain more cancer-causing chemicals		Respiratory health effects from vaporizing
Acute use improves airflow				

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.

1. We found SUBSTANTIAL evidence that marijuana smoke, both mainstream and sidestream, contains many of the same cancer-causing chemicals as tobacco smoke.[2-5]

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, 7].

3. We found LIMITED evidence that smoking marijuana deposits more particulate matter per puff in the lungs compared to tobacco smoke.[1]

4. We found SUBSTANTIAL evidence that marijuana use (inhaled or oral) results in an immediate short-term improvement of lung airflow.[8-10]

5. We found MODERATE evidence that heavy marijuana smoking is associated with mild airflow obstruction.[11-14]

6. We found MIXED evidence for whether or not smoking marijuana is associated with chronic obstructive pulmonary disease (COPD).[14-20]

7. We found INSUFFICIENT evidence to suggest that marijuana smoking alone is associated with emphysema.[12, 13]

8. We found SUBSTANTIAL evidence that heavy marijuana smoking is associated with chronic bronchitis, including chronic cough, sputum production, and wheezing.[11, 13, 17, 21-24]

9. We found LIMITED evidence that heavy marijuana smoking is associated with bullous lung disease.[25-27]

10. We found INSUFFICIENT evidence to determine if smoking marijuana is associated with increased risk of respiratory infections.[23, 28]

11. We found SUBSTANTIAL evidence that heavy marijuana smoking is associated with pre-malignant lesions in the airway.[15, 29, 30]

12. We found MIXED evidence for whether or not marijuana smoking is associated with lung cancer.[31-36]

13. We found INSUFFICIENT evidence to determine if vaporizing marijuana is associated with respiratory health effects[6].

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 the same cancer-causing chemicals as tobacco smoke.

2. Marijuana smoke may deposit more particulate matter in the lungs per puff compared to tobacco smoke.

3. Smoke from water pipes or bongs may contain more cancer-causing chemicals per milligram of THC compared to smoke from unfiltered joints.

4. Regular marijuana smoking is associated with mild decreased airflow in the lungs. However, one-time marijuana use (edible or smoked) is strongly associated with immediate, short-term (1 to 6 hours) improved airflow in the lungs of healthy marijuana users and asthmatics.

5. There is conflicting research for whether or not regular marijuana smoking is associated with chronic obstructive pulmonary disease (COPD).

6. Heavy marijuana smoking is strongly associated with chronic bronchitis, including chronic cough, sputum production and wheezing.

7. Heavy marijuana smoking may be associated with a specific type of lung tissue destruction called bullous lung disease.

8. Heavy marijuana smoking is strongly associated with pre-malignant lesions that may lead to cancer in the airways of your lungs.

9. There is conflicting research for whether or not marijuana smoking is associated with lung 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, 2) developing and targeting public health education and prevention strategies for high-risk subpopulations.

Data Quality Issues

- Standardization of questionnaire data collection to include marijuana use, including method of use, frequency and dose, during spirometry and pulmonary function testing.

- Better quality exposure measures of marijuana use, for example, blood THC levels instead of self-reported cannabis use.

Surveillance

- Monitor statewide prevalence of Chronic Obstructive Pulmonary Disease (COPD) and asthma through existing population-based surveys.
- Monitor health care use involving bullous lung disease using Colorado Hospital Association and/or All-Payer Claims databases.
- Monitor lung cancer incidence using the Cancer Registry.

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, lung function and lung cancer using older subjects with better defined marijuana-use histories.
- 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.
- Improved studies assessing the risk of lung and oropharyngeal cancers related to marijuana use.
- Respiratory effects of newer methods of marijuana use (dabbing, vaporizing).

Definitions

- COPD: often used as umbrella term for emphysema and chronic bronchitis
- Emphysema: lung destruction and air trapping
- Chronic bronchitis: sputum production and cough

Levels of Marijuana Use

- Heavy marijuana use: daily or near daily (5-7 days/week)
- Regular marijuana use: weekly (1-4 days/week)
- Occasional marijuana use: less than weekly
- Acute marijuana use: Used within the last hour.
- Any level of use: evidence for all of the above

Age Groups

- Young Adult: 18 through 24 years of age
- Adult: 25 through 64 years of age
- Older Adult: 65 years of age and older

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Marijuana Use and Extrapulmonary Effects

Systematic Literature Review

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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Introduction

There is a limited body of literature on the potential for marijuana-related adverse health effects other than respiratory, neurological, and mental health. However, it is well known that marijuana use causes a dose-dependent increase in heart rate and smoking marijuana increases the levels of carboxyhemoglobin in the blood.[1] Based on these physiological responses, there is a plausible connection between marijuana use and an increased risk of heart attack (myocardial infarction) and possibly stroke. A small number of hormonal responses to marijuana use also have been documented including some related to spermatogenesis, which provides a possible link with decreased male fertility, prostate cancer and testicular cancer.[2] Finally, since marijuana smoke contains many of the same carcinogens as tobacco smoke, which is a well known cause of bladder cancer, it is plausible to consider marijuana use also may be linked with bladder cancer. Based on these plausible connections, our literature review focused on marijuana use and these outcomes.

Key Findings

Unlike other literature reviews outlined in this document, there were relatively few literature reports of marijuana use related to myocardial infarction, ischemic stroke, male infertility, testicular cancer, prostate cancer and bladder cancer. In fact, the findings as outlined in Table 1 below are categorized as limited, mixed, or insufficient evidence. We found limited evidence that marijuana use may increase risk for both heart attack and some forms of stroke. These findings were most closely associated with recent, and in some cases heavy, marijuana use. Limited evidence also suggests an increased risk in both testicular (non-seminoma) and prostate cancers with marijuana use. Evidence was mixed for whether or not marijuana use increased the risk of male infertility.

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

More study is needed to further define the contribution of marijuana use among other relevant risk factors for these outcomes. As with many other medical specialties, current

collection of information on marijuana use is limited. The link between adverse health outcomes – in cardiology and oncology medical settings – and exposures to marijuana may be demonstrated by the use of well designed, epidemiologic studies, for example case-control studies. Collecting accurate exposure (or dose) information and health outcome data will permit analysis of the data to determine the potential adverse health outcomes in individuals who use marijuana.

The committee recommended population-based public health monitoring using existing data sources such as the Colorado Central Cancer Registry to help identify any increases in the incidence of male reproductive cancers related to marijuana use. In addition, the committee recommended monitoring of Colorado Hospital Association hospitalization and emergency department data to further assess the potential connections between heart attacks, stroke, and marijuana use. Educational programs for adult users, their families, and health care providers who may care for them are needed to ensure more information is shared about the known health effects – and also about what is unknown at present. Education for health care providers on the known health effects of marijuana use may encourage more open dialog between providers and patients.

Additional research is needed on the relationship between marijuana use and risk of heart attack and stroke. Of particular importance is appropriate data collection on the timing of last marijuana use and other substance use in the period preceding these outcomes. High-quality observational research is needed to further assess the risks of infertility, cancer (testicular, prostate, bladder), and marijuana use.

Table 1
Findings Summary: Marijuana Use and Extrapulmonary Effects

Substantial	Moderate	Limited	Insufficient	Mixed
		Increased Risk of Myocardial Infarction (heart attack) with acute use	Death Due to Myocardial Infarction (heart attack) with acute use	Male Infertility
		Increased Risk of Ischemic Stroke	Increased Risk Bladder Cancer	
		Nonseminoma Testicular Cancer		
		Increased Risk of Prostate Cancer		

Evidence Statements

Evidence statements are based on systematic scientific literature reviews performed by CDPHE staff with oversight and approval by the Retail Marijuana Public Health Advisory Committee.

1. We found LIMITED evidence that acute marijuana use increases risk of myocardial infarction.[3, 4]

2. We found INSUFFICIENT evidence that acute marijuana use increases risk of death related to myocardial infarction/cardiovascular event. [5, 6]

3. We found LIMITED evidence that marijuana use increases risk of ischemic stroke.[7-9]

4. We found MIXED evidence for whether or not marijuana use increases risk of male infertility.[10-13]

5. We found LIMITED evidence that marijuana use among adult males increases risk of nonseminoma testicular cancer.[2, 14, 15]

6. We found INSUFFICIENT evidence to suggest that marijuana use in adults is associated with increased risk of transitional cell carcinoma of the bladder.[16-18]

7. We found LIMITED evidence that marijuana use among adult males increases risk of prostate cancer.[18]

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. Acute marijuana use may be associated with increased risk of heart attack among adults.

2. Marijuana use may be associated with increased risk of stroke in adults.

3. Marijuana use may be associated with nonseminoma testicular cancer.

4. Marijuana use may be associated with prostate cancer.

5. There is conflicting research for whether or not marijuana use is associated with male infertility.

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 sub populations.

Surveillance

- Monitor the prevalence of male cancers (prostate, testicular) through the Colorado Central Cancer Registry.
- Analyze emergency department data for associations between marijuana use and cardiovascular events/strokes.

Education

- Public education about the risks of cannabis use in older adults and seniors.

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.

- Assessment during an acute cardiovascular event for timing of last marijuana use, dose, and any concurrent use of other substances.
- Additional, high quality studies assessing the risk of cancers (prostate, testicular, others) related to marijuana use.
- Additional, high quality studies assessing male infertility risks related to marijuana use.

Definitions

Age Groups

- Young Adult: 18 through 24 years of age
- Adult: 25 through 64 years of age
- Older Adult: 65 years of age and older

Levels of Use

- Heavy marijuana use: daily or near daily (5-7 days/week)
- Regular marijuana use: weekly (1-4 days/week)
- Occasional marijuana use: less than weekly
- Acute marijuana use: Marijuana used within the last hour

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Marijuana Use and Injury

Systematic Literature Review

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Primary Author:
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Primary Reviewer:
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Introduction

Injury is defined as physical damage to the body resulting from acute exposure to some form of energy. It is well-known that marijuana use affects reaction time, memory, coordination, concentration, and perception of time and distance.[1] Together these effects cause physical impairment that may lead to an increased risk of an accident while driving, biking, or working. The most well-documented type of injury associated with impairment is motor vehicle accidents. For alcohol, the evidence of increased risk of crash due to impairment is overwhelming. For marijuana use, the body of literature published over the past 40 years is also compelling for the demonstration of significant impairment while driving under the influence of marijuana.

Key Findings

Our literature review focused on the increased risk of injury with marijuana use in a variety of settings (occupational, motor vehicle, recreational). Findings are outlined in Table One: Findings Summary, Marijuana Use and Injury. The committee found substantial evidence that risk of motor vehicle crash doubles among drivers with recent marijuana use. Additionally, we found substantial evidence for a positive relationship between THC blood level and motor vehicle crash risk, that is, the higher the level of THC in blood, the higher the crash risk. Finally, the committee found substantial evidence that the combined use of marijuana and alcohol increases motor vehicle crash risk more than use of either substance alone. For non-traffic injuries, the evidence is limited, but data suggest that the risk of non-traffic workplace injuries may be higher 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 recommended more consistent collection of blood samples following traffic accidents and fatalities, workplace injuries, and other injuries requiring medical attention in order to continue to gather information on level of THC and metabolites to assess dose and impairment. As previously identified in other chapters, current collection of information on

individual marijuana use history by amount/potency, frequency, and method is limited. 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.

Educational programs for adult users, their families, and health care providers are needed to ensure more information is shared about the known health effects and also about what is unknown at present. Educational materials about the potential risks of marijuana use and injury while under the influence should be available and distributed at marijuana dispensaries.

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 also is needed on differences in impairment levels based on marijuana use frequency and tolerance in regular and heavy users.

Table 1.
Findings Summary: Marijuana Use and Injury

Substantial	Moderate	Limited	Insufficient	Mixed
Increased MV crash risk		Increased risk of workplace injury	Injury risk differs by use frequency for MV crash	Increased risk non-traffic injury
THC level and MV crash risk				Combined use and non-traffic injury
Combined use with alcohol increases MV crash risk				Increased risk of recreational injury

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.

1. We found SUBSTANTIAL evidence that risk of motor vehicle crash doubles among drivers with recent marijuana use.[1-3]

2. We found SUBSTANTIAL evidence for a positive relationship between THC blood level and motor vehicle crash risk.[4, 5]

3. We found INSUFFICIENT evidence to suggest that motor vehicle crash risk differs for occasional users as compared to heavy users.[6-9]

4. We found SUBSTANTIAL evidence that combined use of marijuana and alcohol increases motor vehicle crash risk more than use of either substance alone.[4, 5, 10]

5. We found MIXED evidence for whether or not adults who use marijuana are at a higher risk of non-traffic related injuries.[11-17]

6. We found MIXED evidence for whether or not adults who use marijuana are at a higher risk of injury due to recreational activity.[2, 18, 19]

7. We found MIXED evidence for whether or not adults who use marijuana and alcohol combined are at a higher risk of injury than use of either substance alone.[11, 15, 20, 21]

8. We found LIMITED evidence that marijuana use increases workplace injury risk (non-driving injury).[13, 22, 23]

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. Driving soon after using marijuana doubles the risk of a motor vehicle crash.

2. Using alcohol and marijuana together increases the risk of a motor vehicle crash more than using either substance alone.

3. There is conflicting research for whether or not marijuana use is associated with an increased risk of injury during recreational activity among adults.

4. Marijuana use may be associated with increased risk of non-traffic-related, workplace injuries.

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 Issues

- Standardize timing of THC blood testing, relevant to motor vehicle crash, driving under the influence of drugs (DUID), workplace injury, and any injury requiring medical attention.
- Use better quality measure 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.

