Cannabis Control Commission
COMMONWEALTH OF MASSACHUSETTS

# Special Report: Evaluating the Impact of Cannabis Legalization in Massachusetts: State of the Data

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## Purpose

This report has been prepared to inform the Massachusetts Cannabis Control Commission ("Commission") as it seeks to fulfill its research requirements as outlined in *Chapter 55 of the Acts of 2017: An Act to Ensure Safe Access to Marijuana.* The purpose of the report was to identify relevant sources of data, describe key limitations, and raise considerations for additional data collection needed to address the Commission's obligations. The legislation includes, but is not limited to, the following text which informed the scope of this report:

> Section 17. (a) The commission shall develop a research agenda in order to understand the social and economic trends of marijuana in the Commonwealth, to inform future decisions that would aid in the closure of the illicit marketplace and to inform the commission on the public health impacts of cannabis ("marijuana"). The research agenda shall include, but not be limited to:
>
> 1. patterns of use, methods of consumption, sources of purchase and general perceptions of marijuana among minors, among college and university students and among adults;
> 2. incidents of impaired driving, hospitalization and use of other health care services related to marijuana use…and a report on the financial impacts on the state healthcare system of hospitalizations related to marijuana;
> 3. economic and fiscal impacts for state and local governments including the impact of legalization on the production and distribution of marijuana in the illicit market and the costs and benefits to state and local revenue;
> 4. ownership and employment trends in the marijuana industry examining participation by racial, ethnic and socioeconomic subgroups, including identification of barriers to participation in the industry;
> 5. market analysis examining the expansion or contraction of the illicit marketplace and the expansion or contraction of the legal marketplace, including estimates and comparisons of pricing and product availability in both markets;
> 6. compilation of data on the number of incidents of discipline in schools, including suspensions or expulsions, resulting from marijuana use or possession of marijuana or marijuana products; and
> 7. compilation of data on the number of civil penalties, arrests, prosecutions, incarcerations and sanctions imposed for violations of chapter 94C for possession, distribution or trafficking of marijuana or marijuana products, including the age, race, gender, country of origin, state geographic region and average sanctions of the persons charged.
>
> (b) The commission shall incorporate available data into its research agenda, including the baseline study conducted pursuant to Chapter 351 of the acts of 2016…The commission shall annually report on the results of its research agenda and, when appropriate, make recommendations for further research or policy changes.

This report addresses publicly available data for the enumerated items above. Additional items, such an energy and environment, have been included in this report, but should not be considered exhaustive of all research topics of interest to the Commission.

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# I. Executive Summary

This report was prepared to inform the Massachusetts Cannabis Control Commission ("Commission") in its research duties as outlined in *Chapter 55 of the Acts of 2017: An Act to Ensure Safe Access to Marijuana*. We addressed eight domains outlined by the legislation (cannabis use patterns and perceptions; healthcare utilization and costs; impaired driving; ownership and employment trends; cannabis markets; cannabis-related incidents in schools; criminal justice encounters; and economic and fiscal impacts) and energy usage.

For each of the legislatively mandated domains, we reviewed relevant sources of national and state government-collected data and other publicly available data *(i.e. commercially collected data)* to identify sources representative of the Massachusetts population. We consulted the peer-reviewed literature and spoke with key informants from relevant Massachusetts agencies. We also reviewed documents and reports from the first states to legalize and commercialize cannabis for adult use *(e.g. Colorado, Washington State)* to ascertain how other states addressed some of the issues related to monitoring and evaluating this policy change. Finally, we assessed the key limitations of the available data and raise key considerations that can be acted upon to improve existing data collection practices and additional data collection towards the goal of strengthening the Commonwealth's capacity to monitor the impacts of cannabis legalization.

Our assessment suggests that the Commission is well-poised to monitor broad trends related to cannabis, but lacks the capacity, at present, to monitor some important indicators. We provide a summary assessment of the availability and ease-of-access to the necessary data to fulfil the legislative mandate for each domain in the table below. Industry-related data represents an area of strength for the Commission in terms of access to needed data. Cannabis use, impaired driving, and criminal justice domains, on the other hand, present challenges. For example, while existing survey data permit monitoring of the prevalence of past-year and past 30-day cannabis use among youth and adult cohorts over time, data on methods of consumption (*e.g. vaping, edible products*) among Massachusetts residents is limited to one survey conducted in 2017.[1] Similarly, data to quantify the overall number and rate of fatal and non-fatal motor vehicle crashes is readily available, but additional data collection is necessary to monitor cannabis exposure and impairment in crash-involved drivers. A similar pattern is true for arrests for operating under the influence (OUI) and criminal justice system involvement for violations of M.G.L c. 94C Class D drug possession and distribution offenses. In these domains, cannabis-specific incidents cannot easily be disentangled from incidents involving other drugs. For the Commission to fulfill its research mandate, modifications to coding practices by law enforcement agencies (*e.g. creating a separate code for OUI-Cannabis)* may be needed to allow for collection of cannabis-related data. Of additional importance is a focus on increasing capacity to monitor policy impacts among specific, vulnerable subpopulations.

The procurement and rigorous analysis of the many data sources needed to best understand the potentially wide-ranging impacts of cannabis legalization requires significant investment of time, expertise, and resources. We suggest that a portion of funds generated by cannabis sales are

earmarked for research. We further suggest that the legislature consider revising the requirement for annual reporting on the *Chapter 55* indicators and instead require the creation of a longer term *(e.g. five-year*) research roadmap with reporting at intervals that reflect the time needed to develop and undertake rigorous research.

The Commission, in collaboration with external researchers and stakeholders, must undertake rigorous research to evaluate cannabis policy and inform action towards ensuring that the benefits of cannabis legalization are realized most fully, and potential harms are mitigated.

**Table.** Research domains and availability of existing data for monitoring purposes

| Data Domain | Data availability and ease-of-access |
|---|---|
| Cannabis use patterns and perceptions | |
| Healthcare use and costs | |
| Incidents of cannabis-impaired driving | |
| Ownership and employment trends | |
| Cannabis markets | |
| Cannabis-related incidents in school | |
| Criminal justice encounters | |
| Economic and fiscal impacts | |
| Energy | |

Key:

Existing data readily available …….. Data not available

## II. Methods

The data that can be used for monitoring the impact of cannabis legalization at the state level fall, generally, into four categories: 1) survey data; 2) administrative data; 3) special government-compiled datasets; and 4) commercially collected data. The focus of this report is to identify and assess data that can be used to generate estimates that are representative of the Massachusetts population and/or certain sub-populations within it. There are also data collected at the local or regional level within the Commonwealth and data collected as part of ongoing academic or other research studies. A systematic review of those sources was beyond the scope of this report.

To identify sources of data relevant to our purpose, we drew upon government reports from the federal government, Massachusetts, and other states with legal adult-use cannabis markets. We also examined peer-reviewed research studies. We contacted government or commercial database employees to ask about data sources that may be collected, but not regularly reported or to obtain information beyond what is available on public websites or in journal articles. We endeavored to identify and assess the key data sources within each content area. A list of agencies we communicated with is in Appendix B.

Data sources are rarely static over time. Our general approach when we identified a potentially-relevant data source was to evaluate 1) whether it can be used to monitor trends over time for Massachusetts; and 2) the extent to which the data can be applied to address the focal areas of this report. For survey data, we identified the population covered, age range, application process for obtaining data, and date range availability. We determined the information available in these surveys over time for our date range of interest (*i.e. 2011-2019).* For administrative and other data, we sought to understand how to access data, how far back in time data is generally available, as well as any important changes in data systems or coding over time that could influence analyses. We describe the datasets we evaluated that do have cannabis-specific indicators in the tables (Appendix A). Based on the available data and its limitations, we made suggestions for actions the Commission should consider in order to best address the research areas.

We also assessed some national data without indicators that can be used to uniquely identify Massachusetts residents or institutions. Although such datasets are unlikely to be useful for analyzing the impacts of cannabis legalization in the Commonwealth, they helped to inform the considerations we raise regarding potential expansion of data collection in the future.

# III. Data Sources, Limitations, and Considerations

## A. Cannabis use patterns and perceptions

Monitoring cannabis* use is a key aspect of the Commission's research mandate. We examined available data sources to measure cannabis use patterns, perceptions of cannabis and methods of consumption for youth and adults, including high school and college students. We limited this assessment to survey data, as it is currently the most reliable method of assessing these topics. We assessed availability with a goal of understanding utility of the data for making comparisons of "before versus after" adult-use cannabis legalization enactment and implementation. As many data collection methods and specific survey questions have changed over time, we focused on data sources for the time period of 2011-2019 that were available to evaluate marijuana use at the state level, limited to datasets that were able to measure indicators for the Commonwealth.

We identified seven surveys that might be used for this purpose. Of these seven surveys, three are national surveys with the ability to identify Massachusetts residents in the data. The other four surveys are Massachusetts-specific, conducted by state entities, sometimes in conjunction with federal agencies (Table 1).

### Summary of Available Data

The national surveys that can be used to monitor cannabis use patterns, perceptions, and methods of use and consumption for adults and children are the National Survey on Drug Use and Health (NSDUH), [2] National Health and Nutrition Examination Survey (NHANES),[3] and the Youth Risk Behavior Surveillance Survey (YRBSS).[4] All except the YRBSS are conducted annually. The YRBSS is conducted every other year in odd years. State-specific surveys, conducted in conjunction with the national surveys, are available over time as well. The Massachusetts Behavioral Risk Factor Surveillance System (MA BRFSS),[5] Massachusetts Youth Health Survey (MYHS),[6] and Massachusetts Youth Risk Behavior Survey (MYRBS)[7] are available for monitoring and evaluation. Most of the surveys are available with an approximately two-year delay, meaning that as of June 2019, the most recent version available is 2017. Table 2 provides information on availability of specific indicators (ever used marijuana; age of first use; frequency of use; location of use; method of use; source of marijuana; perceptions of marijuana; and reason for use) over time in these datasets.

* Note: The words cannabis and marijuana are used throughout this report. The term "marijuana" has historically been used to refer to the dried flower of the cannabis plant and has been used to associate the drug, negatively, with certain ethnic groups. While the Commission and the authors of this report condemn the racism behind the word and its etymology, most survey questions on U.S. surveys and most state policies about psychoactive forms of the drug use the term marijuana. Alternatively, the term "cannabis" is used to refer to the cannabis plant and its derivative products. This more scientifically accurate terminology is used more often in recent years. This report uses both terms, with the choice depending on the context and an effort to be consistent with surveys and legislation.

The NSDUH collects data on adults, emerging adults (college and non-college attending adults age 18-22) and youth (age 12-18 years). The NSDUH is a valuable source that addresses many of the legislatively mandated items and is available over time. The NSDUH is a nationally representative survey of youth and adults age 12 years and over; participants are sampled in proportion to their representation within the state. It has several detailed questions on the use of marijuana, including frequency, source, perceptions of risk, and marijuana use that results in individual or family problems. The NSDUH includes an indicator of college student status for emerging adults between age 18 and 22 years. State-level indicators are available through a restricted use process, and there are an adequate number of observations to conduct statistical analysis over one- to two- year periods that can represent the population of Massachusetts. Additional data sources that can be used to understand marijuana use among adults are the MA BRFSS, NHANES, and the Massachusetts Marijuana Baseline Health Study (MBHS).[1] The MA BRFSS asks a number of detailed questions that may help to identify problematic marijuana use.

It is not possible, however, to monitor frequency of non-problematic marijuana use, method of consumption, and perceptions of use via the MA BRFSS. The NHANES can be used to make state estimates, but a small number of adults are interviewed in each year, meaning that small samples are likely to be problematic for statistical analysis. If repeated over time, the Massachusetts Marijuana Baseline Health Study[1] population survey conducted by the Massachusetts Department of Public Health (DPH) may provide a useful source for monitoring legislatively mandated priorities, as items on method of use were assessed in that survey that are not available in other data sources. Each of these data sources use survey weights to make results representative of the full Massachusetts civilian, non-institutionalized adult population.
For youth — particularly for high school students — other data sources are available to address cannabis use. The combination of the national YRBSS, the MYHS, and the MYRBS collectively can be used to monitor many, but not all, of the legislatively required indicators. For example, these surveys can be used to monitor cannabis use, age at first use, frequency of use, location of use (*i.e., school grounds*), and perceptions of marijuana. The Commission has utilized the YRBSS to report on lifetime marijuana use, current use, and heavy use.[8]

The YRBSS, MYHS, and MYRBS lack detailed information on the methods of use, source, and reason for use. The NSDUH captures youth ages 12 and over, and is potentially a good source of information, particularly for adolescents who are not attending public schools. Additionally, NHANES is available for youth as well, but with similar limitations to adults. The NSDUH and NHANES are designed to be representative of the population within given age ranges (*e.g. adolescents; emerging adults*). The YRBSS, MYHS, and MYRBS are only administered to students in school on the day the survey is conducted and thus are not designed to be representative of the adolescent population who are not in public middle and/or high schools.[8]

There are also several data sources that are potentially useful for some indications, but that did not meet inclusion criteria, either because they did not ask appropriate questions or cannot be used to develop estimates that are representative of the target population (*e.g. high school students; college students*) residing in the Massachusetts.

Other data sources of note that did not meet inclusion criteria include: Monitoring the Future (MTF)[9] and the American College Health Association National College Health Assessment (ACHA-NCHA)[10] and locally conducted surveys. MTF and ACHA-NCHA are national surveys of high school and college students, respectively. MTF includes multiple detailed questions that pertain to cannabis use including ever use, age of first use, frequency, vaping of marijuana, location, and reason for use, as well as the perceptions and source of marijuana. However, data from Massachusetts-based participants cannot be used to construct estimates at the state level; combinations of states can be used to answer policy questions at the national level (*e.g., states with legal cannabis versus states without*) but Massachusetts estimates cannot be reported separately. The ACHA-NCHA is a survey administered to more than 1.4 million college students age 18 years or older at over 740 colleges and universities across the country, including the University of Massachusetts Amherst. The ACHA-NCHA includes several detailed questions on the use of cannabis, including frequency of use and perceptions of use among peers. Most uses of the ACHA-NCHA for research purposes are limited to examining the results from a single campus, although (non-representative) data are available for very large regions (*e.g., Northeast plus Mid-Atlantic*). In addition to these two surveys, some schools and local substance abuse prevention coalitions in communities throughout Massachusetts conduct independent school-based surveys of middle and/or high school students using instruments that may be linked to prevention programming, such as the Communities that Care[11] survey. Such surveys are not administered in all schools or counties and cannot be aggregated to produce state-level estimates. For evaluation of impact on specific communities, more detailed data may be available in these surveys compared to state or national sources.