Surveillance

- Increase surveillance and centralize reporting of blood THC levels (not just presence/absence of THC) for driving under the influence of drugs (DUID), trauma, and workplace injury surveillance.
- Develop small-scale surveillance projects to assess the use of marijuana among those injured in recreational activities.
- Monitor the prevalence of marijuana use among older adults and the elderly due to the risk of fall-related injuries.
- Monitor self-reported impaired driving behaviors and perceptions of risk associated with impaired driving.

Education

- Public education about marijuana-related impairment (driving, biking, and safety-sensitive activities, including riding with impaired drivers).
- Public education about the risks of marijuana use related to falls in older adults and seniors.
- Public education about the risks of participating in recreational activities while under the influence of marijuana.

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.

- Relationship of saliva and urine levels to blood levels and relationship of all biomarkers to measures of functional impairment.
- Difference in impairment based on frequency of use/tolerance.
- Improvements in roadside testing (e.g., saliva).

Definitions

Age Groups

- Young adult: 18 through 24 years of age
- Adult: 25 through 64 years of age
- Older adult: 65 years of age and older

Levels of Marijuana Use

- Heavy marijuana use: Daily or near daily (5-7 days/week)
- Regular marijuana use: Weekly (1-4 days/week)
- Occasional marijuana use: Less than weekly
- Acute marijuana use: Use within the past hour

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Monitoring Possible Marijuana Related Health Effects

Summary and Key Findings

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

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Introduction

This chapter presents the initial efforts of the Colorado Department of Public Health and Environment (CDPHE) to monitor the potential population-based health effects of legalized marijuana. Through C.R.S. 25-1.5-110, 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 C.R.S 25-1.5-110 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 C.R.S. 24-1.1-110 to help "…make recommendations as appropriate, for policies intended to protect consumers of marijuana or marijuana products and the general public."

We analyzed the data in this chapter using the following four time periods that reflect the status of marijuana legalization in Colorado: 1) years 2000 and before - "prior to legalization of medical marijuana", 2) 2001 - 2009 - the initial period of "medical marijuana legalization", 3) 2010 – 2013 - the period of "medical marijuana commercialization", and 4) 2014 - the first year of retail (recreational) marijuana legalization. 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 utilization.

Rocky Mountain Poison and Drug Center (RMPDC) Exposure Call Data

The Rocky Mountain Poison and Drug Center 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. We analyzed change over time in RMPDC marijuana exposure related call volume.

Colorado Hospital Association (CHA) Data

CHA collects data on hospitalizations (HD) and emergency department (ED) discharges from participating hospitals in the state of Colorado. The data include patient demographics, admission and discharge dates, and up to 30 discharge diagnoses/billing codes (ICD-9-CM

codes). There are over 100 members of CHA which includes the vast majority of Colorado hospitals. However, the database does not include inpatient mental health facilities, ambulatory surgical centers, long term care facilities, and other outpatient treatment facilities. ED visits that result in a hospitalization are counted as a HD, making each HD and ED visit mutually exclusive events. HD and ED visits for non-Colorado residents are included in this database. The CHA HD data are available from 2000 through June of 2014 and the ED visits from 2011 through June of 2014. The CHA dataset was used to investigate rates of HD and ED visits associated with possible marijuana exposures using available diagnosis, and billing codes.

We examined HD and ED visit data in four different ways:

1. Possible marijuana exposures 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. Though psychodysleptic drugs include more than just marijuana, other drugs in this class have low prevalences of use. In addition, the age cut-off of 9 years was chosen to represent children who were unlikely to be intentionally using marijuana. However, these data are not specific for marijuana use or unintentional use. This is a significant limitation.

2. Possible marijuana exposures in patients 9 years and older:
   These data were chosen to represent intentional and unintentional overuse of marijuana by adolescents and adults and consisted of HD or ED visits that were coded with discharge codes related to poisoning by psychodysleptics. Similar limitations apply to these data as described above.

3. Possible Marijuana Exposures, Diagnoses, or Billing Codes in the First Three Diagnosis Codes:
   These data were chosen to represent the HD and ED visits where marijuana was likely a causal or strong contributing factor to the underlying reason for the HD or ED visit. These data consisted of HD and ED visits coded with discharge codes related to poisoning by psychodysleptics or separate codes related to cannabis abuse in the first three diagnosis codes, which are more likely to be clinically significant codes. However, without a full medical record review, we cannot determine with certainty whether marijuana was truly a casual or contributing factor. This is a significant limitation.

4. Possible Marijuana Exposures, Diagnoses, or Billing Codes in Any of 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. For these data, marijuana use is not necessarily related to the underlying reason for the HD or ED visit. Sometimes these data are referred to as HD or ED visits “with any mention of marijuana”. HD and ED visits in this group of data had been coded with the same codes as described in number three above, but the codes could be in any of the 15 to 30 diagnosis codes provided.

Key Findings

RMPDC Data

RMPDC calls represent self-reported human marijuana exposures with actual adverse health effects as reported by the caller. These calls are from the public or health care professionals caring for marijuana exposures. Poison center data are commonly used as a surrogate data source to determine the potential for adverse health effects from exposure to toxins and drugs like marijuana. The following are the key findings from analysis of the RMPDC data. A more detailed report can be found later in this chapter.

- RMPDC marijuana related exposure calls remained fairly constant with no significant upward or downward trend prior to medical marijuana commercialization (2001 to 2009).
- RMPDC marijuana related exposure calls have been gradually increasing since 2010 which corresponds to the first year of major medical marijuana commercialization in Colorado.
- In 2010, the first year of major medical marijuana commercialization, calls to the RMPDC related to marijuana more than doubled from 44 in 2009 to 95 in 2010.
- In 2014 the first year of retail marijuana sales, RMPDC marijuana related exposure calls increased by 74% from 127 in 2013 to 221 in 2014.
- In 2014, all age categories showed increasing marijuana exposure call counts with the largest increases in children aged 0-8 years and adults 25 years and older.

Colorado Hospital Association Data

The following are the key findings from analysis of the CHA data. A more detailed report can be found later in this chapter.

HD and ED Visits with Possible Marijuana Exposures in Children Under 9 Years Old

- Rates of HD and ED visits with possible marijuana exposures in children up to 9 years old have shown an increasing trend since the legalization of medical marijuana.
- Rates of HD with possible marijuana exposures in children up to 9 years increased more than five-fold from the 2001-2009 time period to the 2010-2013 time period.
- The highest rates observed for both HD and ED visits with possible marijuana exposures in children up to 9 years were in January to June of 2014.
- Rates of ED visits with possible marijuana exposures in children up to 9 years for January through June 2014 were not statistically different from the 2011-2013 time period.
- Rates of HD with possible marijuana exposures in children up to 9 years for January through June 2014 were increased significantly by more than three fold from the 2010-2013 time period.
- Counts of HD and ED visits with possible marijuana exposures in children up to 9 years by county revealed that higher numbers of HD and ED visits were in urban areas compared to rural areas and highest in Denver, Adams, and El Paso counties.

HD and ED Visits with Possible Marijuana Exposures in Patients 9 Years and Older

- Rates of HD with possible marijuana exposures in patients 9 years and older increased by 86% from the 2001-2009 time period to the 2010-2013 time period.
- The highest rates observed for both HD and ED visits with possible marijuana exposures in patients 9 years and older were in January through June 2014.
- Rates of ED visits with possible marijuana exposures in patients 9 years and older increased by 69.4% in January through June 2014 compared to the 2010-2013 time period.
- The rate of HD with possible marijuana exposures in patients 9 years and older for January through June 2014 was not statistically increased compared to the 2010-2013 time period.

HD and ED Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes in the First Three Diagnosis Codes

- Rates of HD and ED visits with possible marijuana exposures, diagnoses, or billing codes used in the first three diagnosis codes showed an increasing trend from 2010 to January through June of 2014
- Rates of HD with possible marijuana exposures, diagnoses, or billing codes used in the first three diagnosis codes increased by 29% from the 2001-2009 time period to the 2010-2013 time period, and by 42% from the 2010-2013 time period to January through June 2014.
- Rates of ED with possible marijuana exposures, diagnoses, or billing codes used in the first three diagnosis codes increased by 49% from the 2010-2013 time period to January through June 2014.

HD and ED Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes in Any of the Listed Diagnosis Codes

- Rates of HD with possible marijuana exposures, diagnoses, or billing codes had an increasing trend from 2000 to January through June of 2014. The same increasing trend was observed in ED visits from 2011 to January through June of 2014.
- Rates of HD with possible marijuana exposures, diagnoses, or billing codes increased by 28% from 2013 to January to June of 2014. A similar increase of 27% was observed for ED visits from 2013 to January to June of 2014.
- Rates of HD with possible marijuana exposures, diagnoses, or billing codes showed significant increases by each time period from 2000 to January through June 2014 with the highest increase of 79% from 2001-2009 to 2010-2013.
- Rates of ED visits with possible marijuana exposures, diagnoses, or billing codes significantly increased by 58% from January through June 2011-2013 to January through June 2014.
- Gender: Rates of HD with possible marijuana exposures, diagnoses, or billing codes significantly increased by each time period from year 2000 to January through June 2014 for both males and females.

- Age: Rates of HD with possible marijuana exposures, diagnoses, or billing codes significantly increased for all age groups from 2001-2009 to 2010-2013 and for those 18 and older for 2010-2013 to January through June 2014.
- Race/Ethnicity: Rates of HD with possible marijuana exposures, diagnoses, or billing codes significantly increased for all race/ethnicities from 2001-2009 to 2010-2013 and from 2010-2013 to January through June 2014.
- County: Rates of HD with possible marijuana exposures, diagnoses, or billing codes were higher in urban areas compared to rural areas for both 2004-2009 and 2010-2013. Rates increased from 2004-2009 to 2010-2013 in Adams, Clear Creek, Gilpin, Larimer, Crowley, Bent, Routt, Eagle, Pitkin, and Moffat counties.

Discussion

The overall intent of these data analyses was to begin to assess the potential impact of legalized marijuana on Colorado health. It is unrealistic to expect that firm conclusions can be drawn from six months to a year of data. However, our data analysis revealed the following observations:

- There are increasing trends of poison center calls, hospitalizations, and emergency department visits possibly related to marijuana in Colorado.
- Though based on only six months of data with the limitations described, the three-fold increase in the hospitalization rates for children with possible marijuana exposures for January through June 2014 compared to 2010-2013 represents an important public health concern that merits further study.
- In general, there were large increases in poison center calls, hospitalizations, and emergency department visits observed after medical marijuana was commercialized in 2010 and additional increases after retail (recreational) marijuana was legalized in 2014.
- There were similar increasing trends in hospitalization rates following medical marijuana commercialization and retail marijuana legalization for all genders, age groups, and race/ethnicities.
- Rates of hospitalizations and emergency department visits were generally higher in more urban counties. However, we also observed increases in hospitalizations in more rural counties.

All of these increases should be interpreted carefully in the context of the data limitations described. The observed increases have many potential explanations including the increased availability and use of marijuana in Colorado, an overall increased awareness regarding marijuana, changes in physician care or reporting related to marijuana, an increased honesty in reporting marijuana use to health care providers, or changes in coding practices by hospitals and emergency departments. In addition, for hospitalizations and emergency department visits, possible marijuana related cases account for 1% or less of the total Colorado hospitalizations or emergency department visits. More data and time are needed to determine if the observed increases are a direct and sustained result of Colorado marijuana use.

Recommendations & Future Directions

Based on these data, there are four main recommendations:

1. Continue using RMPDC and CHA data to monitor trends in potential marijuana health effects to assess the impact over time.
2. Data analyses should be expanded to include intent (reason), medical outcome and clinical effects from marijuana exposures.
3. Perform more detailed data analyses on unintentional exposures to marijuana in children under 9. This includes additional primary data collection on these events from medical records to assess the severity of the outcome, the source of the exposure, and possible public health intervention strategies.
4. Explore working with organizations such as the National Center for Health Statistics to improve the specificity of marijuana-related diagnosis and billing codes for hospitalization and emergency department visits.

In addition, to further elucidate specific health outcomes that may be related to marijuana use, CDPHE and the Retail Marijuana Public Health Advisory Committee are performing more in-depth analyses of RMPDC and CHA data. Over the next year, we will focus on injuries and acute health outcomes such as myocardial infarction and ischemic stroke in relation to marijuana exposure. We also will work with a hospital in a Colorado ski town to collect new data regarding marijuana use associated with ski-related injuries.

Rocky Mountain Poison and Drug Center (RMPDC) Data, 2000-2014

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Primary Authors:

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Primary Reviewers:

Judith Shlay, MD MSPH, Associate Director of Denver Public Health, Director of Health Promotion and Performance Improvement, Medical Director of the Immunization and Travel Clinic, Denver County Local Registrar, Professor of Family Medicine, University of Colorado School of Medicine.

Introduction

The Rocky Mountain Poison and Drug Center 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. 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.

Methods

RMPDC data were queried to assess counts of calls received regarding marijuana exposures. Counts of calls related to possible marijuana exposures were quantified by calendar year (Figure 1) for calls with marijuana exposures only and calls with marijuana exposures in combination with other drug exposures. Counts of calls with possible marijuana exposures were stratified into four age categories (Figure 2): 0-8 years, 9-17 years, 18-24 years, 25 years or older, and unknown age. To determine significant differences in numbers of calls related to marijuana across years, a Wald Chi-square test was performed using univariate Poisson regression.[1,2] A Bonferroni correction was used to adjust for multiple comparisons. There were 13 comparisons making the *p*-value required for significance less than or equal to 0.004.