## Limitations

Collectively, the data available to measure cannabis use patterns, methods of consumption, and general perceptions of cannabis are adequate in some respects, but there is substantial room for improvement. Comparisons to other states suggest that the Commonwealth lags in collection of cannabis-specific information for the general population and for specific subpopulations (*i.e. pregnant women; parents).* One valuable data source that is available in some other states, but not in Massachusetts, is nationally comparable questions related to cannabis use asked as part of the Behavioral Risk Factor Surveillance System (BRFSS).[12] In 2016, the Centers for Disease Control and Prevention (CDC) developed a cannabis ("marijuana") module with questions about the drug that states could add to their state BRFSS survey, but Massachusetts has not added this module. The module includes items on mode of marijuana consumption and the reason for cannabis use *(i.e. medical versus non-medical use).* Instead, the MA BRFSS has added state-specific questions, including questions added prior to 2016, related to cannabis use that are detailed above, but are not comparable to questions asked in the optional national module. This condition limits the utility of BRFSS data in Massachusetts for making comparisons to other states for this period.

Key limitations of the existing datasets are: 1) inadequate sample size in the primary datasets that can be used to monitor these indicators; 2) not assessing patterns, perceptions, and methods of

cannabis use in sufficient detail; and 3) inadequacy of these data to monitor specific vulnerable populations.

Regarding sample size, the best sources to monitor a wide variety of indicators as legislatively mandated include national data sources that have Massachusetts specific indicators. These have adequate sample size at the state level. They are not, however, designed to be representative of smaller areas (*e.g. counties*) and likely have an insufficient number of observations to be useful in monitoring use among most vulnerable groups and/or minority groups.

The second major limitation is regarding the extent to which available data can be used to assess the patterns, perceptions, and methods of consumption in a detailed fashion that are representative of the Massachusetts population. For example, for the general adult population, there are no state-representative population surveys that monitor the method of use *(e.g. smoking, vaping, consuming edibles*) or location of use over time. For youth, there are no Massachusetts-representative, general population surveys that monitor the method of use, location of use (*i.e. beyond school grounds*), or reason for use (*i.e. medical versus non-medical*). The Massachusetts Marijuana Baseline Health Study[1] population survey may be a useful data source towards monitoring methods of use among adults if the survey is repeated and if data are made available for analysis.

Relatedly, the terminology used in many surveys questions about cannabis leave open the potential for ambiguity about what is measured. Most surveys use the term "marijuana," which has historically referred to the dried flower from the cannabis plant and to THC-containing products. Given the proliferation of cannabidiol (CBD) products that are low in THC, there is a possibility that some individuals would respond to survey items about "marijuana" by indicating CBD use and not THC use. The existing surveys do not ask respondents to distinguish between use of or perceptions of CBD products and THC products. In order to ensure comparable data from year to year, additional empirical research into how individuals understand survey items about "marijuana" or "cannabis" may be useful in conjunction with additional items that classify cannabis use as use of THC with and without CBD and/or other cannabinoids.

The third limitation is a lack of data sources used to monitor use for specific vulnerable populations, including pregnant women, veterans, and individuals with serious or co-occurring mental health disorder and/or substance use disorders. For example, the national Pregnancy Risk Assessment Monitoring System (PRAMS)[13] survey has a set of optional questions regarding cannabis use before, during, and after pregnancy. Massachusetts has not adopted these questions in the ongoing wave of the PRAMS, which limits the ability to monitor marijuana use in this group. Several other surveys (*e.g. NHANES*) ask respondents about their military service, but it is unknown whether there is sufficient sample size within this group to monitor effects of cannabis legalization on veterans. Individuals with serious mental health disorder and/or substance use disorder may be differentially affected by cannabis legalization;[14] several of the surveys have measures to assess the presence of current or past mental illness and/or substance use disorder, but it is unknown whether they have sufficient detail or sample size to assess impacts on these groups in Massachusetts in particular.

We limited this assessment to survey data, but there may be other administrative data that could be used to assess use patterns at the state and local level, including medical cannabis patient registries and adult use cannabis sales. Better understanding the utility of these data sources to understand broad patterns of use and methods of use may be an important component of ongoing evaluation.

### Considerations

Major changes to existing survey data collection would improve the use of secondary data towards fulfilling the legislative mandate: 1) using consistent wording for existing MA BRFSS questions about cannabis over time and adding questions related to cannabis patterns of use, modes of consumption, and other related behaviors; 2) additional primary data collection to assess priority subpopulation groups and/or specific questions not otherwise addressed, such a patterns of substance co-use; and 3) the addition of cannabis questions to the MA PRAMS survey to monitor use among pregnant women.

Massachusetts has not adopted the optional BRFSS marijuana module offered by the CDC and used in other states. The MA BRFSS includes state-specific questions related to problematic cannabis use, but these questions are not consistent over time and have not been asked of the full sample, limiting usefulness and sample size. Additional questions could be added to the BRFSS conducted in Massachusetts, including but not limited to the CDC's marijuana module, to better assess overall cannabis use for the general adult population and monitor specific aspects related to the legislatively mandated priorities. These may include more general questions about cannabis use, method of use, source of purchase, and location of use. Although the MA BRFSS is a powerful data source that may be leveraged to gather additional information with the addition of specific questions, it is limited in its ability to focus on specific subpopulations *(i.e. pregnant women)* based on the overall goal of being representative of the state population.

If there are particular questions that are of importance based on legislative and agency priorities that cannot be added to the MA BRFSS, additional primary data collection may be of interest to the Commission. For example, the MBHS assessed legislatively mandated items not available from other sources. The continuation of this survey would be appropriate to collect data over time on, for example, methods of use for adults in the Commonwealth. Additional primary data collection by the Commission to assess methods of use and source of purchase for youth is encouraged.

The third consideration is to expand the PRAMS survey to be monitor cannabis use among pregnant women. This would allow the Commission to evaluate the impacts of cannabis legalization on this population and further assess potential and experienced impacts on pregnant women and infants.

## B. Healthcare use and financial impacts on the state healthcare system

The authorizing legislation requires the Commission to monitor incidents of hospitalization and use of other healthcare services related to cannabis use and the financial impacts on the state healthcare system for hospitalizations related to cannabis. We assessed availability of data to address health outcomes, healthcare utilization, and financial impacts on the state healthcare system by identifying and examining survey and administrative data.

We focused on data available nationally with an indicator for Massachusetts and on Massachusetts-specific data sources. We identified key datasets that can be used for monitoring the mandated priority areas. Below, we describe in detail the datasets we determined to be the most comprehensive and potentially useful for this purpose.

### Summary of Available Data

#### Survey Data

First, we note the availability of survey data that may be useful in simultaneously identifying self-reported cannabis ("marijuana") use and health and healthcare outcomes (Table 3). These surveys can be used – based on the information available within – to assess two types of questions: 1) comparing healthcare utilization such as utilization of mental health services for cannabis users (or, for example, frequent users) versus non-users; and 2) assessing healthcare utilization specifically reported to be related to cannabis use. The National Health and Nutrition Examination Survey (NHANES)[3] and National Survey on Drug Use and Health (NSDUH),[2] ask about cannabis use and a variety of questions related to self-reported health and certain healthcare utilization outcomes; the NSDUH also includes items specifically related to health services used for cannabis use.

There are three Massachusetts-specific surveys that contain information about healthcare use and cannabis ("marijuana") use. Since 2015, the Massachusetts Behavioral Risk Factor Surveillance System (MA BRFSS) has asked questions about past-year use of emergency department (ED), medical, or professional counseling services for adverse effects of cannabis use. The Marijuana Baseline Health Study (MBHS) specifically assessed ED or urgent care visits related to cannabis use. The third survey, the Massachusetts Youth Risk Behavioral Survey (MYRBS) contains information about cannabis use and frequency and about suicide attempts that required medical treatment.

#### Administrative Data

We identified a large number of national and state-level administrative datasets that can be used to monitor the impacts of cannabis legalization on health outcomes, healthcare utilization, and financial impacts on the state healthcare system (Table 4). These data sources may be valuable in measuring the impact of cannabis legalization on the healthcare system, allowing for detailed empirical analysis around cannabis use and related problems. A number of these data sources

contain *International Classification of Diseases – Ninth Revision* (ICD-9-CM) and ICD-10-CM (hereafter called ICD-9/10 codes) that indicate cases of cannabis-related disorders with codes for cannabis use, cannabis abuse, and cannabis dependence. The presence of such codes will allow analysis of the prevalence of those conditions in the populations covered by the datasets, described below. These data can be used to examine changes in health system use due to potential secondary impacts of increased marijuana use such as comorbid physical and behavioral health conditions (*e.g., other substance use disorders)* or involvement in a motor vehicle crash.

National individual-level data for prescription drugs (IQVIA prescription data)[15] and Medicare health insurance claims[16] are available with significant costs and application processes. The IQVIA prescription data cover a substantial proportion of outpatient prescriptions, but do not include other linked healthcare utilization. Medicare health insurance claims are a valuable way to analyze impacts of cannabis legalization using linked health insurance claims with inpatient, outpatient, and (potentially) prescription drug information; Medicare is the primary health insurer for the elderly (65+) and those with disabilities. To measure acute care utilization, including ED visits and inpatient stays, the State Emergency Department Data (SEDD) and State Inpatient Database (SID)[17] available from the Agency for Healthcare Research and Quality may be of potential interest if regional or national comparisons are of interest. Two other national data sources are the National Poison Data System (NPDS) and the Treatment Episode Data Set (TEDS).[18,19] These sources measure calls to poison control centers for information and exposure and admissions/discharges from state-funded substance abuse treatment centers, respectively. Both sources can be limited to information on cannabis exposure and abuse.

There are limitations of the national data sources, both in the time frame of availability (*e.g., SEDD, SID, and NPDS*) and in the contents of the data (*e.g., TEDS*). Massachusetts has additional and overlapping data available from state government sources. For example, the Massachusetts CaseMix data[20] provides similar data to that which is distributed through the SID and SEDD, but has more recent years of data available in the Massachusetts-specific version. Similarly, the Massachusetts Department of Public Health, Bureau of Substance Abuse Services (BSAS) maintains the Substance Abuse Management Information System (SAMIS)[21] with admissions and discharge data similar to what is in TEDS. However, SAMIS includes more detailed information, such as both lower level geographic identifiers *(e.g. ZIP code)* and an indicator of veteran status. The Massachusetts and Rhode Island Regional Center for Poison Control and Prevention (RPC)[22] deposits data for calls from Massachusetts and Rhode Island to the NPDS and has worked with state agencies and researchers to analyze Massachusetts-specific data. Poison data are of use for evaluating impacts of cannabis exposure resulting and not resulting in a healthcare visit. The Massachusetts State Trauma Registry[23] contains information at the state level; states are not identifiable in the national version of this registry. The Department of Mental Health (DMH) Mental Health Information System (MHIS) records information about treatment records for those receiving services from DMH. Primary diagnoses in these data pertain to mental health conditions and secondary diagnoses, which may include substance use disorders *(e.g. cannabis use disorder)* are available.

Finally, there are three Massachusetts-specific data sources that may be of particular interest to the Commission for monitoring cannabis-related health system impacts: 1) the Massachusetts All Payer Claims Data (MA APCD);[24] 2) Massachusetts CaseMix Data;[20] and 3) the Massachusetts Public Health Data Warehouse (MA PHDW).[25]

***Massachusetts All Payer Claims Data***

The Massachusetts Center for Health Information and Analysis (CHIA) maintains the MA APCD which includes health insurance enrollment and claims data — both medical claims and pharmacy claims — from commercial insurers and Medicaid.[†] It includes claims from inpatient and outpatient settings, with associated procedure codes and detailed diagnosis data. Data are generally available for a five-year period (currently 2013-2017), which supports time-series analyses. The APCD data are available to government and academic applicants, with varying restrictions related to data privacy and varying costs.

In the MA APCD, procedure codes and National Drug Codes allow for analysis of health system utilization (*e.g. inpatient admissions, emergency department visits, outpatient visits*) and pharmaceutical use. Diagnosis codes can identify primary and secondary diagnoses related to cannabis use, cannabis abuse, and cannabis dependence. Analyses of total healthcare spending and spending on a particular episode of care are possible at the individual level with some limitations. Individuals can be followed over time and across plans, which allows for detailed individual level analysis, as well as for specific population groups including groups by age, sex, and geography (*e.g. 5-digit ZIP Codes*) with some restrictions based on protecting patient privacy. Importantly, though, there may be some limitations to the availability of claims with procedures and diagnoses related to substance use disorders (including, but not limited to, cannabis use disorder). The MA APCD can be used to determine total healthcare spending for most individuals in the dataset.

***Massachusetts CaseMix Data***

Massachusetts CHIA also maintains the CaseMix data which includes the Hospital Inpatient Discharge Database (HIDD), Outpatient Observation Database (OOD), and the Emergency Department Database (EDD). Combined, these data include all hospital and ED discharges from Massachusetts acute care hospitals, along with associated charges. These data include discharges

[†] The inclusion of Medicaid data requires additional application materials and undergoes an additional review process. Medicare Advantage and secondary Medicare plans ("Medigap") are included, as these are generally private insurance. Medicare fee-for-service claims are not included; they are available to government users, but are not combined into the main dataset. We discuss Medicare fee-for-service and Medicare Advantage claims available directly from the Centers for Medicare and Medicaid Services separately. Changes in reporting requirements for self-insured employers were impacted by a Supreme Court ruling in 2016. These self-insured employers can now optionally contribute to the APCD, and the proportion of these insurers who contribute their data has been falling over time. At the end of 2017, only about 25% of members covered by self-insured employers were included in the APCD.

for both insured and uninsured individuals. The CaseMix data are available to government and academic applicants, with associated costs.

Similar diagnosis codes to examine cannabis related diagnoses are available as for the MA APCD. Additionally, detailed individual level analysis is possible. The data can be sorted for specific population groups by age, sex, and geography. In contrast to the MA APCD, hospital encounters related to substance use disorder diagnoses are included and all insurance types, such as self-pay, are included over time. The primary specific limitation of the CaseMix data is that it can only measure hospital utilization; it is not possible to calculate total healthcare spending.