Results

From 2001 to 2009, RMPDC call volume related to marijuana exposures remained fairly constant. However, in 2010 marijuana related calls significantly increased by more than double from 44 to 95[1]. From 2010 to 2013 counts of calls related to marijuana did not significantly increase. In 2014 calls related to marijuana exposures significantly increased by 74.0% from 127 to 221[2]. These increases appear to be driven by both calls with marijuana exposure only and calls with marijuana exposure in combination with other substances (Figure 1). All age categories show increasing trends in counts of calls related to marijuana exposures with the highest burden in children aged 0-8 years and adults 25 years and older for 2014 (Figure 2). These preliminary findings suggest counts of calls for marijuana exposures and possible adverse health outcomes have increased overall and across age categories over marijuana legalization eras since year 2000.

Limitations

Limitations of poison center data include participation bias: calls are self-reported, not all individuals with symptoms call the RMPDC, and not all health care providers managing patients with marijuana exposures call the poison center. Therefore, the number of cases

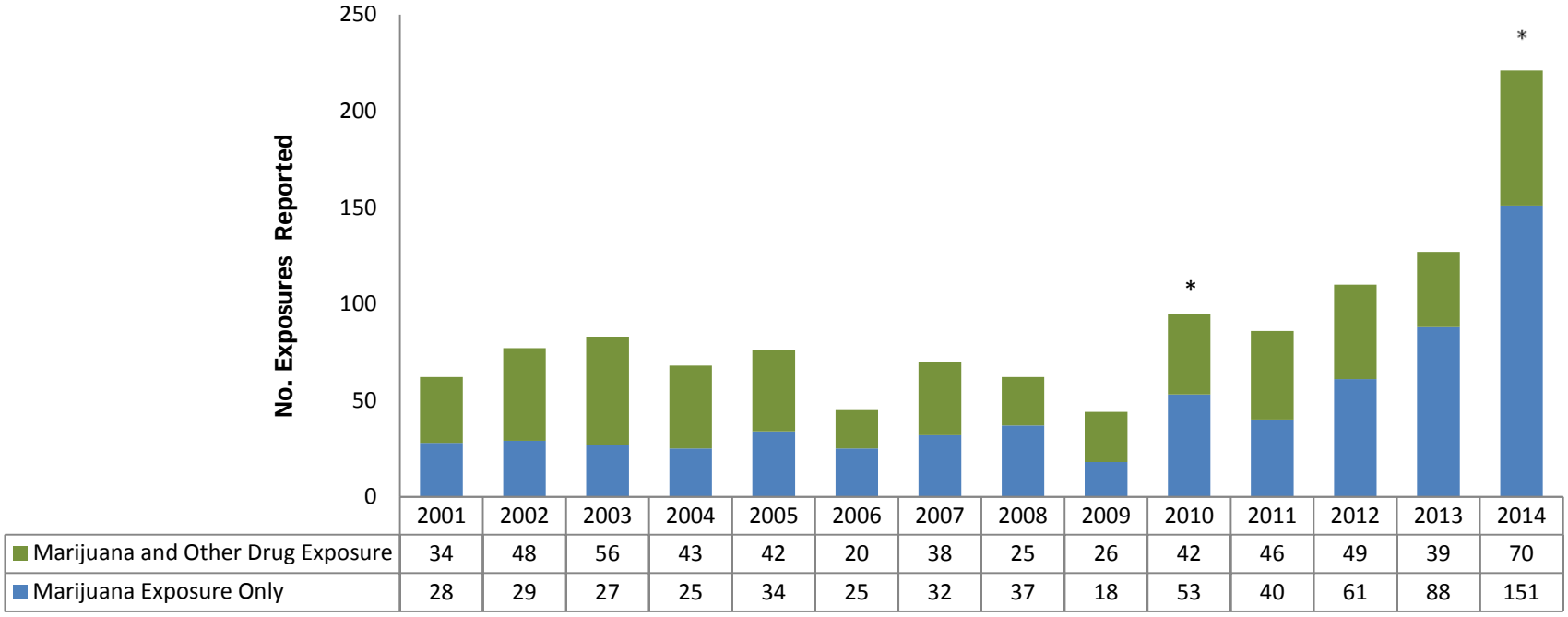
[1] ($X^2(1, N=1,226)=17.82$, $p<0.0001$)
[2] ($X^2(1, N=1,226)=24.75$, $p<0.0001$)

reported is likely an underestimate of the population that needs the services of either RMPDC or urgent/emergency medical services for a toxic exposure.

References

1. UCLA. SAS Data Analysis Examples Poisson Regression.
2. SAS. The GENMOD Procedure. In: *SAS OnlineDoc*. Version 8. Available at: http://www.math.wpi.edu/saspdf/stat/chap29.pdf.

Figure 1
Rocky Mountain Poison and Drug Center Marijuana Exposure Calls through December 31, 2014



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Marijuana and Other Drug Exposure	34	48	56	43	42	20	38	25	26	42	46	49	39	70
Marijuana Exposure Only	28	29	27	25	34	25	32	37	18	53	40	61	88	151

Marijuana Legalization Era	Medical Marijuana Legalized	Medical Marijuana Commercialized	Retail Marijuana Legalized

* Counts significantly increased from previous year with a p value <0.001.

Major Findings

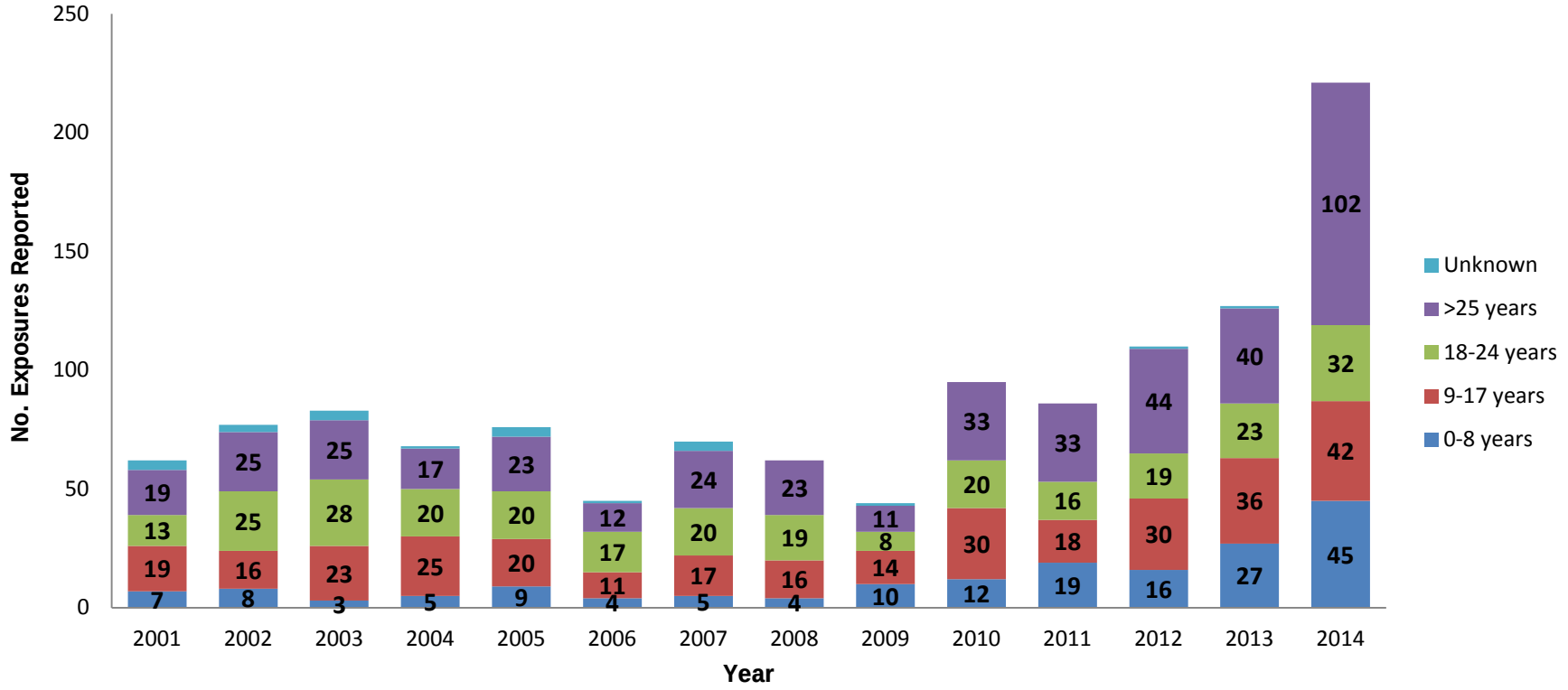
- Counts of calls remain fairly constant from 2001 to 2009.
- In 2010 calls related to marijuana significantly increased by more than double from 44 to 95 and in 2014 calls related to marijuana significantly increased by 74.0% from 127 to 221.

Data Details

- Data Source: Rocky Mountain Poison & Drug Center Calls received reporting marijuana exposure.
- 2014 data is January 1, 2014 through December 31, 2014.
- Graph shows number of calls received where each call is an individual exposure case.

Poison Center Data is typically used as a surrogate data source to determine the potential for adverse health effects from exposure to chemicals and drugs.

Figure 2
Rocky Mountain Poison and Drug Center Marijuana Exposure Calls through December 31, 2014 by Age Group of Case



Marijuana Legalization Era	Medical Marijuana Legalized	Medical Marijuana Commercialized	Retail Marijuana Legalized

Major Findings

- All age categories show increasing trends in calls related to marijuana exposures beginning in 2010.
- The largest increases from 2013 to 2014 were in children aged 0-8 years and adults 25 years and older.

Data Details

- Data Source: Rocky Mountain Poison & Drug Center Calls received reporting marijuana exposure.
- 2014 data is January 1, 2014 through December 31, 2014.
- Graph shows number of calls received where each call is an individual exposure case.
- Poison Center Data is typically used as a surrogate data source to determine the potential for adverse health effects from exposure to chemicals and drugs.

Colorado Hospital Association Data, 2000-2014

Retail Marijuana Public Health Advisory Committee
Final Approval: January 12, 2015

Primary Authors:

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Judith Shlay, MD MSPH, Associate Director of Denver Public Health, Director of Health Promotion and Performance Improvement, Medical Director of the Immunization and Travel Clinic, Denver County Local Registrar, Professor of Family Medicine, University of Colorado School of Medicine.

Technical Advisor:

Kirk Bol, MSPH, Program Manager, Vital Statistics, Colorado Department of Public Health and Environment.

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 up to 30 ICD-9-CM discharge diagnoses/billing codes and procedure codes. There are over 100 members 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, and other outpatient treatment settings. ED visits that result in a hospitalization are counted as an HD making each HD and ED visit mutually exclusive events. HD and ED visits for non-Colorado residents are included in this database. The CHA HD data are available from year 2000 through June of 2014 and the ED visits data from 2011 through June of 2014. The full year of 2014 data will not be available until March 2015. The CHA dataset was used to investigate rates of HD and ED visits associated with possible marijuana exposures, diagnoses, and billing codes.

Methods

Marijuana Exposures, Diagnoses, and/or Billing Codes

To determine HD and ED visits that were possibly associated with marijuana four ICD-9-CMdiagnosis codes were used. ICD-9-CM is a set of codes established by the World Health Organization and modified by the U.S. Centers for Disease Control. These codes are used to assign alphanumeric codes to patient diagnoses. The four codes used in these analyses were:

- E854.1 - Accidental poisoning by psychodysleptics (hallucinogens)
- 969.6 - Poisoning by psychodysleptics (hallucinogens)
- 305.2 - Nondependent cannabis abuse
- 304.3 - Cannabis dependence

For codes E854.1 and 969.6, psychodysleptics includes cannabis derivatives, lysergide (LSD), marihuana (derivatives), mescaline, psilocin, and psilocybin. The prevalence of use of other drugs in this category is low. HD and ED visits with possible marijuana exposure, diagnoses, or billing codes were determined by the presence of any of the four discharge codes. When examining HD and ED visits with marijuana exposures, only codes E854.1 and 969.6 were used. Each HD or ED visit with marijuana associated codes was counted once regardless of the number of marijuana associated codes listed. More details are provided in Appendix, Monitoring Possible Marijuana Related Health Effects, Hospitalization and Emergency Department Visits, Methods and Results.

We examined HD and ED visit data in four different ways:

1. Possible marijuana exposures 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. Though psychodysleptic drugs include more than just marijuana, other drugs in this class have a low prevalence of use. In addition, the age cut-off of 9 years was chosen to represent

children who were unlikely to be intentionally using marijuana. However, these data are not specific for marijuana use or unintentional use. This is a significant limitation.

2. Possible marijuana exposures in patients 9 years and older: These data were chosen to represent intentional and unintentional overuse of marijuana by adolescents and adults and consisted of HD or ED visits that were coded with discharge codes related to poisoning by psychodysleptics. Similar limitations apply to these data as described above.

3. Possible Marijuana Exposures, Diagnoses, or Billing Codes in the First Three Diagnosis Codes: These data were chosen to represent the HD and ED visits where marijuana use was likely a causal or strong contributing factor to the underlying reason for the HD or ED visit. These data consisted of HD and ED visits coded with discharge codes related to poisoning by psychodysleptics or separate codes related to cannabis abuse in the first three diagnosis codes which are more likely to be clinically significant codes. However, without a full medical record review, we cannot determine with certainty whether marijuana was truly a casual or contributing factor. This is a significant limitation.

4. Possible Marijuana Exposures, Diagnoses, or Billing Codes in Any of 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. For these data, marijuana use is not necessarily related to the underlying reason for the HD or ED visit. Sometimes these data are referred to as HD or ED visits "with any mention of marijuana". HD and ED visits in this group of data had been coded with the same codes as described in number three above, but the codes could be in any of the 15 to 30 diagnosis codes provided.

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 these findings.

- 2000 – Prior to Legalized Medical Marijuana
- 2001-2009 – Medical Marijuana Legalized
- 2010-2013 – Medical Marijuana Commercialized
- 2014 – Retail (Recreational) Marijuana Legalized

Demographics

HD and ED visits were stratified by gender, age, race/ethnicity, and county. More details on the demographics can be found in Appendix X.

Statistical Analysis

The SAS version 9.3 (SAS Institute Inc.) statistical software package was used for all statistical analyses. Details on the analysis populations can be found in Appendix X. Rates of HD and ED visits were calculated with the number of HD or ED visits with marijuana associated discharge 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. Rates of HD and ED visits were compared across years and marijuana legalization eras, and stratified by gender, age, race/ethnicity, and county. In examining rates across years, a percent change was calculated by each year to compare the trends across time. To determine significant differences in rates across marijuana legalization eras, a Wald Chi-square test was performed using univariate logistic regression.[1,2] A Bonferroni correction was used to adjust for multiple comparisons and the *p*-values required for significance were less than or equal to 0.001 and 0.003 for HD and ED visits respectively.

Results

A summary of the results can be found with the following figures and detailed results can be found in Appendix X.

Limitations

The use of marijuana-related ICD-9-CM 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 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 reporting marijuana use to health care providers, or changes in coding practices by hospitals and emergency departments. Changes in coding practices could result in an over or underestimate HD and ED visit rates depending on the marijuana legalization era.

Furthermore, overall rates are not adjusted for gender, race/ethnicity, or age. Stratification of rates by these demographics show they differ across these demographics, meaning some populations may have a higher burden than others.

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 diagnosis 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 associated code reflects that marijuana use was noted by the treating physician. Therefore, this summary quantifies HD and ED visits with marijuana associated 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.

Due to inconsistent and partial reporting by hospitals, early years of the HD data may be incomplete as well as 2011 ED visits data. Also, the data is cleaned in six-month intervals and

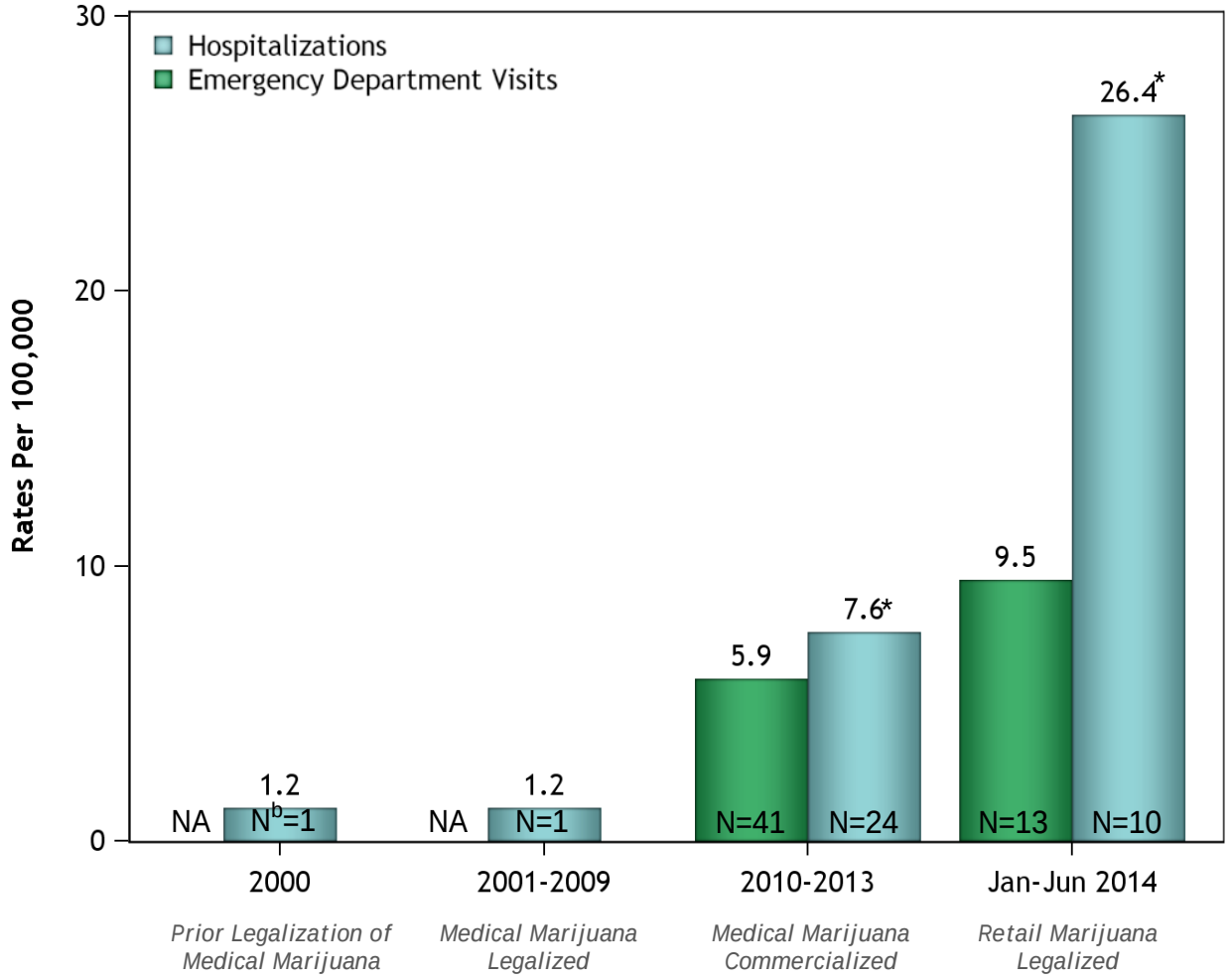
geocoded annually, making January through June the only available CHA data for 2014 and the county level data could only be examined from 2004 to 2013. Further limitations of the CHA data include the inability to link patients to multiple visits meaning the data cannot be analyzed at the individual patient level. The data must be interpreted as HD or ED visit events, which does not account for one individual with multiple events.

References

1. SAS. The GENMOD Procedure. In: *SAS OnlineDoc*. Version 8. Available at: http://www.math.wpi.edu/saspdf/stat/chap29.pdf.

2. UCLA. SAS Topics: Logistic (and Categorical) Regression. Available at: http://www.ats.ucla.edu/stat/sas/topics/logistic.htm. Accessed December 1, 2014.

Figure 1. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures[a] in Children Up to 9 Years per 100,000 HD and ED Visits in Children Under 9 Years Old by Time Period in Colorado.



[a] ICD-9-CM codes 969.6 and E854.1 were used to determine HD and ED visits with possible marijuana exposures.
[b] The Ns are the total number of HD or ED visits with possible marijuana exposures, diagnoses, or billing codes in the specified time period.
* Rate significantly increased from previous time period with a p-value <0.001.

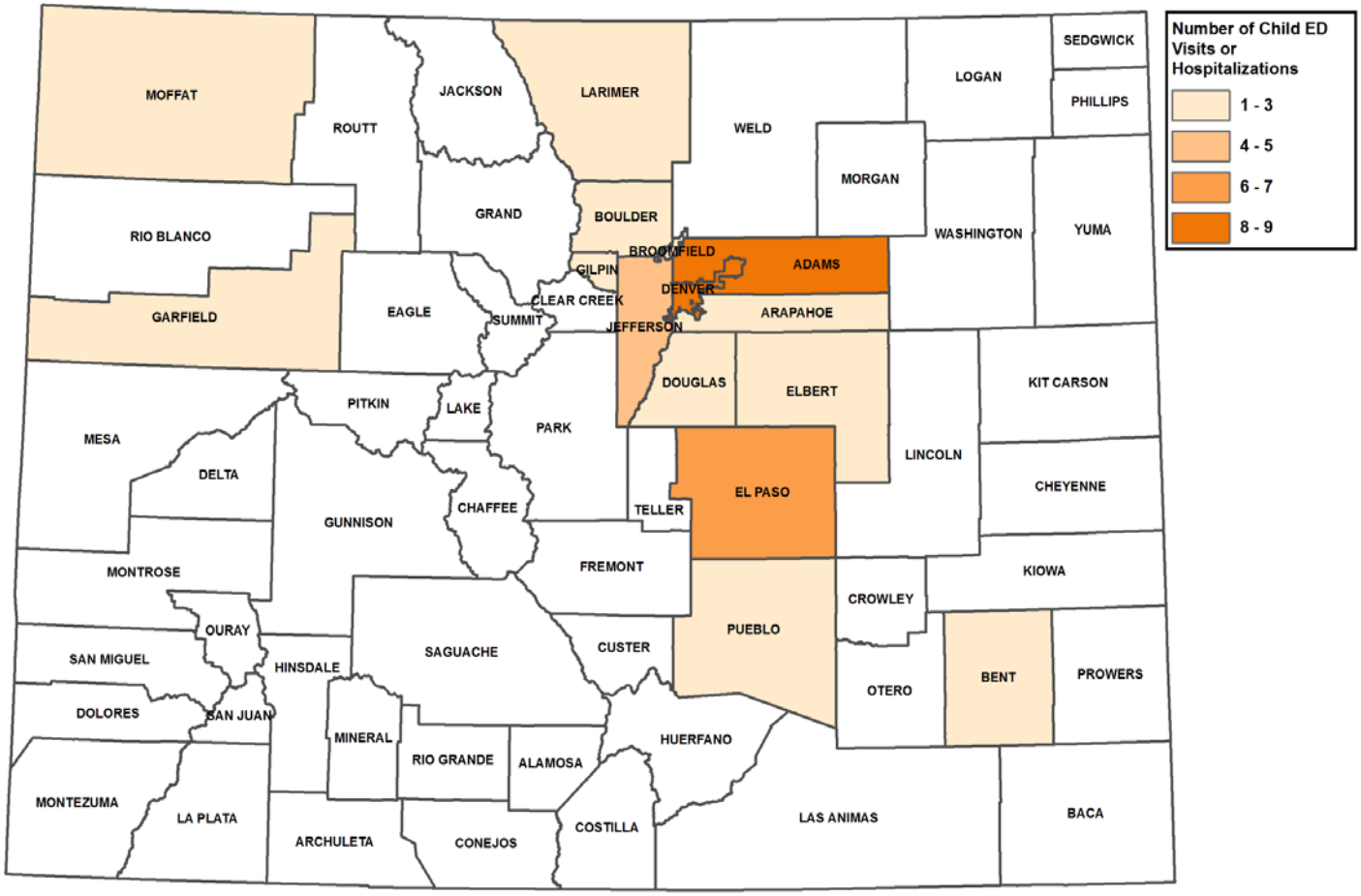
Major Findings

- Rates of HD and ED visits had an increasing trend from 2001-2009 (2011-2013 for ED visits) to January through June 2014.
- Rates of HD with possible marijuana exposures in children up to 9 years significantly increased from 2001-2009 to 2010-2013 by more than 5-fold.
- The highest rates for both HD and ED visits were in January to June of 2014 of 9.5 and 26.4 respectively.
- The rate of ED visits for January through June 2014 was not statistically significantly different from the 2011-2013 time period.
- The rate of HD for January through June 2014 increased more than three-fold, a statistically significant increase.

Data Details

- Data source: Colorado Hospital Association (CHA)
- 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available.
- A single individual can be represented more than once in the data; therefore, the rate is HD or ED visits per 100,000 HD or ED visits in children under 9.

Map 1. Numbers of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures[a] in Children Under 9 Years Old in Colorado from 2004-2013 by County.



[a] ICD-9-CM codes 969.6 and E854.1 were used to determine HD and ED visits with possible marijuana exposures.

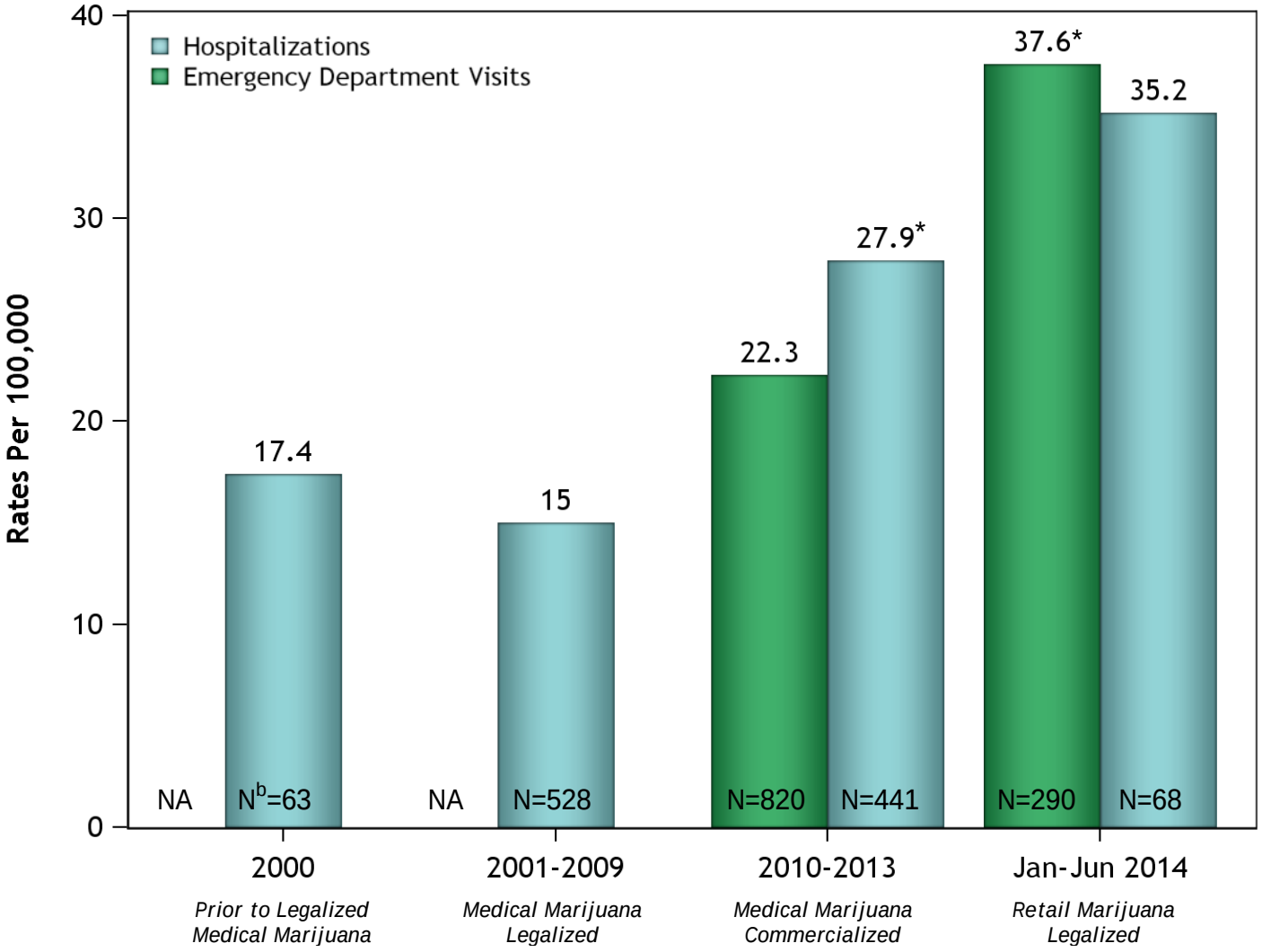
Major Findings

- Numbers of HD and ED visits were highest in Denver, Adams, and El Paso counties.
- Higher numbers of HD and ED visits were in urban areas compared to rural.