***Massachusetts Public Health Data Warehouse***

The Massachusetts PHDW, maintained by the Massachusetts Department of Public Health (DPH), is a unique resource that links a large number of government data sources at the individual level for residents of the Commonwealth. This includes the MA APCD, CaseMix data, mortality and medical examiner data, SAMIS and DMH data, ambulance data, housing data, criminal justice encounters, and data from the Veterans Administration. The expanded list includes more than twenty data sources, with annual updates, planned in the final version. This data warehouse is impressive in size and scope. It was originally developed to monitor the ongoing impact of the opioid epidemic in Massachusetts, and it has significantly improved knowledge of the health costs of the epidemic through joint research projects with DPH and academic researchers. As of June 2019, DPH is still working with data providing partners, with the goal of having data available in the early fall 2019. The availability of the PHDW will be for researching public health priorities that impact morbidity and mortality in the Commonwealth as identified by DPH. The PHDW will be available through the posting of Notices of Opportunity, which will focus on very specific topics such as health equity and social determinants of health.

***Other data sources***

In addition to the sources detailed above, there are a number of other data sources that may be of interest for analyzing impacts of cannabis legalization, including administrative data linked to survey data, other health insurance claims data, and electronic health records from specific healthcare entities. Although they may not be representative of the Massachusetts population, and were thus not included for in-depth review in this report, these data sources may be of interest for the analysis of special populations or to fill gaps in knowledge due to restrictions on data use or limitations of the data.

Additional data sources available from state government agencies may be of interest, but at present have limitations that likely outweigh their value for the Commission's work. Specifically, we assessed data on deaths (Massachusetts Registry of Vital Records and Statistics), ambulance trips (Massachusetts Ambulance Trip Records Information System),[26] prescription drugs (*e.g., Medicaid, Medicare Part D*), and the prescription drug monitoring program (Massachusetts Prescription Monitoring Program). Due to the very small number of incidents with cannabis involvement recorded (*e.g., deaths*) and restrictions on the ability to

separate cannabis from other drugs (*e.g., Massachusetts Ambulance Trip Records Information System*),[26] we consider these of limited utility.

There are also several surveys linked to administrative data that are used by researchers to assess impacts of policy changes on healthcare utilization. These are potentially useful because they allow evaluation of national trends in healthcare utilization and spending across settings; however, based on the relatively small sample sizes and small proportion of individuals expected to receive diagnostic codes related to cannabis use, we anticipate they will not have sufficient sample sizes to be useful for the purposes of this analysis. These surveys do not include specific questions about marijuana use. These data include the Medical Expenditure Panel Survey (MEPS),[27] National Ambulatory Medical Care Survey (NAMCS)/ National Hospital Ambulatory Medical Care Survey (NHAMCS),[28] and National Health Interview Survey (NHIS).[29]

Additional private sources of health insurance claims data target populations of interest but have different limitations on their use. We include links to a selection of these datasets here for those who may be interested in learning more about these sources: FairHealth,[30] Health Care Cost Institute,[31] IBM MarketScan Research Databases,[32,33] IQVIA National Disease and Therapeutic Index (NDTI),[15] OptumLabs, Veteran's Health Administration (VHA) Corporate Data Warehouse,[34,35] and VHA National Patient Care Database.[36]

There are some sources of electronic health records that are available in Massachusetts from different healthcare systems. We do not enumerate them here due to substantial differences in availability, usefulness, information available, and size of health system. This type of data may be an important consideration in validating use of ICD-9/10 codes as a method of identifying impacts of cannabis legalization on the healthcare system.

## Limitations

The Commonwealth has substantial data available to monitor impacts of cannabis legalization on the healthcare system. Understanding the limitations of these resources is important to optimize their use and develop recommendations to improve their suitability for this purpose. Due to differences in data collection methods and use cases, we examine the limitations of survey and administrative data separately.

### Survey data

The primary limitations of survey data for evaluating impacts on health outcomes, healthcare utilization, and financial impacts on the healthcare system are in the sample size of available surveys and in the accuracy of self-reported healthcare utilization. The sample sizes of these datasets make it difficult to evaluate the impacts of rare occurrences (*e.g., cannabinoid hyperemesis syndrome)* on health outcomes. However, these survey data sources can allow for the evaluation of self-reported cannabis ("marijuana") use and self-reported health and other general health outcomes that are not available in administrative data. Some surveys contain questions about acute care utilization specifically related to cannabis use. Depending on

prevalence, this information may not be captured accurately by surveys with small to moderate sample sizes.

**Administrative data**

The administrative data available in the Commonwealth are particularly rich, with available data spanning hospital utilization; an APCD with extensive information about outpatient, inpatient, and prescription drug utilization; and a linked data warehouse combining many government data sources linked at the individual level. These data support measurement of policy impacts on the state Medicaid system and state funded substance use treatment, which are of importance for state healthcare costs. These administrative data do have significant limitations, however, which if not resolved will severely impact their utility for monitoring the impact of cannabis legalization on the healthcare system of the Commonwealth.

Several limitations impact most of these administrative data, which rely on ICD-9 and ICD-10 codes to identify cannabis related encounters: 1) changes in diagnostic codes and use over time; 2) clinician coding of cannabis use; and 3) availability of claims with substance use disorder diagnoses; and 4) limitations of data sources that may be of high value to evaluating public health in the Commonwealth; and 5) ability to identify vulnerable populations of special interest to the Commission.

The first limitation in the use of administrative data relying on diagnosis codes is that there were required changes from the use of ICD-9 to ICD-10 codes in 2015 and changes in mapping of codes from the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5) to ICD-10 codes beginning in 2018. Both changes in coding may affect the use of these datasets over longer time series for analyses related to cannabis.

The second limitation is related to the clinician coding of cannabis related conditions. Clinicians may not code cannabis related disorders due to stigma and/or legal consequences, a perception that cannabis use is not clinically important, limited time to look up cannabis-specific codes, and underuse of codes that do not contribute to payment and/or health severity calculators.

The third limitation, which is based on different interpretations of laws related to healthcare privacy, is that administrative data that contain health insurance claims may have redacted information for substance use disorder related diagnoses and procedures (*e.g. methadone administration*). The availability of claims with substance use disorder diagnoses within these administrative data are uneven and inconsistent among applicants and over time, which may make it difficult to fully assess impacts of cannabis legalization.

The fourth limitation is related to the innovative Massachusetts Public Health Data Warehouse, which is a unique resource in the Commonwealth. This dataset was originally developed to monitor statewide impacts related to opioid use – and in particular – opioid overdoses but is being reconstructed to address much broader set of public health priorities. The individual level linkage among datasets is a particularly powerful tool for longitudinal analyses. However, there

is not currently a process to gain access to the data outside of DPH Notice of Opportunities, which limits access to research questions that are of particular interest to DPH. As such, there may be significant limitations for the evaluation of cannabis legalization without formal collaboration between DPH and the Commission.

The fifth limitation of the available administrative data is the ability to identify and monitor impacts on the healthcare system related to vulnerable populations. For pregnant women, college-aged adults, and individuals with serious mental illness and/or substance use disorder the administrative data are likely to contain indicators of these conditions and ages and thus will likely be appropriate ways of monitoring. These individuals will appear in the data proportional to their use of the healthcare system. For veterans, these data sources may not be adequate to monitor the impacts of cannabis legalization on their healthcare utilization; many veterans, particularly those with service-related disability, use the Veterans Administration healthcare system, which has separate administrative data that is not recorded in the civilian healthcare system. To monitor impacts on this specific population, partnerships with the Veterans Administration to access their rich healthcare utilization and electronic health records is likely to be necessary. A large proportion of veterans may also use healthcare in the general healthcare system through private or public insurance, but we are unable to identify their veteran status in the administrative data.

## Considerations

Our assessment of available data yields several key considerations. Considerations surround better understanding how important several of the limitations we have identified are in evaluating impacts of cannabis legalization on the healthcare system. The four priorities include: 1) understanding clinician coding of cannabis related behaviors in administrative data; 2) understanding the importance of substance use disorder redactions in administrative data for research purposes; 3) potential collaboration with DPH for use of the PHDW to analyze impacts of cannabis legalization; and 4) understanding the work of other states and regions in monitoring impacts of cannabis legalization and the opioid epidemic and development of new data sources for this purpose.

First, understanding clinician testing and coding of cannabis related behaviors in administrative data will help to understand links between healthcare use and whether full information is available in administrative data. For example, prior to legalization, clinicians may not have entered cannabis use into electronic health records unless it was directly clinically relevant for a specific encounter due to concerns around legality and stigma. After legalization, there may be changes in clinician behavior and/or recording of this information. Additionally, administrative data primarily come from billing information, so understanding how diagnosis codes are being applied based on clinician observation will be important. This recommendation may include comparison of electronic health records and administrative data, or primary data collection to better understand the extent to which cannabis use and dependence may or may not be captured accurately, and changes over time in this behavior.



Second, understanding exact methods of substance use disorder redaction in available datasets and whether these change over time is of importance. For example, the most recent information available suggested that users may be able to obtain non-redacted substance use disorder claims from the MA APCD, but other identifying information (*e.g., service dates*) would not be available simultaneously. This factor limits the ability of researchers to better understand causal relationships by analyzing, for example, the timing of dispensary openings and changes in healthcare utilization in a small geographic area.

Third, better understanding ongoing plans for the issuance of targeted Notices of Opportunity to use the PHDW may be of strategic importance to the Commission. This data source may be a powerful resource to examine a holistic set of health outcomes, but currently has major limitations to its use for cannabis-related monitoring and research.

Fourth, similar to the MA PHDW, researchers studying the opioid epidemic in other states and nationally have extensively explored the question of linked datasets to monitor and evaluate impacts of the epidemic and identifying ways to improve public health.[37,38] To evaluate the impacts of cannabis on the healthcare system, different types of data may need to be linked and monitored than are currently under consideration. For example, cannabis legalization is less likely to impact mortality than changes to public health strategies targeting opioid use disorder, and thus the inclusion of death data may be less critical in data warehouses. However, other items may be of more strategic value including items such as medical cannabis licenses, and dispensary sales.

## C. Incidents of impaired driving

The authorizing legislation requires research on incidents of impaired driving. In field settings *(e.g. at the roadside, in a hospital*), measurement of cannabis-related driving impairment from biological measures alone is limited by the current state of the science[1,39] and Massachusetts does not have a *per se* limit for delta-9-tetrahydrocannabinol (THC) that can be used as legal evidence of driving impairment. Nonetheless, several different types of data are available that relate to the issue of driving under the influence of cannabis, each with strengths and limitations.

### Summary of available data

Massachusetts has a number of state-complied data sources that are relevant to cannabis and driving, including administrative data that address motor vehicle crashes, crash-related injuries, and law enforcement stops and arrests. Survey data are also available that address self-reported incidents of driving under the influence of cannabis. We identified three national data sources that allow identification of cannabis exposure among Massachusetts drivers and five available Massachusetts-specific data sources (Table 5).

**Crash and incident related data**

We considered data relevant to impaired driving along a continuum of decreasing severity of the incident: fatal crashes, injury-causing crashes requiring medical care, crashes involving minor injuries or property damage, and incidents when no crash occurs but law enforcement suspects impaired-driving.

The primary national data source that can be used to monitor indicators related to cannabis and driving in Massachusetts is the Fatality Analysis Reporting System (FARS).[40] FARS is a census of police-reported fatal injuries suffered in motor vehicle crashes in the United States. FARS includes more than 140 data elements characterizing the details of each crash as well as the vehicles and people involved.[41] This data can be readily downloaded from the National Highway Traffic Safety Administration's website and is currently available from 1975 to 2017. Information available includes whether the person was tested for alcohol and/or drugs, the test type(s), and the test results, including specific drug types found. A general code for cannabinoids as well as specific codes for THC are included, though FARS does not provide quantitative toxicology results for drugs. State-level trends in both the proportion of fatal crash-involved drivers tested for drugs and the proportion of tested drivers with a positive result for THC or its metabolites can be monitored over time within a state. However, the presence of THC or other cannabinoids does not mean the driver was *impaired* by cannabis use and variations in testing procedures over time and a low number of surviving drivers being tested are key limitations.[1,42] The National Incident-Based Reporting System (NIBRS)[43] is a national data source that includes incident-level data for crimes that include driving under the influence and the data are available for Massachusetts from the Executive Office of Public Safety and Security (EOPSS). However, alcohol and drug related offenses are grouped together under a single code for driving under the influence; cannabis-specific incidents cannot be identified.

Cannabis-specific information is limited or lacking in most existing datasets, but for monitoring crashes that cause serious nonfatal injury or involve drivers that survive crashes that are fatal for another person, state-level data sources must be used and the Massachusetts Trauma Registry likely provides the best information of the existing sources. Data from Massachusetts Drug Recognition Expert (DRE) program contains the findings from evaluations of individuals suspected by law enforcement of being under the influence of one or more drugs made by specially trained law enforcement officers; such evaluations can occur both after a crash and when a driver is stopped at the roadside and no crash has occurred.

The Massachusetts Trauma Registry is overseen by the Massachusetts Department of Public Health (DPH). All Massachusetts hospitals operating as a designated trauma center are required to submit data to the State Trauma Registry. There are required data elements that collect information on the cause and severity of trauma, as well as demographic information. Starting in 2017, drug and alcohol screenings, if known, became required elements.[23,44] Diagnosis codes that reflect the mechanism of the traumatic injury allow identification of persons involved in motor vehicle collisions, although the extent to which codes identify drivers versus other vehicle occupants needs additional assessment. The data include patient demographic information. With

IRB-approval and an application process, DPH makes trauma registry data available for analysis by qualified researchers. Hospital claims and discharge datasets (*e.g. APCD, CaseMix*) described above (*Section B: Healthcare utilization and financial impacts on the state healthcare system*) may also have some utility for identifying the co-occurrence of ICD-9/10 codes for motor vehicle collisions and diagnoses related to cannabis use *(e.g. cannabis use disorder; cannabis intoxication).* Such analyses would be subject to similar limitations as described above.