Data Details

- Data source: Colorado Hospital Association (CHA)
- Data geocoded from 2004 forward.
- 2014 data has not been geocoded and therefore not included in the map.
- Counties shown in white have no reported HD or ED visits with possible marijuana exposures in children under 9.
- A single individual can be represented more than once in the data, therefore the count is HD or ED visits.

Figure 2. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures[a] in Patients 9 Years and Older per 100,000 HD and ED Visits in Patients 9 Years and Older by Time Period in Colorado.



[a] ICD-9-CM codes 969.6 and E854.1 were used to determine HD and ED visits with possible marijuana exposures.
[b] The Ns are the total number of HD or ED visits with possible marijuana exposures, diagnoses, or billing codes in the specified time period.
* Rate significantly increased from previous time period with a p-value <0.001.

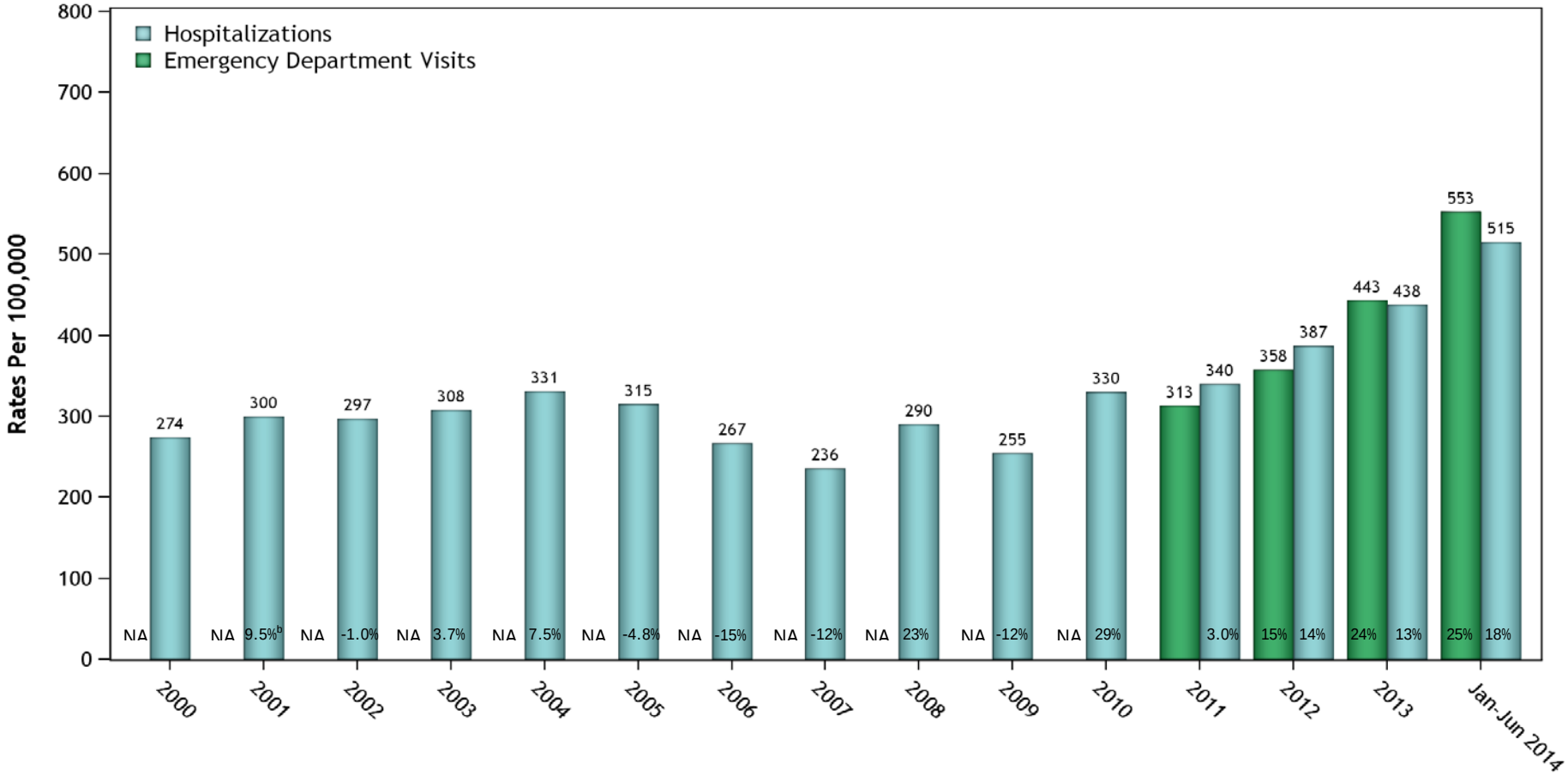
Major Findings

- Rates of HD with possible marijuana exposures in patients 9 years and older significantly increased from 2001-2009 to 2010-2013 by 86.0%.
- The highest rates for both HD and ED visits were in January through June 2014 of 35.2 and 37.6 respectively.
- The rate of HD for January through June 2014 was not significantly increased from 2010-2013.
- The rate of ED visits significantly increased from 2011-2013 to January through June 2014 by 69.4%.

Data Details

- Data source: Colorado Hospital Association (CHA)
- 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available.
- A single individual can be represented more than once in the data; therefore, the rate is HD or ED visits per 100,000 HD or ED visits in patients 9 years and older.

Figure 3. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes[a] in the First Three Diagnosis Codes per 100,000 HD and ED Visits by Year in Colorado.



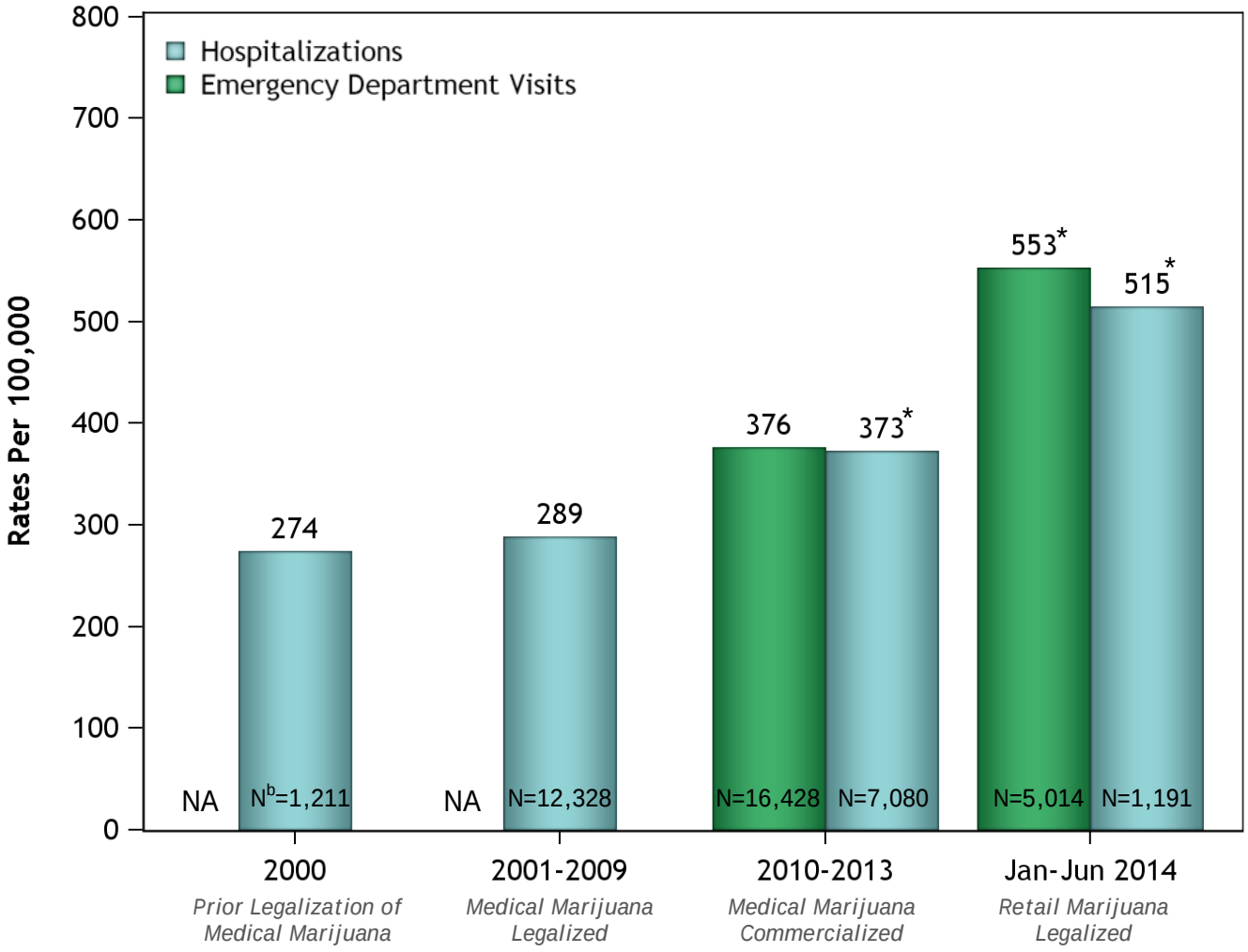
[a] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 in the first 3 listed diagnosis codes were used to determine HD/ED visits with possible marijuana exposure, diagnoses, or billing codes.
[b] Percent change in rates of HD and ED visits compared to the previous year.

Major Findings

- Rates of HD and ED visits with possible marijuana exposures, diagnoses, or billing codes in the first three diagnosis codes showed an increasing trend from 2010 to January through June of 2014.
- The highest increase in rates of HD was from 2009 to 2010 with an increase of 29%.
- For rates of ED visits the highest increase was from 2013 to January through June 2014 of 25%.
- The highest rates of HD and ED visits were in January through June 2014 of 515 and 553 respectively.

Data Details: Colorado Hospital Association Data, 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available.
A single individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 100,000 total HD or ED visits.

Figure 4. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes in the First Three Diagnosis Codes per 100,000 HD and ED Visits by Time Period in Colorado.



[a] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 in the first three listed diagnoses codes were used to determine HD and ED visits with possible marijuana exposure, diagnoses, or billing codes.
[b] The Ns are the total number of HD or ED visits with possible marijuana exposures, diagnoses, or billing codes in the specified time period.
* Rate significantly increased from previous time period with a p value <0.001.

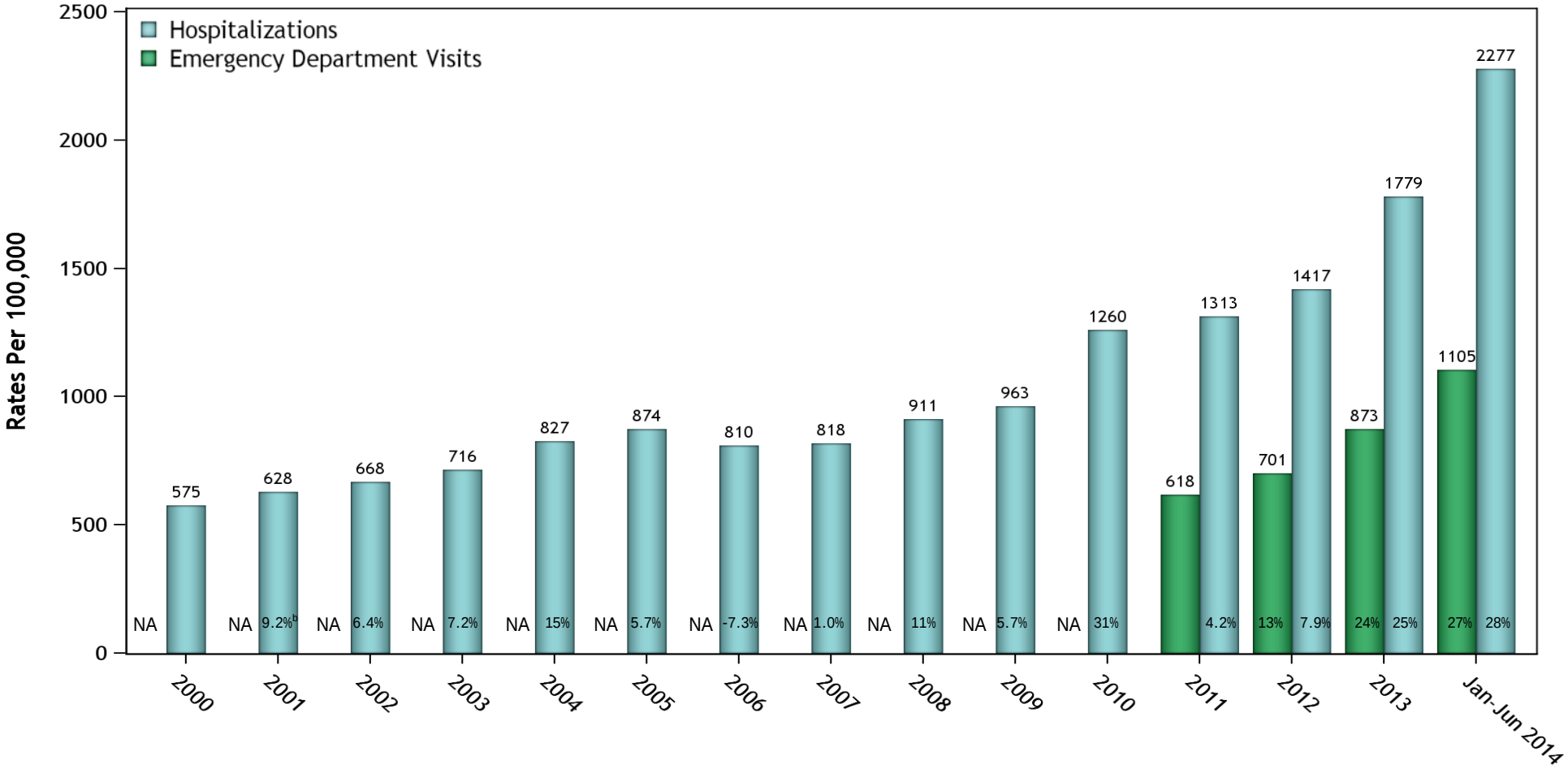
Major Findings

- Rates of HD with possible marijuana exposures, diagnoses, or billing codes in the first three diagnosis codes significantly increase by 29.1% from 2001-2009 to 2010-2013 and by 42.3% from 2010-2013 to January through June 2014.
- Rates of ED visits with possible marijuana exposures, diagnoses, or billing codes in the first three diagnosis codes significantly increase by 48.5% from 2011-2013 to January through June 2014.
- The highest rates of HD and ED visits were in January through June of 2014 of 515 and 553 respectively.

Data Details

- Data source: Colorado Hospital Association (CHA)
- 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available.
- An individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 100,000 total HD or ED visits.

Figure 5. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes[a] per 100,000 HD and ED Visits by Year in Colorado.



[a] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 were used to determine HD and ED visits with possible marijuana exposure, diagnoses, or billing codes.
[b] The Percent change in rates of HD and ED visits compared to the previous year.

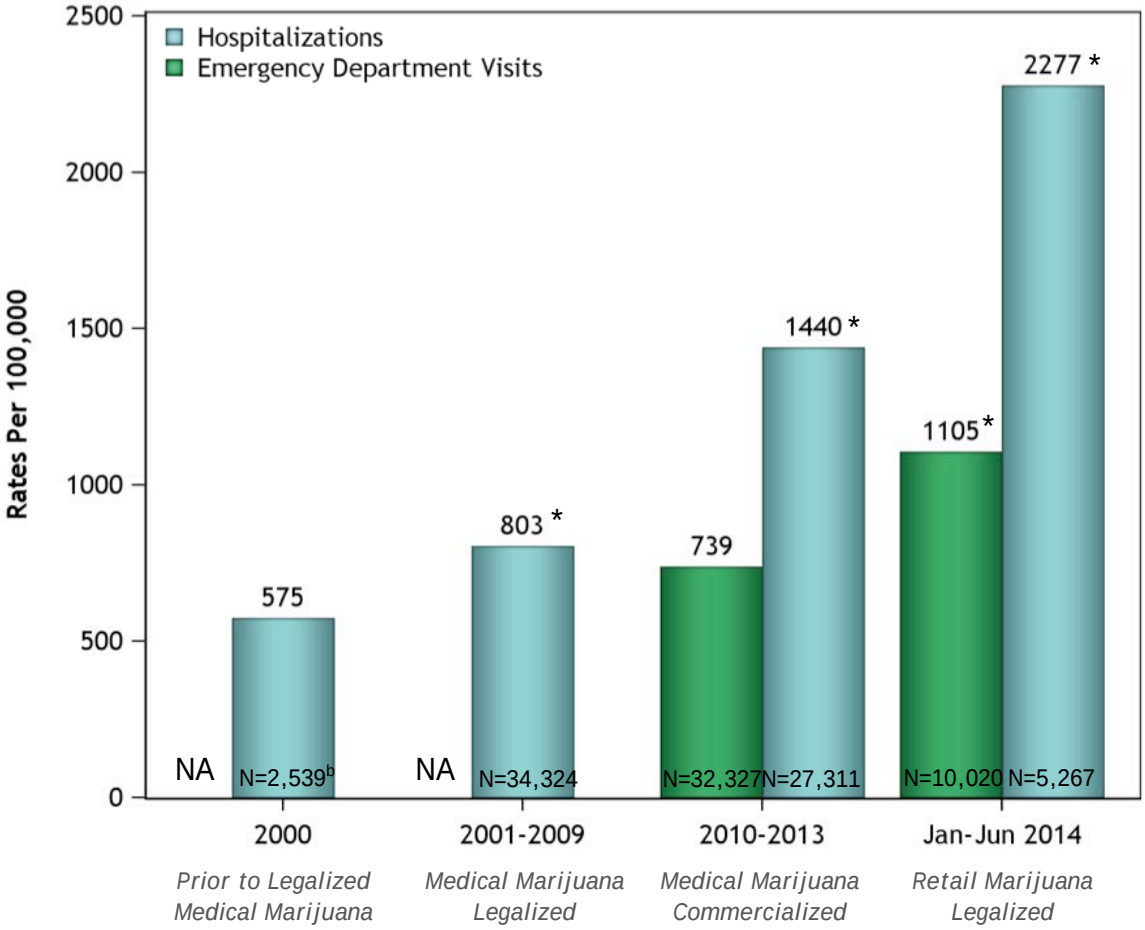
Major Findings

- Rates of HD and ED visits with possible marijuana exposures, diagnoses, or billing codes show an increasing trend over all years of available data.
- There was a 28% increase in rates of HD and a 27% increase in rates of ED visits with possible marijuana exposures, diagnoses, or billing codes from 2013 to January to June of 2014.

Data Details

- Colorado Hospital Association (CHA), 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available.
- An individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 100,000 total HD or ED visits.

Figure 6. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes[a] per 100,000 HD and ED Visits by Time Period in Colorado.



[a] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 were used to determine HD and ED visits with possible marijuana exposure, diagnoses, or billing codes.
[b] The Ns are the total number of HD or ED visits with possible marijuana exposures, diagnoses, or billing codes in the specified time period.
* Rate significantly increased from previous time period with a p value <0.001.

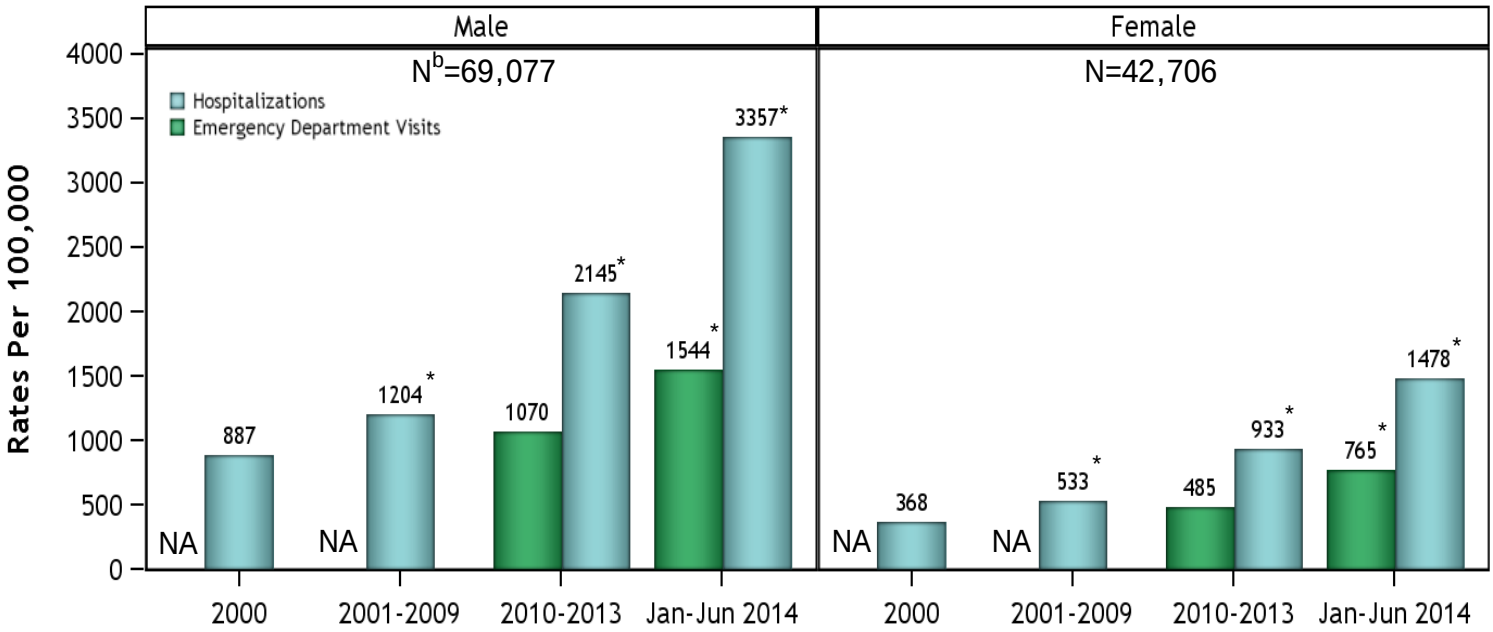
Major Findings

- Rates of HD with possible marijuana exposures, diagnoses, or billing codes significantly increased by each time period from 2000 to January through June 2014 with the highest increase of 79.3% from 2001-2009 to 2010-2013.
- Rates of ED visits significantly increased by 58.3% from January through June 2011-2013 to January through June 2014 from 698 to 1,105.
- The highest rates for both HD and ED visits were in January through June 2014 of 2,277 and 1,105 respectively.

Data Details

- Data source: Colorado Hospital Association (CHA)
- 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available.
- An individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 100,000 total HD or ED visits.

Figure 7. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes[a] per 100,000 HD and ED Visits by Time Period in Colorado and Gender.



[a] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 were used to determine HD and ED visits with possible marijuana exposure, diagnoses, or billing codes.
[b] The Ns are the total number of HD and ED visits with possible marijuana exposures, diagnoses, or billing codes for each gender.
* Rate significantly increased from previous time period with a p value <0.001.

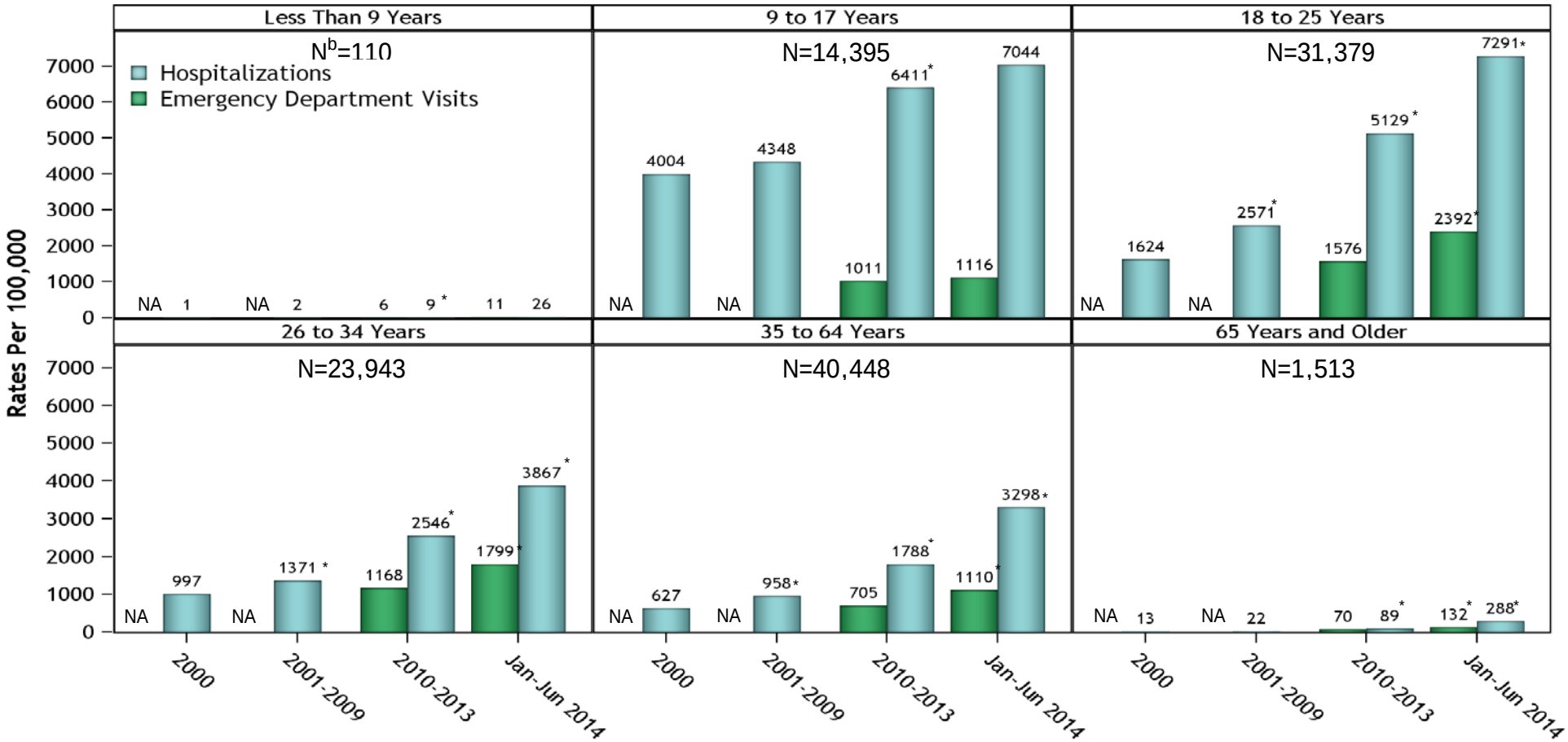
Major Findings

- Rates of HD with possible marijuana exposures, diagnoses, or billing codes significantly increased by each time period from year 2000 to January through June 2014 for both males and females.
- Rates of ED visits significantly increased from 2011-2013 to January through June 2014 for males and females.