Drug Recognition Experts (DREs) are specially trained law enforcement officers who receive specialized training to be able to administer several types of assessments and render an expert opinion on whether an individual is under the influence of specific drugs. DREs are frequently called upon to differentiate unsafe driving behaviors stemming from drug ("substance") influence and medical and/or mental health conditions, which makes them an important part of the process of assessing cannabis-impaired driving.[39] The state DRE coordinator is required to collect and submit an annual report for the International Association of Chiefs of Police (IACP) that include the number and percent of all DRE evaluations resulting in the DRE's judging that cannabis was the impairing substance.[39] These data, which are available starting in 2010, have been made available to the Commission and included in previous reports.[39]

Available datasets that are relevant to impaired driving but do not systematically include indicators of cannabis-specific involvement in crashes are: The Massachusetts Ambulance Trip Record Information System (MATRIS),[26] the Crash Data System (CDS) owned by the Massachusetts Department of Transportation Registry of Motor Vehicles (RMV) Division; the Massachusetts State Police data on operating under the influence (OUI) offenses. All these data are available via an application process or partnership with the relevant state agency.

MATRIS includes data on alcohol or drug use indications, but there is no specific code to indicate suspected or admitted cannabis.[45] The RMV's CDS tracks all crashes in which a person operating a motor vehicle is killed or injured or in which there is damage in excess of $1,000 to a vehicle or other property.[46] At present, CDS data could be used to track overall number of crashes in Massachusetts and in specific counties or geographic areas, but it does not include information on cannabis involvement in a standardized way. Some information may be available through searching the free text fields for cannabis-related words *(i.e. marijuana, weed, pot)* but this would not provide a systematic assessment.

The Massachusetts State Police collect data on the incidents of operating under the influence (OUI), including "OUI-Alcohol" and "OUI-Drugs", and "OUI-Unknown Substance" by recording violations of M. G. L. c. 90, § 24., *Driving while under influence of intoxicating liquor, etc.*).[39] However, the data does not distinguish between different classes of drugs or between specific drug(s). These data include information on: county in which the incident took place; action taken by the Massachusetts State Police law enforcement (arrest, citation, no action, protective custody, summons, or under investigation); whether the incident resulted in a crash or not; and information about driver race/ethnicity, gender, and Massachusetts residency. The Commission's Research Department has analyzed and reported on these data previously.[39] Municipalities may collect data that allow identification and tracking of cannabis-related incidents of OUI-Drugs, but this is not required and is not systematically implemented across

Massachusetts. The Commission has analyzed and reported on such data from Boston Police Department.[39]

After an individual is arrested for OUI-Drugs, the case may result in charges files in court. The Massachusetts Executive Office of the Trial Court maintains a database of records made in connection with a case or proceeding.[45] This statewide database collects data on charges filed in District and Municipal courts for drug-related OUI charges including charges first offenses, repeated offenses, offenses that cause serious injury, and those that involve recklessness or negligence. Like the Massachusetts State Police data, OUI-Drug charges are not categorized by the specific substance or drug. Thus, the number or percentage of charges that are related to driving under the influence cannot be tracked without a manual review of data. Such an undertaking may be possible in partnership with the Executive Office of the Trial Court, which makes records available for scholarly, educational, journalistic, and governmental purposes. Specific requests are fulfilled based on the discretion of the Court Administrator, in consultation with the Chief Justice of the Trial Court. The trial court does not provide data on an individual, case-level basis, though it works with data requestors to prepare and provide aggregated statistics. Even in aggregate, location of the offense and demographic information may be suppressed to protect the privacy rights of individuals.

**Survey data**

The Substance Abuse and Mental Health Services Administration's (SAMHSA) National Survey on Drug Use and Health (NSDUH) is an annual, national survey of youth (age 12-18 years) and adults (18 years and older). The NSDUH data can be used to generate population estimates that are representative at the state level.[47] In 2016, the NSDUH added a question about the number of times in the past 12 months the respondent has driven a vehicle while under the influence of marijuana.[47] These data could be used to estimate self-reported driving under the influence of marijuana from 2016 to the present among youth, emerging adults *(i.e. individuals age 18-24 years),* and adult cohorts.

Population-level survey data pertaining to adults driving under the influence includes the Massachusetts Behavioral Risk Factor Surveillance System (MA BRFSS), the Massachusetts Marijuana Baseline Health Study (MBHS). The MA BRFSS is a modified version of the national BRFSS survey that collects data on health risk factors among Massachusetts residents and has over 7,000 residents annually.[48] Starting in 2015, the Massachusetts survey has asked respondents if there were "times in the past year when you were under the influence of marijuana in situations where it could cause you or others harm? For example, when you were driving a car or operating a machine?"[49] Because the survey item asks about two behaviors, it is not possible to disentangle them to estimate the prevalence of driving under the influence of marijuana alone.

The Massachusetts Marijuana Baseline Health Study (MBHS) included a survey fielded in 2017 that was designed to represent Massachusetts adults. Adults who reported past 30-day cannabis ("marijuana") use were asked to provide information on past 30-day driving under the influence of cannabis.[1] These data could provide valuable information on trends over time if the survey is repeated.

The Youth Risk Behavior Survey (YRBS), conducted in partnership with CDC and the Department of Elementary and Secondary Education, includes an item on cannabis ("marijuana") and driving. This survey is administered every other year in a representative sample of Massachusetts high schools. It includes a question that asks respondents if in the past 30 days they have driven a car after using cannabis. The Massachusetts Youth Health Survey (MYHS) uses the same question on past 30-day driving after using cannabis and it is administered to middle and high school students.[7,50] Analysis of these surveys would allow self-reported driving after marijuana use to be tracked across the time for school-attending youth.

### Special data sources

In addition to the data described above, there may be information available from specialty surveys from state entities. In 2018, the Commission sent a survey to all of the 351 municipality Law Enforcement Agencies (LEAs) in the state of Massachusetts and Massachusetts State Police to obtain information on existing procedures and resources available for assessing cannabis-impaired driving, including access to DREs and number of officers with Advanced Roadside Impairment Driving Enforcement (ARIDE).[39] The MSP and 84 municipalities responded to the survey (24% response rate). If repeated, this survey could be useful for monitoring changes over time. The Commission also participated in the development of a Public Awareness Campaign, *More About Marijuana,* which included information related to cannabis-impaired driving. The methodology the Commission relied on to evaluate *More About Marijuana* included an online panel survey weighted to represent the Massachusetts adult population. This survey presents an opportunity to assess self-reported information about driving under the influence and knowledge about its risks and related law.

In Washington State, roadside studies of alcohol and drug use have been useful sources of information about cannabis use among drivers[51] Roadsides studies typically include random selection of drivers who voluntarily agreed to participate, during various days and times, and provide researcher with anonymous oral fluid and/or blood samples for testing as well as self-reported information on alcohol and drug use. Drivers were not subject to criminal penalty if the oral and blood samples revealed the presence of drugs or alcohol. Several MA counties participated in the 2013-2014 National Roadside Study of Alcohol and Drug.[52-54] This study could provide a useful baseline reference if Massachusetts is able to conduct a future roadside survey.

## Limitations

### Crash and incident related data

The limitations of the crash and incident related data fall into several main categories: 1) reliance on cannabinoid testing indicates exposure to cannabis and not impairment by cannabis; 2) coding inconsistencies; and 3) lack of inclusion of cannabis-specific indicators.

Data that rely on toxicology testing for THC or its metabolites are subject to important limitations. After inhalation or ingestion, THC can accumulate at different rates in different individuals based on variables that include adiposity, amount and method of use, and frequency of use.[1,39] The presence of THC in biological samples (e.g. *blood, oral fluid, urine*) does not indicate impairment.[53] Extensive discussion of the state of the science for quantifying cannabis exposure in different fluid matrices are presented elsewhere.[39] While FARS data include a comprehensive collection on many aspects of fatal motor vehicle crashes, drug related variables are relatively limited and are often not reported, especially for surviving drivers.[55] FARS data only records up to three drugs for each driver and does not include the amount of each drug detected. In instances when four or more drugs are detected, the first three drugs are reported based on a hierarchy.[55] FARS does not include quantitative drug levels. Furthermore, there is considerable variation between laboratories across and within state lines with regard to equipment, procedures, and training of personnel in conducting drug testing.[56]

Other crash-related data sources have important limitations. Like FARS, the Massachusetts Trauma Registry Data drug screen results are based on toxicology testing. Urine drug screening is the predominant form of testing for cannabis in routine emergency department care, and this measure indicates cannabis exposure in approximately the past month.[57] Only five positive drug screening results are included in the data, and no coding hierarchy is provided. Thus, in polysubstance cases, cannabis may be present but not reported. There also may be variation and non-adherence to submission guidelines, including incomplete or erroneous data[58,59] and challenges due to different coding practices (see further discussion of this issue above in *Section B. Healthcare use and financial impacts on the state healthcare system*).

A key challenge of other existing data sources on crashes and most law enforcement data is that there is not a specific indicator for cannabis-involvement. There is no field in which to report suspected cannabis involvement on the crash forms utilized by police to document crashes in Massachusetts. This impacts the CDS. It is technically possible to search the narrative information which may include mention of cannabis, but there are likely inconsistencies in whether suspected cannabis-involvement is documented. Further, the many terms that may be used *(e.g. marijuana, weed, or pot)* present additional challenges. There may be inconsistencies across entities contributing to the CDS.

At present, Massachusetts State Police data on OUI offenses includes a category for "OUI-Drugs" that does not differentiate between types of drug. Thus, incidence of cannabis-involved crashes cannot be accurately assessed at present.[39] Similarly, Massachusetts Courts are not statutorily mandated to categorize drug-related OUIs based on the specific drug or substance involved. For the Commission to obtain insights into charges filed, sentencing, convictions, and incarcerations for cannabis-related motor vehicle offenses in Massachusetts, it would involve an iterative process with the Executive Office of the Trial Court to identify whether it is possible to establish a suitable dataset.

And additional limitation of police and other justice system administrative data is that the extent to which polysubstance incidents — defined, for our purposes, as incidents that involve cannabis

and alcohol or cannabis and another drug — are not well tracked. Typically, if someone is found to be have a blood alcohol level above the *per se* limits, investigation of other sources of impairment stops there because an arrest can be made on a charge of OUI-Alcohol. Thus, measurement of polysubstance impairment from drugs and alcohol together is likely subject to significant underreporting in the presently data collected.[39]

**Survey data**

Population survey data, in general, has limitations stemming from the fact that it is self-reported and not corroborated by testing of biological samples. Surveys also can be impacted by selection bias if individuals who use marijuana are more or less likely to complete the survey compared to others. Survey data are also subject to recall bias and the possibility of social desirability bias.[60] Additionally self-reported data are subject to individual interpretation of what it means to be "under the influence" of a drug. No existing population survey puts, for example, a time frame (*e.g. 2-3 hours*) into the question of driving after cannabis use. In addition, no adult survey asks about riding as a passenger with a driver under the influence of cannabis, or whether this behavior occurs with children or other passengers in the vehicle.

Each survey has certain strengths and weaknesses. That the MA BRFSS has only one question encompassing both driving under the influence of cannabis and all other potentially harmful situations is a key limitation. The Massachusetts Baseline Health Study survey data may provide a valuable resource for the Commonwealth, having been designed specifically to address the potential impacts of cannabis legalization. However, it is unclear if the survey will be repeated, and if so, on what time interval.

## Considerations

Due to the limitations of the data sources described above, no single dataset currently compiled in Massachusetts can track all incidents of cannabis-impaired driving in the Commonwealth. In addition to analysis of several different existing sources to establish the best sense of patterns in cannabis involvement in motor vehicle crashes and in driving under the influence of cannabis, we suggest: 1) new data collection; 2) modifications to improve existing data collection; 3) detailed assessment of datasets to inform potential for modifications to datasets; and 4) funding research that will help to advance the science of detecting cannabis impaired driving.

We recommend monitoring the presence of THC in crash-injured drivers for both fatal and nonfatal collisions, despite the notable limitation that the presence of THC is not indicative of impairment.[61] Nonetheless, such data can be useful for making comparisons over time (assuming testing methods do not change or that change is accounted for) or across different locations, and for making comparisons to roadside studies of non-crash injured drivers (a method for estimating crash risk).[62] According to the most recent Massachusetts Strategic Highway Safety Plan,[63] the Highway Safety Division is planning to examine the possibility of conducting a Massachusetts Roadside Study of Alcohol and Drug Use by Drivers, as noted in its 2018 recommendations. We support acting on this recommendation as a way to monitor the proportion of THC-positive

drivers on Massachusetts roadways over time. Querying drivers about the recency of substance use would also prove useful, and in combination with testing of crash-injured drivers, a roadside study would permit rigorous estimation of crash risk from cannabis.

With regard to modifications to existing data collection efforts, we note that police records from motor vehicle crashes would be strengthened for purposes of tracking cannabis-involvement if there were standardized fields in which to report officer suspicion of cannabis involvement, and to provide information from any chemical, behavioral, or specialty (*i.e. DRE*) testing conducted.

Data compiled by the Massachusetts State Police and local police departments on incidents involving OUI-Drugs cannot be used to monitored cannabis-involved offenses, specifically, unless a change to reporting requirements and practices is made. This may require a change to the OUI laws and inclusion of a specific category for OUI-Cannabis. Such a change would be of great benefit to monitoring OUI-Cannabis, although there is room for debate around how a determination of could be made since a single chemical or behavioral test does not exist for cannabis-impairment at present. Such issues are discussed at length in the Commission's January 2019 Public Safety Report.[39]

Although the NSDUH may be useful for tracking self-reported driving under the influence of cannabis in adults and youth, we recommend partnership with independent researchers and/or DPH regarding state-specific surveys that would allow estimation at the regional level not possible in NSDUH. Specifically, we suggest a new wave of data collection to follow up on the Massachusetts MBHS survey items on cannabis and impaired driving. The MYHS could be improved regarding impaired driving if the survey included additional questions that asked about riding in a vehicle with a driver who was under the influence of cannabis or other social norms related to cannabis marijuana and driving. Efforts to test the reliability and validity of self-reported items measuring driving under the influence are suggested including efforts to partner with national entities addressing this issue *(e.g. Centers for Disease Control and Prevention; Council of State and Territorial Epidemiologists.)*

Regarding further assessment of data sources, we recommend evaluation of the extent to which some of the possible limitations to the FARS dataset exist for Massachusetts. Although the FARS data is available from the National Highway Traffic Safety Administration (NHTSA) we recommend partnership with Massachusetts Department of Transportation, the agency that compiles and reports to FARS to assess consistency of over time (*i.e. laboratory reporting of THC specifically vs. grouping into a general code for cannabinoids).* This may necessitate further collaboration with the Office of the Chief Medical Examiner, as drug information in FARS data is compiled from medical examiner toxicology reports.

Assessment of the extent to which ICD-9/10 codes and specific drug use variables in the Massachusetts Trauma Registry dataset can be utilized for monitoring cannabis-related cases is a recommended next step. Massachusetts DPH's Injury Surveillance Program is examining impaired driving crashes, as well as the impact of mixing illicit and licit drugs and alcohol, by utilizing a variety of data sources to better understand the magnitude and characteristics of such crashes. Partnership with the ISP on their current effort to link hospital data with crash data and



providing support for analyses specific to cannabis would be an appropriate way to improve knowledge of the types of crashes that involve cannabis, where they occur, and costs.

## D. Ownership and Employment trends

The authorizing legislation requires the Commission's research agenda to address "*ownership and employment trends in the cannabis industry examining participation by racial, ethnic and socioeconomic subgroups, including identification of barriers to participation in the industry*." The Commission collects data on a number of indicators related to monitoring ownership and employment in the cannabis industry. In addition, the Commission established an Economic Empowerment Priority Review Program that was designed to help support cannabis business ownership by individuals from demographic and geographic groups that have borne a disproportionate share of negative consequences (*e.g. arrests, incarceration*) from marijuana prohibition and enforcement policies.[64] There is also a Social Equity Program designed to "*build a pathway for individuals and businesses that wish to build, enter, and support a robust adult-use cannabis marketplace regardless of their desired level of involvement or area of specialty*."[65] The social equity program provides training, and technical assistance to support cannabis industry participation by people from communities that have previously been disproportionately harmed by marijuana prohibition and enforcement.

### Summary of available data

#### Business ownership and workforce

Cannabis industry workforce data is collected by the Commission via the application process[66] and the Massachusetts Cannabis Industry Portal (Mass CIP).[66] All owners and controlling parties of Marijuana Establishments and Medical Marijuana Treatment Centers and individuals working in the cannabis industry are considered Marijuana Establishment "Agents." Detailed demographic information is collected including: residential address, gender, age and race/ethnicity.[‡] Additionally, disadvantaged business enterprise (DBE) data are collected on a voluntary basis, which includes: 1) Women-owned businesses; 2) Veteran-owned businesses; 3) Minority-owned businesses; 4) Lesbian, Gay, Bisexual, Transgender-owned business; and 4) two or more DBE business types. These data can be used to assess trends in cannabis business ownership and evaluate the impact of specific programs that may be implemented to support diversity of cannabis business ownership.

[‡] Native Hawaiian or Other Pacific Islander (Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, Marshallese), American Indian or Alaska Native, Middle Eastern or North African (Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian), Asian (Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese), Black or African American (of African Descent, African American, Nigerian, Jamaican, Ethiopian, Haitian, Somali), Hispanic, Latino, or Spanish (Mexican or Mexican American, Puerto Rican, Cuban, Salvadoran, Dominican, Colombian), White (German, Irish, English, Italian, Polish, French), Some Other Race or Ethnicity, Identified as Two or More Ethnicities, or Declined to answer.

**Barriers to entry**

The Commission will pursue research on barriers to entry into Massachusetts' legal cannabis market. This mixed methods project will include experienced and anticipated barriers to enter the cannabis industry for current and potential entrants, demographic cohorts, and entities. The results of this work would inform further research and provide insights for policymaking. In October 2019, the Commission assessed Positive Impact Plans based on a review of Social Equity Program applications and other materials.[67] Consequently, the Commission is undertaking efforts to revise guidance on the Positive Impact Plan and ensure its purpose is understood by all applicants and the public.

### Limitations

Because participants voluntarily self-report demographic characteristics, the information may be incomplete. Additional anticipated limitations of the planned research design include potential challenges with recruitment and retention of study participants, which will be necessary to fully assess the varying barriers to entry of diverse current and potential applicants.

### Considerations

Through existing data collection by the Commission, the geographic and demographic composition of cannabis business owners, including controlling entities, and agents can be monitored. Providing monetary compensation for study participants, a standard practice in academic research, could increase the likelihood of enrolling and maintaining a diverse study population and lead to higher post-baseline retention rates.

## E. Cannabis markets

The authorizing legislation calls for "*a market analysis examining the expansion or contraction of the illicit marketplace and the expansion or contraction of the legal marketplace, including estimates and comparisons of pricing and product availability in both markets."* There are two general approaches to estimating drug market size: 1) supply side (*i.e. production-based and seizure-based*); and 2) demand side (*e.g. consumption-based and expenditure-based*) estimates. These can be applied to both legal and illegal markets. In Colorado and Washington, the first states to implement legal, adult-use marijuana regulations, teams of academic, government, and nonprofit firm researchers conducted market analyses.[68,69] Methodology of these analyses included internet surveys to estimate expenditures and details of cannabis products utilized. Since that time private sector market analysis firms have expanded their practices to include legal marijuana markets and firms specializing on marijuana market intelligence have begun publishing materials.

## Summary of available data

### Legal market

Supply side estimates of the legal market can be obtained through Metrc, the seed-to-sale tracking system utilized by the Commission.[70] Implemented on April 1, 2018, and updated in real time, this data collection allows monitoring the legal marketplace. The data maintained by the Commission includes three categories of data for the adult-use industry: 1) agent registration; 2) applications and licenses; and 3) sales and product distribution. The applications and licenses data include varying licensing timelines and mechanisms, including: 1) application and license review; 2) status of applications opened; 3) total applications under review by type; and 4) licenses awarded by type. As different license types are added, these categories will change. The sales and product distribution category contains indictors of sales in dollars and units of different types of products sold. Market data is published on the Commission's website and the raw data can be used by the Commission to fulfill its research agenda.

Broadly speaking, demand side estimation of cannabis markets has been done utilizing estimates of the number of cannabis users and frequency of cannabis use from general population surveys and combining this with information about expenditures.[68,69,71] Population surveys described previously in this report, such as the National Study on Drug Use and Health, and Massachusetts Behavioral Risk Factor Surveillance Survey[5] are available for can be used towards estimating the number of cannabis users and frequency of use, but do not include detailed information on expenditures nor stratify out by market where cannabis and/or cannabis products were obtained (*i.e. licit or illicit market*). Use of these sources towards market estimation would require them to be combined with information on pricing or expenditures from other sources. The Massachusetts Marijuana Baseline Health Study[1] assessed the number of cannabis users, frequency of use, and expenditures, but did not directly assess whether cannabis users obtained cannabis via the licit or illicit market.

### Illegal market

Researchers sometimes use information on cannabis seizures by law enforcement to help estimate the size of illicit markets,[72] but this data does not provide a comprehensive picture. Several websites have developed cannabis price indices which could potentially be used towards estimating the size of the illicit market. Price of Weed, a global price index, crowdsources the street value of cannabis.[73] The Budzu website also provided crowdsourced information about cannabis prices, with prices in dollars ($) per gram.[74] Prices are broken down into four categories for purchase location (dispensary medical, dispensary recreational, street medical, street recreational) and provided for low, medium, and high quality cannabis. On a near daily basis, these sites list new submissions documenting self-reported location (at the city/town level), price, quantity, and quality. Seedo,[75] which sells a hydroponic growing device, and ABCD,[76] a public relations firm, have created a Cannabis Price Index[77] utilizing Google Maps search results and crowdsourced city surveys. They provide estimates of the price of cannabis per gram, in U.S.

dollars, for 120 large cities, including some U.S. cities. Their methodology is included in the website.

**Legal and illegal markets**

BDS Analytics,[78] a company based in Boulder, Colorado is the official data partner of the National Cannabis Industry Association[79] and currently documents sales in both legal and illegal markets in Arizona, California, Colorado, and Oregon. The cannabis industry data company provides "data-driven insights, market intelligence, and complete consumer understanding."[78] BDS Analytics had made predictions about cannabis ("marijuana") sales in Massachusetts for 2019, suggesting that 76.3% of marijuana sales are through the illicit marketplace.[80] The methods utilized to generate this estimate are proprietary.

The Commission's Research Department is collaborating on *The International Cannabis Policy Study* (Principle Investigator, Dr. David Hammond, University of Waterloo), an ongoing epidemiologic study conducted in Canada and the United States surveilling varying cannabis use patterns and outcomes, including: problem use, and legal and illicit market sourcing.[81] This ongoing study will provide information for 2018 and 2019 about Massachusetts markets that allows for a preliminary assessment of "the expansion or contraction of the legal marketplace, including estimates and comparisons of pricing and product availability in both markets." These data will be incorporated into future reports by the Commission.

### Limitations

Data needed for demand side estimates of expenditures are not routinely collected by the state, but would be an important part of market analyses, especially those that seek to address the illicit market. The *International Cannabis Policy Study* may help to address this challenge.

Reliable data to inform supply side estimates pricing, product availability, and potency in illicit markets is also not available, due to the nature of the illicit marketplace. Information on the illicit market is limited to that which could be obtained from industry analysts and crowdsourced information. Industry analysts may have valuable data, but assessment of costs and potential biases is necessary before use of such data could be recommended. Crowdsourced data is subject to selection bias. Because of this, we do not recommend the use of such data unless efforts to evaluate its reliability through comparison to a survey-based demand side information and supply side information.

### Considerations

A market size study including monitoring changes over time would be needed to meet these legislative requirements. The robust seed-to-sale data maintained by the Commission is helpful towards this end, but monitoring of the illicit market will take additional data and support from

law enforcement agencies. We suggest Massachusetts take a multidisciplinary approach to developing market studies, similar to the approaches by Washington and Oregon.[68,69]

## F. Cannabis-related incidents in schools

The authorizing legislation calls for the Commission to "*compile data on the number of incidents of discipline in schools, including suspensions or expulsions, resulting from cannabis ("marijuana") use or possession of marijuana or marijuana products*."

### Summary of available data

The Department of Elementary and Secondary Education (DESE) collects discipline data from school districts, charter schools, and virtual schools, per M.G.L. c. 71, §37H and 603 C.M.R. 53.14**.** Schools are required to report all incidents involving drugs, violent, or crime-related offenses on school property and any resulting suspensions or removals imposed on the student offender(s). Reportable disciplinary actions include in-school suspension lasting more than ½ a school day, out of school suspension, expulsion, removal by an impartial hearing officer or by school personnel to an alternative setting, and emergency removal. Reportable offenses that relate to cannabis include "marijuana use" and "marijuana possession."

The information collected by DESE include the date of incident, school name/code, first and last name of disciplined student, date of birth of disciplined student, offense indicator (whether it is reportable), whether the incident resulted in disciplinary action and if so what type, start and end of discipline, days of school missed as a result of discipline, type of education services provided to student during discipline. They also gather information about school-related arrests including type of offense, the number of student victims, number of school personnel victims, number of non-school personnel victims, number of offenders (both student and non-student), description of offense, and whether the incident resulted in injury.[82] Much of this information is publicly available for 2001-2017 via the online Student Discipline Data Report which allows assessment—at the district and school level—for marijuana use and marijuana possession by race/ethnicity, gender, special education, economic advantage, limited English proficiency (LEP), and high need status. The online reports do not allow assessment of more than one category (*i.e. Black girls in Andover*). Confidential student level data, however, can be accessed by qualified researchers working under appropriate data sharing agreements.

### Limitations

DESE compiles valuable information about the incidents of student discipline, including suspension and expulsion resulting from cannabis ("marijuana") use or possession at school. One limitation of these data are that data may be censored to protect student anonymity when reports are requested at the school district-level and there are fewer than six offenses reported in a given time period. Additionally, student-level data to support analyses that incorporate multiple

variables (*i.e. demographic information and gender and location*) is needed assess whether students from minority groups are disproportionally impacted by school discipline related to cannabis. Procurement of these within the disciplinary data for purposes of the research agenda will require collaboration with external researchers with Institutional Review Board (IRB) capabilities.

### Considerations

Through a more research-intensive collaboration with DESE or a collection of new data, exploration of the demographic and other factors associated with cannabis-related discipline at school would provide insights into whether and how changing cannabis policies may impact different student subpopulations regarding discipline. We suggest a formal collaboration with researchers with IRB capabilities to ensure adequate data procurement and analyses.

## G. Criminal justice encounters

The Commission's research mandate includes "*the compilation of data on the number of civil penalties, arrests, prosecutions, incarcerations and sanctions imposed for violations of Massachusetts General Law (M.G.L.) Chapter 94C for possession, distribution or trafficking of marijuana or marijuana products, including the age, race, gender, country of origin, state geographic region and average sanctions of the persons charged*." The Commission's April 2019 report provided a baseline assessment in this topic area based on readily available data and literature review.

### Summary of available data

The present State of the Data assessment included review of the Commission's April 2019 report and identification of additional data sources that may be relevant to cannabis-related prosecutions, incarcerations, sanctions imposed, average sanctions of the persons charged for violations of M.G.L. c. 94C, and civil penalties.[83] Including those previously described by Doonan and Johnson,[83] we identified one national data source with a state indicator and six Massachusetts-specific sources that can be utilized to address these indicators (Table 6).