Data Details

- Data source: Colorado Hospital Association (CHA)
- 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available.
- An individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 100,000 total HD or ED visits.

Figure 8. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes[a] per 100,000 HD and ED Visits by Time Period in Colorado and Age.



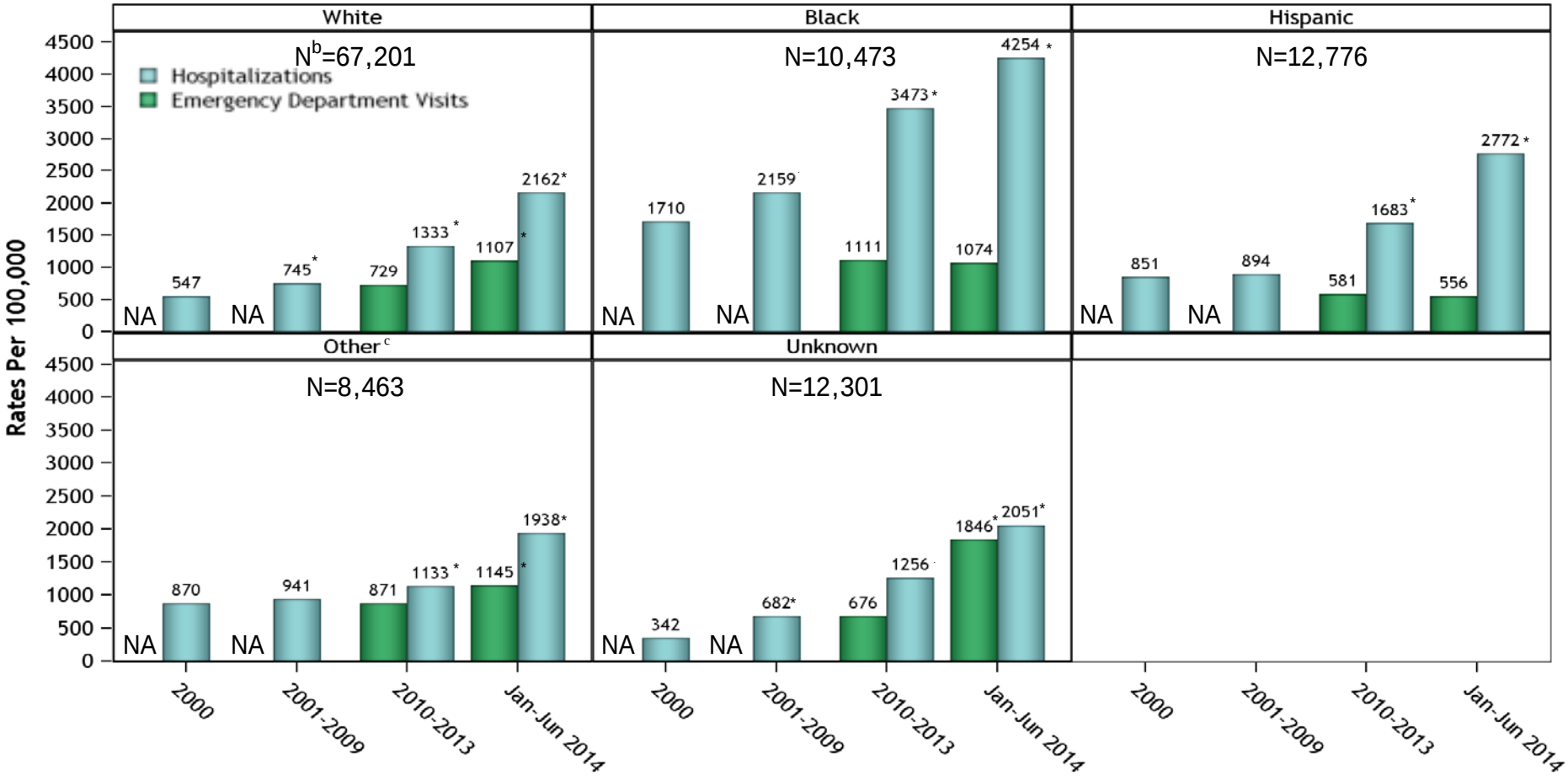
[a] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 were used to determine HD and ED visits with possible marijuana exposure, diagnoses, or billing codes.
[b] The Ns are the total number of HD or ED visits with possible marijuana exposures, diagnoses, or billing codes in the specified age group.
* Rate significantly increased from previous time period with a p value <0.001.

Major Findings

- Rates of HD with possible marijuana exposures, diagnoses, or billing codes significantly increased for all age groups from 2001-2009 to 2010-2013 and for those 18 and older for 2010-2013 to January through June 2014.
- Rates of ED visits with possible marijuana exposures, diagnoses, or billing codes significantly increased from 2011-2013 to January through June 2014 for all age groups except 9 to 17 years.

Data Details: Colorado Hospital Association (CHA), 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available. An individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 100,000 total HD or ED visits.

Figure 9. Rates of Hospitalizations (HD) and Emergency Department (ED) Visits with Possible Marijuana Exposures, Diagnoses, or Billing Codes[a] per 100,000 HD and ED Visits by Time Period in Colorado and Race/Ethnicity.



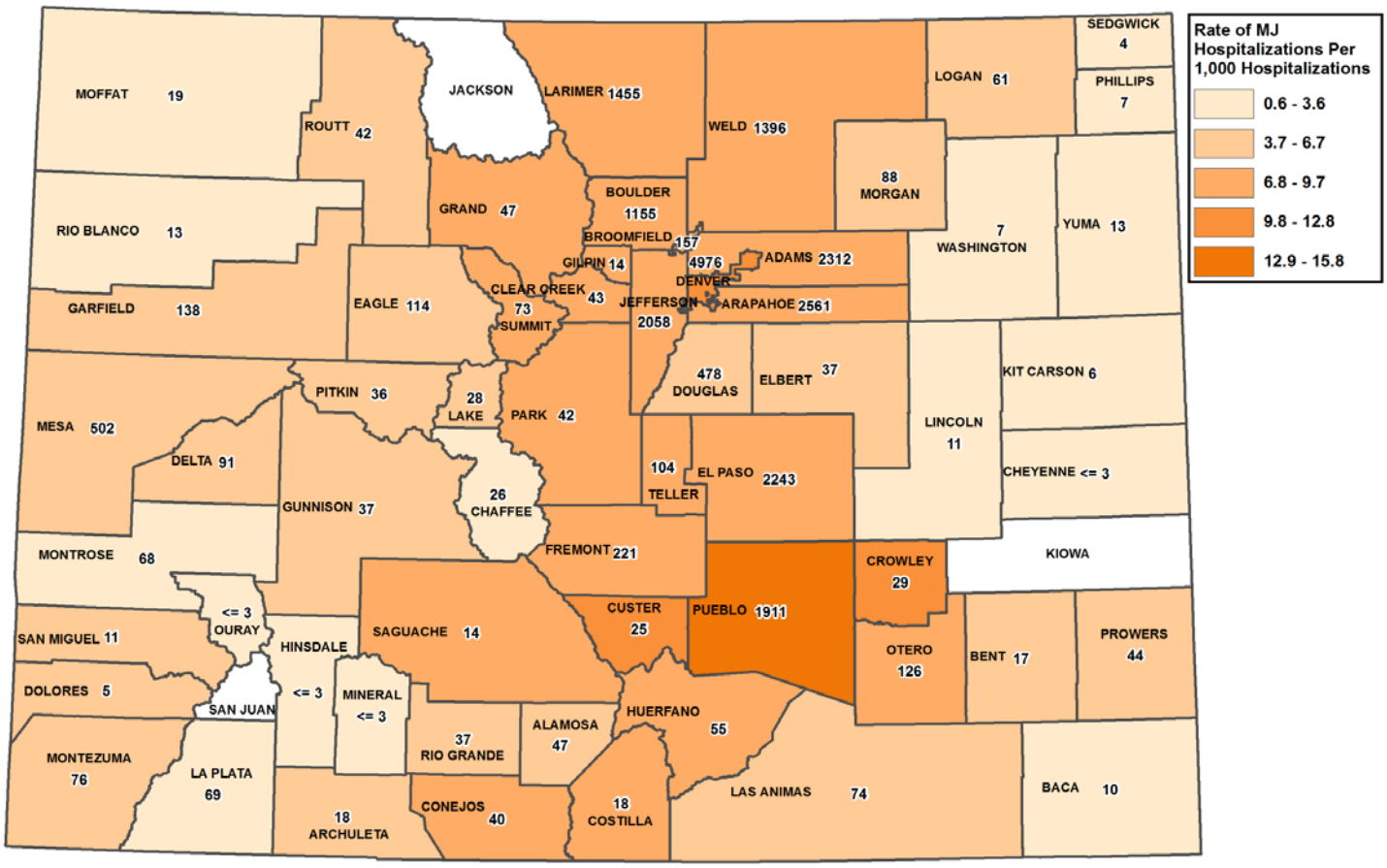
[a] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 were used to determine HD and ED visits with possible marijuana exposure, diagnoses, or billing codes.
[b] The Ns are the total number of HD or ED visits with possible marijuana exposures, diagnoses, or billing codes for each race/ethnicity.
[c] Other race includes Asian, Native American, and other race.
* Rate significantly increased from previous time period with a p value <0.001.

Major Findings

- Rates of HD with possible marijuana exposures, diagnoses, or billing codes significantly increased by each time period from 2001-2009 to January through June 2014 for all races/ethnicities.
- Rates of ED visits with possible marijuana exposures, diagnoses, or billing codes significantly increased from 2010-2013 to January through June 2014 for white, other, and unknown races.

Data Details: Colorado Hospital Association (CHA), 2014 data is January 1, 2014 through June 30, 2014. NA=Data not available. An individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 100,000 total HD or ED visits.

Map 2. Rates and Numbers[a] of Hospitalizations (HD) with Possible Marijuana Exposures, Diagnoses, or Billing Codes[b] Per 1,000 HD in All Ages in Colorado From 2004[c]-2009.



[a] The number inside the counties is the total number of HD with possible marijuana exposures, diagnoses, or billing codes in the specified county.
[b] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 were used to determine HD with possible marijuana exposure, diagnoses, or billing codes.