**Arrests**

At the federal level, the Uniform Crime Reporting program, run by the Federal Bureau of Investigation, is a valuable resource for monitoring indicators in Massachusetts relevant to this topic. It encompasses the National Incident Based Reporting System (NIBRS), which provides individual and aggregate data on crime incidents, including data on both perpetrators and victims. Data about cannabis-related incidents are included such as cultivating or manufacturing; transporting, transmitting, and importing; distributing or selling; possessing or concealing; buying or receiving; and using or consuming.[83] At present, a majority of Massachusetts

municipalities contribute data to NIBRS. The Boston Police Department (BPD) does not contribute to NIBRS. Key demographic information is included in NIBRS *(e.g. age, race, ethnicity, gender, and residency status),* which is important when measuring inequities between and among groups. Such analyses were undertaken by the Commission's Research Department and previously reported for the baseline period before the widespread implementation of retail cannabis sales for adult use.[83]

At the state level, The Massachusetts State Police tracks data on cannabis ("marijuana") and Class D violations (a class that encompassed cannabis and several other drugs) across the state, in accordance with M.G.L. c. 94C. Data from MSP encompass violations for: cannabis trafficking into the state, cannabis possession greater than and less than two ounces, cultivation/manufacturing a Class D substance, distributing or intention to distribute a Class D substance, possession of a Class D substance, and drug violations near a school or park.[83] Key demographic information, as described above, are also included here. Additionally, the Massachusetts' State Police CrimeSOLV is a statewide database that collects crime statistics such as cannabis or hashish law enforcement seizures and compiles them into tables and charts.[83]

Data are also collected on the municipality-level across the state of Massachusetts on violations of M.G.L. c. 94C-Class D violations including: distribution of Class D substances; possession with intent to distribute a Class D substance; cannabis possession; and cannabis trafficking. Obtaining municipal level data, if not provided via NIBRS, requires coordination with municipal authorities *(e.g. Boston Police Department).*

The New England High Intensity Drug Trafficking Area (HIDTA) is a program administered by the Office of National Drug Control Policy and aims to reduce drug trafficking in New England by disrupting drug trafficking organizations and improving the efficiency and effectiveness of law enforcement organizations.[84] The New England HIDTA program employs a team of analysts who have access to several state and national databases that can be used to assess cannabis-related crimes. Statewide databases include data from the Massachusetts State Police and on the federal level, the New England HIDTA has access to the FBI Sentinel database which includes investigative, intelligence, personnel, and administrative data collected by the FBI,[85] the Domestic Highway Enforcement Initiative which includes data about highway enforcement, and the National Search and Seizure Database. Collaboration with the HIDTA is needed to produce reports on cannabis trafficking and other highway enforcement activities. Data from HIDTA has been used for monitoring purposes in other states that have legalized cannabis.[86]

**Sentencing**

The Massachusetts Executive Office of the Trial Court (EOTC) maintains a Trial Court Case Management Database which provides access to court records such as court papers, documents, exhibits, orders, recordings, and dockets made in connection with a case or proceeding. Requests can be submitted for data from all courts across the state *(e.g. superior, district, juvenile, trial, appeals)* on sentencing, conviction, and incarceration related to cannabis offenses. The EOTC

can provide compiled (*i.e. aggregate*) statistics on charges filed in District and Municipal courts for drug-related charges. Data can be requested that includes demographic information such as county, age, gender, and race/ethnicity; however, these specifications might be withheld if the sample size is too small in order to protect the anonymity of offenders. The categories of cannabis offenses that can be compiled include those related to "marihuana possession (+1 oz)", "marijuana trafficking" with various categories by weight, as well as Class D offenses that may be related to cannabis (*e.g. possession of a class D drug; distribution or possession with intent to distribute a Class D drug)*. Standard data fields do not permit separation of Class D violations by the specific drug or substance involved. Requests are fulfilled based on the discretion of the Court Administrator, in consultation with the Chief Justice of the Trial Court."[87]

**Incarcerations**

The Massachusetts Department of Correction (DOC) is a data source for information on incarcerations including on length of sentences, length of time served, and conditions of release *(i.e. parole supervision, probation supervision, no post release supervision).* The information compiled includes information from inmates such as gender, race/ethnicity, age, and governing offense. Offenses are classified according to the M.G.L c 94C categories and mirror those maintained by municipal law enforcement and the trial court *(i.e. Distribution of Class D substance; Possession with intent to distribute a Class D substance; marijuana possession; and marijuana trafficking.)* Researchers and state agencies can submit proposals that seek to access data from the Department of Correction per the Research Proposal Policy 103 CMR 180.[88] All proposals are approved on a case by case basis. Most cannabis-related convictions result in sentences of fewer than 2.5 years and time for these convictions is typically served in the Massachusetts Houses of Correction (which are managed at the county level), rather than the Department of Correction which oversees incarceration of persons who are sentenced to 2.5 years or longer. For data on cannabis-related convictions resulting in sentences of fewer than 2.5 years, the individual county-based House of Correction must be contacted about data access. Every county-based House of Correction has their own process for requesting research data, as well as the types of data available.

## Limitations

The NIBRS has several limitations with regard to tracking cannabis-related offenses, including the fact that submitting data is voluntary and not all states or law enforcement agencies provide data.[83] In addition, Boston, the largest city in the state of Massachusetts, does not submit data to the NIBRS, limiting the ability of this dataset to accurately capture statewide cannabis-related offences.[83] The MSP data on cannabis-related offenses is valuable, but it is worth noting that race/ethnicity is collected by law enforcement based on both asking individuals directly and by officer inference, which could result in inaccurate assumptions about race.[83] The Massachusetts State Police (MSP) CrimeSOLV is a limited resource because it does not include all cities and towns in the state of Massachusetts and cannot be used to generate statewide statistics.[83]

The HIDTA data has several limitations with regard to monitoring cannabis related offenses. First, New England HIDTA has prioritized their efforts around combatting the opioid epidemic, as well as the increase in trafficking of fentanyl, crack, cocaine, and methamphetamine. Cannabis has not been a priority area. There may be overlap with data available from the Massachusetts State Police. Access to data maintained by this agency would require development of partnerships; the sharing of individual-level data outside the agency may not be possible.

Categorization of cannabis-related offenses in existing databases with information about arrests, prosecutions, incarcerations and sanctions maintained by the MSP, municipal police departments, the Executive Office of the Trial Court, The Massachusetts Department of Correction and Massachusetts Houses of Correction are limited by the way that the statues regarding cannabis and class D offenses are framed. It may not be possible to separate Class D violations related to cannabis from Class D violations pertaining to other drugs without extensive partnership and individual-level case review.

The data provided by the MA EOTC from the Trial Court Case Management Database may provide critical insights into sentencing and convictions for cannabis-related offences in the state of Massachusetts, but these data are not released at the case level. In partnership with the EOTC, the Commission can access such information for future reports. A codebook or listing of data elements is not available, thus obtaining trial court data will likely involve an iterative process with the agency to establish a suitable dataset.

Regarding incarceration, because most individuals who serve time for cannabis-related offenses would do so in a county house of correction, the data is decentralized and held within each county. Procurement of that data would involve requests to each county separately.

### Considerations

Data to assess violations of M.G.L. c94C are available from different state agencies and will require several different steps and a considerable amount of time to obtain the information needed to address the research mandate. The Commission's Research Department has already begun these processes, but additional steps will be needed to address the full scope of the legislation. The Commission will likely need to partner with researchers operating under an Institutional Review Board (IRB) to develop proposals for submission to criminal justice agencies for the purpose of procuring relevant data. In some cases, only aggregate statistics may be provided and collaboration with the other state agencies may be needed to ensure adequate staff time to respond to requests that involve manual data abstraction.

There is no mechanism in place to track payment of fines associated with civil penalties for cannabis possession. We recommend that the Commission consider tracking these incidents in partnership with the Executive Office of Public Safety and Security (EOPSS) and local municipalities, so that the extent of civil penalties can be monitored. Ideally, basic demographic

information would be compiled to allow monitoring of potential inequities in the distribution of who receives civil penalties.

## H. Economic and fiscal impacts

As specified in the legislation, the research duties of the Commission include monitoring the economic and fiscal impacts for state and local governments including the impact of legalization on the production and distribution of marijuana in the illicit market and the costs and benefits to state and local revenue.

The reliable estimation of economic impacts requires specialized research skills and estimation of impacts at the state level requires different models than impacts for local jurisdictions. The Marijuana Baseline Health Study[1] included development of an economic model to assess state-level costs.[§] The model, completed in 2018, incorporated data from a combination of sources including those described in other sections within this report. It is a starting point for development of a new model to reflect hypothetical and observed impacts.

Development of a new economic model would encompass many data sources which are described throughout this report and would combine estimates of the impact on key indicators in the domains described here with fiscal information from state agencies, and preciously established cost estimates.

The cannabis tax rate is key to the calculation of the benefits to revenue. At present, Massachusetts cannabis sales are subject to a regular state sales tax of 6.25% in addition to a 10.75% excise tax. The law allows municipalities to solicit a local sales tax of up to 3% of annual revenue earned through commercial cannabis sales. However, this ruling does not prohibit cities and towns from crafting "benefit pacts" with prospective adult-use cannabis businesses that can result in additional revenue to the municipality. There are 351 municipalities in Massachusetts. Assessment of impacts on local revenue must be done in partnership with the municipal entities. To assess the extent to which such activities are revenue-neutral for municipalities would require comparison of funds expended on policing in/around cannabis businesses with funds obtained from those businesses. Significant data-gathering efforts to obtain municipal-level information may be needed to assess local impacts. Some information is likely contained within applications submitted by business applicants to the Commission as part of the licensing and regulatory process.

To assess the fiscal impact of legalized adult-use cannabis, updated estimates and new models with assumptions based on the observed changes since retail, adult-use cannabis sales begin are

[§] We refer the reader to Task 3, Chapter 1 (p. 235) in the Marijuana Baseline Health Study final report for detailed information on the key domains for economic modeling and sources of data for estimates of costs and benefits to state funds.

needed. We suggest that the Commission consider establishing a partnerships with qualified researchers and experts in cannabis policy to fulfill this legislative mandate.

## I. Energy

Energy and environment data and measures are of critical interest to the Commission. Chapter 55 Section 78 expressly requires the Commission to establish energy and environmental standards, and authorized the Energy and Environmental Workgroup to provide recommendations to the Commission on: (i) ways to reduce energy and water usage in the marijuana industry; (ii) mitigating other environmental impacts; (iii) annual energy audits, energy efficiency measures, energy conservation measures and energy conservation project; (iv) additional best practices that would ensure marijuana establishment compliance with standards, resulting in the publication of guidance on best management practices on energy usage and reporting, water usage, waste management, and integrated pest management in 2019. It is imperative for the Commonwealth to assess and monitor, on an ongoing basis, potential energy and environmental impacts in accordance with c.55.

Cannabis cultivation is energy intensive. Indoor growing facilities often utilize high intensity lighting, fans, ventilation, cooling, water pumps, and dehumidifiers. A recent report from the Massachusetts Department of Energy Resources (DOER) noted that the energy use intensity per square foot in a cannabis cultivation facility was orders of magnitude higher than other commercial and industrial uses. Accordingly, monitoring the impact of cannabis legalization on energy, and particularly electricity, use is of importance to the Commission as the Commonwealth works towards emission reduction targets.[89]

The total size of the New England electric market at retail prices is about $19 billion annually and the Massachusetts market is almost $9 billion.[90] Prior analyses in other cities and regions have shown that a small fraction of overall electricity consumption is due to cannabis cultivation,[91] but the impact of cultivation may be larger for smaller geographical units (i.e. municipalities).

### Summary of available data

Using a combination of document and website review and contact with key stakeholders, we identified key indicators, potential data sources, and limitations of data sources related to electricity use. The key indicators for monitoring electricity consumption related to cannabis legalization in the Commonwealth are usage and pricing. We identified four potential primary data sources for electricity consumption in the Commonwealth, which we detail below: U.S. Energy Information Administration, ISO New England,[92] electricity suppliers, and Massachusetts Department of Public Utilities (DPU).

In considering empirical analyses that might be conducted to identify changes in electricity use at the regional or state level, other data sources would need to be incorporated. The majority of

year-to-year fluctuation in electricity consumption is driven by changes in weather patterns, and particularly summer weather both in average temperatures and in multi-day weather events; this includes humidity, with the dew point being an important indicator to consider. Long-term trends in electricity consumption relate to economic activity, changes in energy efficiency regulation, electric vehicles, manufacturing, demographics, and other factors. Two types of potential analyses seem possible using available data: 1) If individual address level data can be obtained (discussion below) then electricity generation related to cannabis cultivation could be calculated; or 2) Changes in state-level energy consumption related to cannabis legalization using comparisons pre and post legalization and Massachusetts versus New England states. It is difficult to draw conclusions about cause-and-effect these analyses because of data quality and the extent to which analyses, particularly changes in state-level energy consumption, can control for non-cannabis cultivation related factors.

### *U.S. Energy Information Administration*

The U.S. Energy Information Administration provides the official energy statistics of the U.S. government. They aggregate several data sources to produce monthly estimates of electricity retail sales, which are a proxy for end-use consumption. These estimates are available at the state level and the distribution company level, annually, but are not available at the five-digit ZIP code level or more granular geographic areas.

### *ISO New England*

ISO New England (ISO-NE) is a regional entity that has three major roles in the electricity sector: operating the power system of New England, administering wholesale electricity markets, and power system planning.[92] ISO-NE has publicly available data at the load zone level for the three zones in Massachusetts (*i.e., Northeast Massachusetts, Southeast Massachusetts, and Western/Central Massachusetts*). These data capture the total energy usage in terms of consumption and wholesale prices. They include electricity delivered to residential and commercial customers by electricity suppliers as well as wholesale market participants. These data exclude "behind the meter" production and consumption, which includes methods such as rooftop solar panels and a hospital generator where power might be produced and consumed simultaneously and would not be reported in these data. This lack of behind the meter data may underestimate total electricity consumption in the state.

### *Electricity Suppliers*

Another potential source of electricity data is electricity suppliers, who may be able to supply information related to consumption and spending on electricity at retail prices and may potentially be able to see behind the meter production/consumption. Commercial and residential customers in Massachusetts can receive their electricity from a number of suppliers, depending on their address location.

There are four electric companies serving residential and commercial customers in Massachusetts: Eversource Energy East; Eversource Energy West; National Grid; and Unitil. We

were not able to get in contact with all these suppliers; our limited interactions suggest that customer privacy would be a deterrent to obtaining information at the account or address level.

In addition to these four electric companies, there are 40 communities with municipal light plants (MLP) that serve 50 municipalities in the Commonwealth. For example, the City of Holyoke is served by Holyoke Gas and Electric. These MLPs are generally not regulated by the Department of Public Utilities in the same way as other entities.[93]

There is a trade organization of MLPs – Massachusetts Municipal Wholesale Electric Companies (MMWEC) – representing about half of the MLPs. MMWEC is subject to public records requests in Massachusetts. MMWEC maintains data on the electric loads (consumption) at the municipality level for their 20 members, and they are able to release these data for research purposes. However, they neither receive nor release address level data; each MLP is likely to have a different policy or process by which address/account level data are or are not available.

Large commercial entities that consume a significant amount of electricity may participate in the wholesale market; if they participate directly in the wholesale market, then their consumption information is not available from any of the electric suppliers or MLPs, but may be available from the wholesale participant directly. An example of a company that participates directly in the wholesale market that may be relevant for the cannabis industry is Shipyard Brewing Company in Portland, ME.

***Massachusetts Department of Public Utilities***

The DPU oversees the reliability and costs of electricity provided in Massachusetts and oversees and implements clean and renewable energy initiatives. DPU also regulates retail delivery service provided by electric utility companies. DPU collected a significant amount of detailed information regarding conservation efforts through the MassSave program.[94] However, it does not appear that they obtained address/account level data on electricity consumption through the extensive implementation and ongoing evaluation process.

## Limitations

There are two primary limitations to the data available to monitor electricity consumption: 1) availability of address level information; and 2) changes in data included in each source over time.

To calculate changes in electricity consumption associated with legalization of cannabis in the Commonwealth, the two potential analysis methods are discussed above. Limitations of calculating changes at the state level using comparisons over time include fluctuations in electricity consumption based on weather and economic factors. It may be difficult to assess the relationship between changes in electricity consumption and cannabis legalization, particularly given the small size of cannabis electricity consumption relative to the overall market. For example, a one million square foot cannabis cultivation facility is expected to have electricity

consumption at wholesale prices of approximately $600,000 annually, although this potentially varies substantially depending on the lighting type, insulation level, and location.[89]

This suggests that the collection of address level information for legal cultivators is necessary to adequately assess electricity consumption. The main potential sources of these data that we identified are the electricity suppliers in Massachusetts. Getting address and account level information is likely to be difficult for research purposes without intense cooperation between the Commission and suppliers and/or new regulations related to the release of these data. Suppliers cited confidentiality concerns regarding individual level data, and MMWEC does not maintain the information meaning that data would have to be collected from each of the 40 MLPs individually if available.

The second limitation is changes in what data are available from each source over time, with changes in renewable energy penetration and retail versus wholesale distribution. For example, the data from ISO-New England excludes "behind the meter" electricity production and consumption. As solar panels become more common, more electricity production and consumption falls into this category, which may impact the use of these data for analyses over time. Accounting for this would also be important even with information from electric suppliers, as accurately accounting for the full amount of power consumed (whether from traditional electric sources or from solar panels) is important to fully understand the impact of cannabis legalization. Additionally, understanding the role of wholesale distribution and any changes over time in the market is important; this is available in some data sources and not others, and may be an important component of overall electricity use.

### Considerations

Two primary considerations related to data available to monitor impacts of cannabis legalization on electricity use include the following: 1) mandated or voluntary collection of electricity use from legal cultivators; and/or 2) collection of address or highly local (*e.g., census block*) electricity consumption by a state agency.

Our primary suggestion is to obtain address/account level information for electricity consumption by legal cultivators through a mandated request for cannabis cultivators to make their account information available to the Commission as part of the licensing process. If cultivators, for example, submitted their electric bills on a quarterly basis to the Commission or other government entity, analysis could be conducted on total electricity consumption by legal cultivators. Understanding whether these accounts are primarily through electricity suppliers versus wholesale markets, and the related role of behind the meter electricity production/use in these data is particularly important in understanding the role of renewable energy sources. One major limitation of mandated provision of electric information is that this is unlikely to capture electricity use by home growers and/or unlicensed cultivators (either before or after legalization).

A second consideration if cultivators are not mandated to provide electricity information is to have a state agency collect highly local (*e.g., address level or census block level*) electricity

consumption data to match with licensing information. This could then be used to determine electricity consumption. Additional legislation authorizing the collection of this information is likely to be necessary given current data limitations. Potential state agencies that might be of interest for the collection of this information are the DPU, which regulates electric suppliers and retail delivery service, and the DOER, which uses data to determine state energy use and progress towards clean energy goals. Further exploring the capacity of these public entities to collect and securely administer this information may be of strategic value.

Revised regulations from the Commission require cannabis cultivators to submit electricity and water usage information with all renewal applications.[95] This is an important step towards measuring impacts of cannabis legalization on energy usage and will help towards meeting emission reduction targets.

## IV. Conclusions

A substantial number of data sources exist for evaluating and monitoring the potential impacts of cannabis legalization in the Commonwealth of Massachusetts pursuant to the legislative mandate in *Chapter 55 of the Acts of 2017: An Act to Ensure Safe Access to Marijuana*. Findings for the state of the data of the nine domains evaluated in this report are summarized below.

**Table.** Research domains and availability of existing data for monitoring purposes.

| Data Domain | Data availability and ease-of-access |
|---|---|
| Cannabis use patterns and perceptions | |
| Healthcare use and costs | |
| Incidents of cannabis-impaired driving | |
| Ownership and employment trends | |
| Cannabis markets | |
| Cannabis-related incidents in school | |
| Criminal justice encounters | |
| Economic and fiscal impacts | |
| Energy | |

Existing data readily available ……..……. Data not available

For each domain, we highlight several key conclusions:

**Cannabis use patterns and perceptions**

- Data from existing population surveys are available to monitor cannabis use.

- Detailed information on patterns of use, locations of use, cannabis storage practices are only available for certain populations and certain timeframes.
- Data pertaining to specific subpopulations *(i.e. pregnant women and individuals with mental illness)* or priority populations *(i.e. emerging adults)* are also limited.
- Additional data collection is should be considered.

**Healthcare use and financial impacts on the state healthcare system**

- Massachusetts has a number of datasets that can contribute to monitoring this area.
- It will be important to assess and acknowledge the impact of potential changes in reporting/coding of cannabis-related incidents related to its changing legal status and stigma as well as limitations to data availability.

**Incidents of cannabis-impaired driving**

- There are significant limitations to the available data to measure cannabis involvement in motor vehicle crashes, especially non-fatal crashes.
- While self-reported incidents of driving under the influence of marijuana are measured in several data sources, co-use of marijuana and other substances *(i.e. alcohol)* is also of concern and cannot be tracked over time with existing data.
- Changes to data collection practices for police crash reports and when officers arrest someone for operating under the influence to ensure that OUI-cannabis is recorded separately from other drugs would improve monitoring in this area.
- Recognizing that it does not indicate impairment directly, assessment of THC in crash-injured drivers and roadside survey data collection should be explored. Additional research into measurement of cannabis impaired driving should be considered.

**Cannabis-related incidents in schools**

- Existing data on education is an area of strength.
- Working in partnership with researchers that have access to an IRB and with the DESE, the Commission can evaluate cannabis-related incidents in schools.

**Ownership and employment trends; cannabis markets**

- Data in these areas are collected by the Commission and available for monitoring.

**Criminal justice encounters**

- Many cannabis-related interactions with the criminal justice system are generally not tracked in ways that allow cannabis-related cases to be separated from cases related to other drugs.
- Changes to coding of cannabis-related encounters in criminal justice system data should be considered.
- Centralized tracking of civil offenses related to cannabis should be considered.

**Economic and Fiscal Impacts**

- Specialized research skills are needed to assess economic and fiscal impacts.
- Many of the data sources reviewed in this report, and additional data collection that may be undertaken based on the considerations raised here, could inform such analyses.

**Energy**

- Existing data sources, at the time of publication of this report, are not available to meet the Commission's interest regarding electricity use.
- As the most recent set of regulations are implemented, the Commission will be better poised to monitor this issue.

**Additional considerations and conclusions**

For some data sources, the extent to which certain limitations impact the usability or generalizability of the data cannot be known until data is obtained, cleaned, and evaluated. Research to understand the data quality and its limitations, which may involve both qualitative and quantitative analysis, should be considered.

Massachusetts was a leader among states in the development of provisions for social equity licensing. However, research needed to effectively evaluate the impact of such a licensing structure on communities of disproportionate impact lag behind because of data collection practices that do not allow the unique identification of indicators such as cannabis-involved incidents of impaired driving or criminal justice system involvement for specific cannabis-related offense types. Steps to address may require additional research and changes to existing laws; these are both appropriate steps to consider.

The annual requirement for reporting on the indicators in the authorizing legislation may be incompatible with the time and effort it takes to conduct high quality research. Revision of the annual reporting requirement to allow for the creation of a longer-term research agenda for the Commission and reporting on intervals that are consistent with conduct of research on par with peer-reviewed academic work would benefit the Commonwealth.

Based on this assessment of the state of the data, significant resources may be needed to support rigorous research that would allow the Commission to evaluate changes in the key areas that will inform the Commonwealth on the impact of cannabis legalization and actions needed to maximize benefits and reduce harms. There are opportunities for Massachusetts to be a leader among states with regard to understanding the impacts of cannabis legalization if research activities and regulatory activities are better coordinated with a goal of evaluating regulatory changes.

# V. Appendices

## Appendix A. Tables

[Tables start on next page.]

Table 1. Summary of survey data available to monitor cannabis use patterns, perceptions, and modes of consumption

| Data Name | Source | Population Included | Age Range | Number of individuals | Years / Frequency | Access and cost | Website |
|---|---|---|---|---|---|---|---|
| **National data with Massachusetts indicator** | | | | | | | |
| National Health and Nutrition Examination Survey (NHANES) | Centers for Disease Control and Prevention (CDC) | U.S. residents (civilian, non-institutionalized) | All | 5,000 per year | 1999-2016, annually (with two-year panels) | Public use, free<br><br>*Limited use at Research Data Center required for state indicators and drug use questions for children | NHANES |
| National Survey on Drug Use and Health (NSDUH) | Substance Abuse and Mental Health Services Administration (SAMHSA) | U.S. civilian, non-institutional population | 12+ | 65,000 per year | 1971-2017, annually | Public use, free<br><br>*Restricted use at Research Data Center required for state indicators | NSDUH |
| National Youth Risk Behavior Surveillance Survey (YRBSS) | CDC | Middle and high school students<br><br>*Massachusetts high schools only | 11-18 | 15,000 per year | 1990-2017, odd years | Public use, free<br><br>*State data requires application process | YRBSS |

| Data Name | Source | Population Included | Age Range | Number of individuals | Years / Frequency | Access and cost | Website |
|---|---|---|---|---|---|---|---|
| **Massachusetts data** | | | | | | | |
| Massachusetts Behavioral Risk Factor Surveillance System (BRFSS) | CDC and Massachusetts Department of Public Health (MA DPH) | Massachusetts residents (civilian, non-institutionalized) | 18+ | 7,000 | 1984-2017, annually | Limited use, free<br><br>*requires application process | MA BRFSS |
| Massachusetts Marijuana Baseline Health Study | MA DPH | Massachusetts adults (non-institutionalized) | 18+ | 3,000 | 2017, one time | No information available | MBHS |
| Massachusetts Youth Health Survey (MYHS) | MA DPH | Massachusetts middle and high school students | 11-18 | 5,500 | 2007-2017, odd years | Limited use, free<br><br>*requires application process | MYHS |
| Massachusetts Youth Risk Behavior Survey (MYRBS) | MA DPH and CDC | Massachusetts high school students | 13-18 | 3,300 | 2007-2017, odd years | Limited use, free<br><br>*requires application process | MYRBS |

Table 2. Detailed information for survey data to monitor cannabis use, 2011 to most recent available year

| Data Name | Ever used marijuana | Age of first use of marijuana | Frequency of use | Location of use | Method of use | Source of marijuana | Perceptions of marijuana | Reason for use (e.g., medicinal) |
|---|---|---|---|---|---|---|---|---|
| **National data with Massachusetts indicator** | | | | | | | | |
| National Health and Nutrition Examination Survey (NHANES) | 2011-2016 | 2011-2016 | 2011-2016 | N/A | N/A | N/A | N/A | N/A |
| National Survey on Drug Use and Health (NSDUH) | 2011-2017 | 2011-2017 | 2011-2017 | N/A | N/A | 2011-2017 | 2011-2017 | 2013-2017 |
| National Youth Risk Behavior Surveillance Survey (YRBSS) | 2011-2017 | 2011-2017 | 2011-2017 | 2011 | 2015 | N/A | N/A | N/A |
| **Massachusetts data** | | | | | | | | |
| Massachusetts Behavioral Risk Factor Surveillance System (BRFSS) (state-specific questions) * | 2015-2017** | N/A | N/A*** | N/A | N/A | N/A | N/A | 2015-2017 |
| Massachusetts Marijuana Baseline Health Study | N/A | N/A | 2017 | N/A | 2017 | N/A | 2017 | 2017 |
| Massachusetts Youth Health Survey (MYHS) | 2011-2017 (odd years) | 2011-2017 (odd years) | N/A | N/A | N/A | N/A | 2011-2017 (odd years) | N/A |

| Data Name | Ever used marijuana | Age of first use of marijuana | Frequency of use | Location of use | Method of use | Source of marijuana | Perceptions of marijuana | Reason for use (e.g., medicinal) |
|---|---|---|---|---|---|---|---|---|
| Massachusetts Youth Risk Behavior Survey (MYRBS)**** | 2013-2017 (odd years) | 2013-2017 (odd years) | 2013-2017 (odd years) | 2013-2017 (odd years) | N/A | N/A | 2017 | N/A |

Note: * MA BRFSS contains other questions about marijuana use over time, but does not ask questions consistently outside of the noted periods. **MA BRFSS does not explicitly ask about ever using marijuana, but asks about use in past year. *** MA BRFSS asks about problematic use, but not about frequency of use. ****MYRBS questionnaires from 2013-2017 available online.