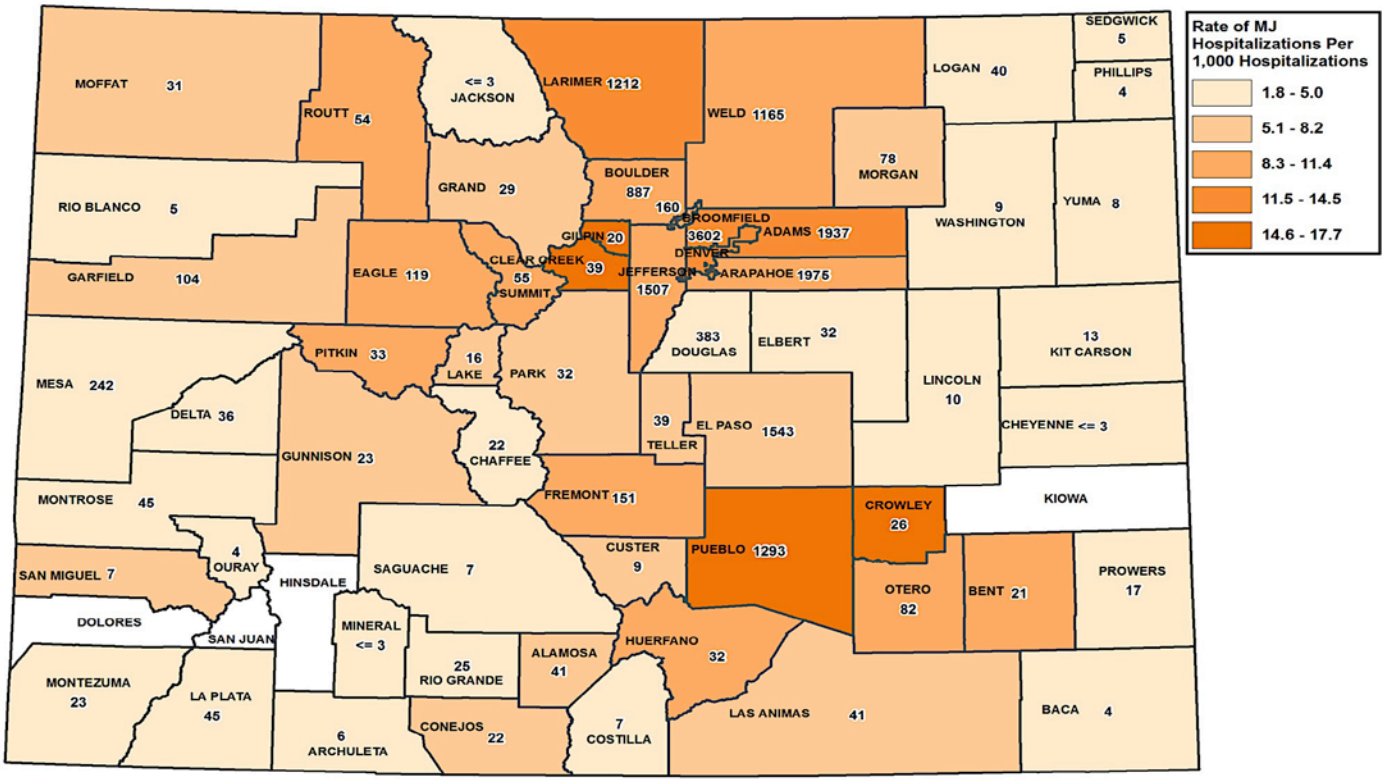
Major Findings

- Rates of HD with possible marijuana exposures, diagnoses, or billing codes were increased in urban areas compared to rural areas.
- The highest rates were in Denver, Custer, Pueblo, and Crowley counties.

Data Details

- Data source: Colorado Hospital Association (CHA)
- Data geocoded from 2004 forward.
- Counties shown in white have no reported HD with possible marijuana exposures, diagnoses, or billing codes.
- An individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 1,000 HD.

Map 3. Rates and Numbers[a] of Hospitalizations with Possible Marijuana Exposures, Diagnoses, or Billing Codes[b] per 1,000 Hospitalizations in All Ages in Colorado From 2010-2013.



[a] The number inside the county is the total number of HD with possible marijuana exposures, diagnoses, or billing codes in the specified county.
[b] ICD-9-CM codes 305.2, 304.3, 969.6, and E854.1 were used to determine HD with possible marijuana exposure, diagnoses, or billing codes.

Major Findings

- Rates of HD with possible marijuana exposures, diagnoses, or billing codes were increased in urban areas compared to rural areas.
- Rates increased in Adams, Clear Creek, Gilpin, Larimer, Crowley, Bent, Routt, Eagle, Pitkin, and Moffat counties from 2004-2009.
- The highest rates were in Denver, Adams, Clear Creek, Gilpin, Larimer, Pueblo, and Crowley counties.

Data Details

- Data source: Colorado Hospital Association (CHA)
- 2014 data has not been geocoded and therefore not included in the map.
- Counties shown in white have no reported HD with possible marijuana exposures, diagnoses, or billing codes.
- An individual can be represented more than once in the data; therefore, the rate is HD or ED visits with marijuana codes per 1,000 HD.

Retail Marijuana Public Health Advisory Committee Roster (2014-2015)

Mike Van Dyke, Ph.D., CIH

CDPHE Retail Marijuana Program Representative, Committee Chair

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 15 years working in public and occupational health focusing on chemical exposures, environmental and occupational epidemiology, and risk communication.

Alvin C. Bronstein, MD

Poison Center Representative

Dr. Bronstein is the Medical Director of the Rocky Mountain Poison Center (RMPC). RMPC, a division of Denver Health and Hospital Authority, serves as the poison center for four states. He is an Associate Professor in the Department of Emergency Medicine, University of Colorado School of Medicine. He is on the Board of the American Association of Poison Control Centers and has been appointed to several CDC panels on biosurveillance. Dr. Bronstein has authored a number of articles, book chapters, and textbooks in the field of medical toxicology. His research interests include creating new methods for delivering poison information

Ashley Brooks-Russell, PhD, MPH

Colorado School of Public Health Representative

Dr. Russell is an assistant professor at the Colorado School of Public Health and a member of the Pediatric 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. Dr. Russell's current research focuses on the areas of violence and suicide prevention and promoting safe driving.

Laura Borgelt, PharmD

Pharmacologist/Clinical Pharmacy Specialist

Dr. Laura Borgelt is a 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 six 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 medical, nursing, and pharmacy

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 and experience, Dr. Borgelt has extensive knowledge of marijuana with regards to its pharmacology, pharmacokinetics, pharmacodynamics, therapeutic effectiveness, and potential risks. Her evidence-based, balanced approach to identifying marijuana's potential benefits and risks is important to determine its appropriate use.

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 Medical Marijuana Research Grand Program at the Colorado Department of Public Health and Environment (CDPHE). He has worked as a public health practitioner at CDPHE for 22 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.

Tista Ghosh, M.D., 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 the Disease Control and Environmental Epidemiology Division.

Heath Harmon, MPH

Local Public Health Representative

Mr. Harmon has been working at Boulder County Public Health since July of 2000. He has experience in the communicable disease, environmental health, and community health arenas during this tenure, and now serves as the Director of Health Programs. He received a Master's Degree in Public Health from the University of South Florida in May of 2000 and has more than 15 years of public health experience.

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. Dr. Langendoerfer is also an Associate Clinical Professor of Pediatrics at the University of Colorado School of Medicine.

Bruce Mendelson, MPA

Drug Epidemiologist

Mr. Mendelson is the substance abuse epidemiology and data consultant for the Denver Office of Drug Strategy and the Drug Strategy Commission, and for the University of Colorado at Denver (NIDA grant). He has a Bachelors degree in political science from the University of Kansas and a Masters Degree in Public Administration from the University of Colorado at Denver. Mr. Mendelson spent nearly 29 years with the Colorado Alcohol and Drug Abuse Division (ADAD) as an evaluator, planner and data analyst. For twelve of those years, Mr. Mendelson was ADAD's Directory of Evaluation and Information Services. While at ADAD from 1987 through 2004, Mr. Mendelson was the Colorado representative to the National Institute on Drug Abuse's (NIDA) Community Epidemiology Workgroup which required the semi-annual preparation of a report on drug use trends in Colorado.

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.

Judith Shlay, MD, MSPH

Surveillance Epidemiologist/Local Public Health Representative

Dr. Shlay is the Associate Director of Denver Public Health (DPH). She is the Director of Health Promotion and Performance Improvement, the Medical Director of the DPH Immunization and Travel Clinic and is the local registrar for Denver County. Dr. Shlay is 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 25 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 Denver Health's adolescent substance treatment program. His research focuses on clinical studies related to adolescent substance use disorders.

George Sam Wang, MD

Pediatrician

Dr. Wang completed his general pediatric residency and pediatric emergency medicine fellowship at Children's Hospital Colorado, University of Colorado Anschutz Medical Campus, and his medical toxicology fellowship at the Rocky Mountain Poison and Drug Center, Denver Health Hospital. Currently, Dr. Wang 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. In addition, Dr. Wang is a volunteer faculty member with the Rocky Mountain Poison and Drug Center. A major focus of Dr. Wang's current research is prevention of unintentional marijuana exposures among children.

GLOSSARY

Accidental poisoning: unlike unintentional poisoning, the subject knew marijuana or concentrated THC was being ingested or inhaled, but the user did not expect the magnitude of the psychoactive effect.

Acute: characterizing a rapid onset of signs or symptoms of short durations.

Acute marijuana use: Use with in the past hour.

Anencephaly: the absence of a large part of the brain and or skull in a fetus.

Adolescent: individuals 9 years of age through 17 years of age

Adult: individuals age 25 years and older.

Bullous lung disease: term bullous disease of the lungs indicates the presence of bullae, which are abnormal airspaces resulting from the destruction of normal airspace wall tissue.

Cannabinoids: chemical compounds that act on cannabinoid receptors on cells that repress neurotransmitter release in the brain, cannabinoids can be naturally derived – from some varieties of the *Cannabis* plant, or they can be manufactured.

Child: individuals up to 9 years of age

Congenital malformations: conditions present at birth (congenital).

COPD: (Chronic Obstructive Pulmonary Disease) Umbrella term for emphysema and chronic bronchitis

Dose: *see smoked dose or oral dose.*

Emphysema: Lung destruction and air trapping

Evidence, insufficient: The reviewed body of literature identifies 1) a single low quality finding or less, OR 2) the relevant parameters to be examined have not been adequately defined or established.

Evidence, limited: The reviewed body of literature satisfies one of the following criteria; 1) a single medium quality finding only, OR 2) two or more low quality findings in agreement, OR 3) one low quality finding supported by animal studies, OR 4) mixed findings, most favoring one conclusion.

Evidence, mixed: The reviewed body of literature identifies 1) mixed findings, with neither direction dominating, OR 2) mixed findings, with a medium or high quality study on each side.

Evidence, moderate: The reviewed body of language satisfies one of the following criteria; 1) a single high quality finding only, with no opposing findings, OR 2) at least one medium quality finding, plus supporting findings with no opposing findings, supporting findings can include animal studies, OR 3) mixed findings, heavily favoring one conclusion (opposing findings must be low quality), OR 4) many medium quality findings that heavily outnumber opposing findings, OR 5) a single high quality finding from a systematic review or meta-analysis published within the past 10 years.

Evidence, substantial: The reviewed body of language satisfies one of the following criteria; 1) at least 1 high quality finding, plus supporting findings, with no opposing findings, OR 2) at least 3 medium quality findings, with no opposing findings, OR 3) many high quality findings that heavily outnumber opposing findings, OR 4) at least 2 high quality findings from systematic reviews or meta-analyses published within the past 10 years.

Evidence strength level: rank given to *a body of* reviewed evidence based on primary considerations of number and quality of findings.

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.

Extrapulmonary: occurring outside the lungs.

Gastroschisis: a birth defect in which an infant's intestines are outside of the body because of a hole in the abdominal wall.

Heavy use: daily or near-daily use (5-7 days per week)

Injury: physical damage to the body resulting from acute exposure to thermal, mechanical, electrical, or chemical energy.

Ischemic stroke: occurs as a result of an obstruction within a blood vessel supplying blood to the brain

Joint: *see marijuana cigarette*

Low birth weight: infants who weigh less than 5.5 pounds at birth.

Marijuana cigarette: "currently available" marijuana cigarette contains approximately 0.5 gm total weight and 12-23%% THC (potency).

Marijuana dependence: for the purposes of this review, we define marijuana dependence and marijuana addiction to be synonymous.

Medium quality finding: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Myocardial Infarction: another term for a heart attack.

Neural tube defect: birth defects of the brain, spine, or spinal cord. They happen in the first month of pregnancy, often before a woman even knows that she is pregnant.

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

Occasional use: less than weekly use

Older adult: individuals 65 years of age and older

Oral dose: milligrams of THC ingested

Periconception: the time period around conception, around the time of getting pregnant. The *periconception* period usually extends about 2-3 weeks after conception.

Perinatal death: a fetal death (stillbirth) or an early neonatal death.

Premature birth: a birth that takes place more than three weeks before the baby is due — in other words, after less than 37 weeks of pregnancy, which usually lasts about 40 weeks.

Preterm delivery: *See premature birth*.

PRISMA: evidence-based minimum set of items for reporting in systematic reviews and meta-analyses to help authors improve reporting.

Psychosis: often described as "loss of contact with reality." Its components include hallucinations, delusions, impaired insight, and personality changes; presented as unusual or bizarre behavior, difficulty with social interactions, and impairment in activities of daily life.

Recreational injury: any injury outside the workplace and not classified as a motor vehicle (MV) crash.

Regular use: weekly use (1-4 days/week)

Route of Exposure: The physical passageway which the marijuana product takes to enter the body; (for example) oral/ingested, smoked, or topical.

Small for gestational age: (SGA) babies are those who are smaller in size than normal for their gestational age, most commonly defined as a weight below the 10th percentile for the gestational age.

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.

Unintentional poisoning: the unintended ingestion of marijuana; more commonly observed with edible marijuana products

Ventricular septal defect: one or more holes in (or incomplete development of) the wall – the septum – that separates the right and left ventricles of the heart.

Young adult: individuals 18 through 24 years of age.

ABBREVIATIONS

BRFSS: Behavioral Risk Factor Surveillance System
CBD: Cannabidiol
CHA: Colorado Hospital Association
CHS: Child Health Survey
COPD: Chronic Obstructive Pulmonary Disease
DUID: Driving Under the Influence of Drugs
HKCS: Healthy Kids Colorado Survey
IFHL: Influential Factors for Healthy Living survey
IQ: Intelligence quotient
MV: Motor Vehicle
NHSDUH: National Household survey on Drug use and Health
NSDUH: National Survey on Drug use and Health
NTD: Neural Tube Defect
NIDA: National Institute on Drug Abuse.
PAHs: Polycyclic Aromatic Hydrocarbons
PRAMS: Pregnancy Risk Assessment Monitoring System
PRISMA: Preferred reporting Items for Systematic Reviews and Meta-Analyses
RMPDC: Rocky Mountain Poison and Drug Center
SAMHSA: Substance Abuse and Mental Health Services Administration
SCRN: Stillbirth Collaborative Research Network
SIDS: Sudden Infant Death Syndrome
THC: delta 9-tetrahydrocannabinol
WIC: Women, Infants and Children, federal program to provide nutritional support and educational services to at-risk women and children up to age five