Table 3. Survey data to monitor impacts of cannabis legalization on the health system

| Data Name | Source | Population Included | Age Range | Number of individuals | Years / Frequency | Outcomes Measured | Marijuana Use Measures | Access and cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| **National data with Massachusetts indicator** | | | | | | | | | |
| National Survey on Drug Use and Health (NSDUH) | Substance Abuse and Mental Health Services Administration (SAMHSA) | U.S. residents (civilian, non-institutionalized) | 12+ | 65,000 per year | 1971-2017, annually | Emergency department visits; treatment or counseling | Specific questions about treatment related to marijuana (treatment/counseling) and other drugs, including marijuana (emergency department visits) | Public use, free<br><br>*Restricted use at Research Data Center required for state indicators | NSDUH |
| National Health and Nutrition Examination Survey (NHANES) | Centers for Disease Control and Prevention (CDC) | U.S. residents (civilian, non-institutionalized) | All | 5,000 per year | 1999-2016, annually (with two-year panels) | Self-reported health outcomes, healthcare utilization, health indicators (e.g., blood pressure, diet, etc.) | Marijuana use and frequency, specific questions about treatment or rehabilitation for marijuana use | Public use, free<br><br>*Limited use at Research Data Center required for state indicators and drug use | NHANES |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | questions for children | |
| **Massachusetts data** | | | | | | | | | |
| Massachusetts BRFSS | CDC and Massachusetts Department of Public Health (MA DPH) | Massachusetts residents (civilian, non-institutionalized) | 18+ | 7,000 | 1984-2017, annually | Emergency department visits | Specific questions about medical treatment, emergency department visits, or counseling for marijuana use | Limited use, free<br><br>*requires application process | MA BRFSS |
| Massachusetts Marijuana Baseline Health Study | MA DPH | Massachusetts adults (non-institutionalized) | 18+ | 3,000 | 2017, one-time | Emergency department and urgent care visits | Specific questions about emergency department and urgent care visits for marijuana use | No information available | MBHS |
| Massachusetts Youth Risk Behavior Survey (MYRBS) | MA DPH and CDC | Massachusetts high school students | 13-18 | 3,300 | 2007-2017, odd years | Suicide attempt that required treatment | Marijuana use and frequency | Limited use, free<br><br>*requires application process | MYRBS |

Table 4. Administrative data to monitor impacts of cannabis legalization on the health system

| Data Name | Source | Population Included | Age Range | Number of individuals | Years Available | Outcomes Measured | Cannabis Use Measures | Access and Cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| **National data with Massachusetts indicator** | | | | | | | | | |
| IQVIA Prescription Data | IQVIA | 85% of all outpatient prescription (all payers except Veterans Administration) | All | Hundreds of millions | 2010-2017 | Prescription drug health insurance claims | No specific codes | Limited use, significant costs associated<br><br>*requires application process | IQVIA |
| Medicare Data | Centers for Medicare and Medicaid Services (CMS) | Individuals covered by Medicare fee-for-service and Medicare Advantage insurance, eligibility due to disability and/or age | 18+ (mostly 65+) | 44 million<br><br>(5-20% files commonly available for research) | 1999-2017<br><br>(Medicare fee-for-service)<br><br>2015<br><br>(Medicare Advantage) | Healthcare utilization from health insurance claims including inpatient and outpatient services, prescription drug coverage | ICD-9/10 codes related to cannabis | Limited use, significant costs associated<br><br>*requires application process | RESDAC |

| Data Name | Source | Population Included | Age Range | Number of individuals | Years Available | Outcomes Measured | Cannabis Use Measures | Access and Cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| National Poison Data System (NPDS) | American Association of Poison Control Centers | All poison-related calls managed by poison control centers | All | Millions annually | 2012-2019, near real-time | Poison exposure and information calls | Type of poison, including cannabis | Limited use, substantial costs associated for some applicants<br><br>*state level data require application | NPDS |
| State Emergency Department Data (SEDD) | Agency for Healthcare Research and Quality (AHRQ) | All ED discharges, comparable to other available states | All | 2.5 million discharges annually (MA) | 2002-2016, annual | Emergency department visits and associated charges | ICD-9/10 codes related to cannabis | Limited use, costs associated<br><br>*requires application process | SEDD |
| State Inpatient Database (SID) | AHRQ | All inpatient discharges, comparable to other states | All | 800,000 discharges annually (MA) | 2002-2016, annual | Inpatient discharges and associated charges | [+]ICD-9/10 codes related to cannabis | Limited use, costs associated<br><br>*requires application process | SID |

| Data Name | Source | Population Included | Age Range | Number of individuals | Years Available | Outcomes Measured | Cannabis Use Measures | Access and Cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| Treatment Episode Data Set (TEDS) | SAMHSA | Client-level data for substance abuse treatment admissions/ discharges from State Agency | 12+ | 2 million admissions per year | 1992-2017, annually | Substance abuse treatment data | Primary substance for which individual is receiving treatment is cannabis | Public use, free | TEDS |
| **Massachusetts data** | | | | | | | | | |
| Massachusetts All Payer Claims Data | Massachusetts Center for Health Information and Analysis (CHIA) | All insured individuals covered by reporting insurers | All | Millions annually | 2013-2017 | All healthcare utilization (inpatient, outpatient, pharmaceutical) and associated paid amounts | [+]ICD-9/10 codes related to cannabis* | Limited use, costs associated<br><br>*requires application process | APCD |
| Massachusetts Substance Abuse Management Information System (SAMIS) | Massachusetts Department of Public Health (DPH) | Individuals admitted into addiction treatment programs in Massachusetts | 15+ | 109,000 annually | 2008-2017 | Treatment admissions | Primary substance for which individual is receiving treatment is cannabis | Limited use, free<br><br>*requires application process | SAMIS |

| Data Name | Source | Population Included | Age Range | Number of individuals | Years Available | Outcomes Measured | Cannabis Use Measures | Access and Cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| Massachusetts CaseMix Data | Massachusetts Center for Health Information and Analysis (CHIA) | All inpatient, ED, and outpatient observation discharges | All | Millions annually | 2000-2017 | Inpatient discharges, ED discharges, and outpatient observation discharges and associated charges | +ICD-9/10 codes related to cannabis | Limited use, costs associated<br><br>*requires application process | CaseMix |
| Massachusetts Mental Health Information System (MHIS) | MA Department of Mental Health (DMH) | Individuals admitted into DMH facilities and program | All | Thousands annually | 2004-2018 | Mental illness admissions | Secondary +ICD-9/10 codes related to cannabis | Limited use, free<br><br>*requires application process | DMH |
| Massachusetts Public Health Data Warehouse (PHDW) | MA DPH | All individuals in Massachusetts | All | Millions annually | Unknown | Healthcare utilization (inpatient, outpatient, prescription, special services), criminal justice, death, more | +ICD-9/10 codes related to cannabis; treatment services related to cannabis | Limited use, free<br><br>*requires application process for specific purposes defined by MA DPH priorities | PHDW |

| Data Name | Source | Population Included | Age Range | Number of individuals | Years Available | Outcomes Measured | Cannabis Use Measures | Access and Cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| Massachusetts and Rhode Island Regional Poison Center Data | MA/RI Regional Poison Control Center | All poison-related calls managed by the regional center | All | Over 46,000 calls annually | 2009-2018 | Poison exposure and information calls | Type of poison, including marijuana-product codes | Limited use<br><br>*requires application for specific purposes | MA/RI PCC |
| Massachusetts State Trauma Registry | MA DPH | Patients with traumatic injuries receiving emergency services at designated state trauma centers | All | Thousands | 2008-2015 | Trauma utilization, health outcomes | Secondary [+]ICD-9/10 codes related to cannabis | Limited use, free<br><br>*requires application process | Trauma Registry |

[+]International Classification of Diseases (ICD)

* MA APCD is subject to specific policies around inclusion of substance use disorder-related diagnosis and procedure codes; researchers should review the most recent version of dataset documentation provided by CHIA for more information.

Table 5. Summary of data available to monitor cannabis-involved driving

| Data Name | Source | Population Included | Age Range | Number of cases | Years Available | Outcomes Measured | Marijuana – related Measures | Access and Cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| **National data with Massachusetts indicator** | | | | | | | | | |
| Fatality Analysis Reporting System (FARS) | U.S. Dept. of Transportation, National Highway Traffic Administration | Drivers and others involved in fatal MVCs | All ages | 30,000+ | 1975-2018 | Fatal motor vehicle crashes on U.S public roadways | Drug testing performed; cannabinoid toxicology results | Yes, publicly available | FARS |
| National Survey on Drug Use and Health (NSDUH) | Substance Abuse and Mental Health Services Administration (SAMHSA) | U.S. civilian, non-institutional population | 12+ | 65,000 | 1971-2017, annually<br><br>*DUI-M question added in 2016 | Drug use and health behavior including reported driving under the influence | Specific questions about driving under the influence of marijuana | Public use, free<br><br>*Application and Restricted use at Data Center required for state indicators | NSDUH |
| Massachusetts Youth Risk Behavior Survey (MYRBS) | MA DPH and CDC | Massachusetts high school students | 13-18 | 3,300 | 2007-2017, odd years | Health outcome and health behaviors | Past 30-day driving when using marijuana | Limited use, free<br><br>*requires application process | MYRBS |

| Data Name | Source | Population Included | Age Range | Number of cases | Years Available | Outcomes Measured | Marijuana – related Measures | Access and Cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| **Massachusetts Data** | | | | | | | | | |
| Massachusetts Behavioral Risk Factor Surveillance System | CDC and MA Department of Public Health | MA residents (civilian, non-institutionalized) | 18+ | 7,000 | 1984-2017, annually<br><br>*OUI-M question added in 2015 | Health outcomes and behaviors | Question about being under the influence of marijuana in potentially harmful situation (e.g. driving, operating machinery) | Limited use, free<br><br>*requires application process | MA BRFSS |
| Massachusetts Drug Recognition Expert (DRE) Data | MA DRE Coordinator | Drivers evaluated by MA DREs for suspected OUI drugs | all | Hundreds | 2010-2018 | Aggregated information on DRE evaluations and expert opinions on the class of drug or other cause of impairment in a driver | Number and % of evaluations in which DREs concluded a driver was likely under the influence of cannabis | Free<br><br>*requires partnership with state DRE coordinator | MA DRE |
| Massachusetts Marijuana Baseline Health Study (MBHS) | MA DPH | Massachusetts adults (non-institutionalized) | 18+ | 3,000 | 2017, one-time | Emergency department and urgent care visits | Specific questions about emergency department and urgent care visits for marijuana use | No information available | MBHS |

| Data Name | Source | Population Included | Age Range | Number of cases | Years Available | Outcomes Measured | Marijuana – related Measures | Access and Cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| Massachusetts State Trauma Registry | MA DPH | Patients with traumatic injuries receiving emergency services at designated state trauma centers | All | Thousands annually | 2008-2015 | Trauma utilization, health outcomes | Drug screening indicator; ICD-9/10 codes related to cannabis and to motor vehicle injury | Limited use<br><br>*requires application process | Trauma Registry |
| Massachusetts Youth Health Survey (MYHS) | MA DPH | Massachusetts middle and high school students | 11-18 | 5,500 | 2007-2017, odd years | Health outcome and health behaviors | Past 30-day driving when using marijuana | Limited use, free<br><br>*requires application process | MYHS |

Table 6: Summary of data available to monitor cannabis-related criminal justice encounters

| Data Name | Source | Population Included | Age Range | Number of individuals | Years available | Outcomes measured | Cannabis-related measures | Access and cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| **National data with Massachusetts indicator** | | | | | | | | | |
| National Incident-Based Reporting System (NIBRS) | Federal Bureau of Investigation | Incident-based crime reporting in the U.S. | All | Thousands annually | 1989-2018 | Crime incidents | Cannabis cultivating/manufact-uring, transporting, distributing/selling, possessing/concealing, buying/receiving, using/consuming. | Public use, free<br><br>*MA data is available from MA EOPPS with data sharing agreement | NIBRS FBI |
| **Massachusetts data** | | | | | | | | | |
| Boston Police Department (BPD) Data | BPD | Arrests in Boston, MA | All | Hundreds | 2000-2018 | Violations; demographic information | Offenses characterized according to M.G.L 94C, Class D: Distribution; Possession w/ intent to distribute; Possession; and Trafficking. | Limited use | BPD |
| High Intensity Drug Trafficking | New England High Intensity Drug | Drug trafficking information | All | Thousands annually | 1999-2018 | Drug searches and seizures | Cannabis searches and seizures | Limited use, free | New England HIDTA |

| Data Name | Source | Population Included | Age Range | Number of individuals | Years available | Outcomes measured | Cannabis-related measures | Access and cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| area (HIDTA) data | Trafficking area (HIDTA) | | | | | | | *requires formal collaboration between New England HIDTA and researcher | |
| Massachusetts Department of Correction Data | Massachusetts Department of Correction | Individuals incarcerat-ed in state correction facilities* | All adults | Thousands annually | 2009-2018 | Location of incarceration, sentence length, time served | Offenses characterized according to M.G.L 94C: Distribution of a Class D Drug; Possession w/ intent to distribute Class D Drug; marijuana trafficking, marijuana possession. | Limited use, free<br><br>*requires application process | DCS |
| Massachusetts State Police (MSP) Data | MSP | Arrests | All | Thousands annually | 2010-2018 | Violations; demographic information | Offenses characterized according to M.G.L 94C: Distribution of a Class D Drug; Possession w/ intent to distribute Class D Drug; marijuana trafficking, marijuana possession; violations near school or park | Limited use, free<br><br>*requires application process | MSP Public Records Request |

| Data Name | Source | Population Included | Age Range | Number of individuals | Years available | Outcomes measured | Cannabis-related measures | Access and cost | Website |
|---|---|---|---|---|---|---|---|---|---|
| Massachusetts State Police (MSP) CrimeSOLV SOLV data on cannabis seizures | Massachusetts State Police | Incident-based crime reporting in Massachusetts (data reported to NIBRS) | All | Thousands annually | 2017-2018 | Violations; demographic information | Offenses characterized according to M.G.L 94C, Class D: Distribution; Possession w/ intent to distribute; Possession; and Trafficking | Public use, free | MSP CrimeSOLV |
| Massachusetts Trial Court Data | The Massachusetts Executive Office of the Trial Court | Individuals tried in Massachusetts courts | All (including records from juvenile court) | Thousands annually | 2000-2018 | Sentencing, convictions, demographic information | Offenses characterized according to M.G.L 94C: Distribution of a Class D Drug; Possession w/ intent to distribute Class D Drug; marijuana trafficking, marijuana possession | Limited use, free<br><br>*requires application process | MA Trial Court |

*Data on individuals incarcerated in county-level Houses of Correction must be obtained from each county, each via a unique data sharing process.

## Appendix B. List of key informant agencies

Federal Bureau of Investigation (FBI) - Boston Division

Massachusetts Center for Health Information and Analysis (CHIA)

ISO New England

Massachusetts Department of Criminal Justice Information Services (DCJIS)

Massachusetts Department of Corrections (DOC)

Massachusetts Department of Public Health (DPH)
- Special Projects
- Bureau of Healthcare Safety and Quality
- Injury Surveillance Program
- Office of Data Management and Outcomes Assessment

Massachusetts Department of Elementary and Secondary Education (DESE)

Massachusetts Department of Public Utilities (DPU)

Massachusetts Department of Transportation (DOT)

- Registry of Motor Vehicles (RMV)

Massachusetts Executive Office of Public Safety and Security (EOPSS)

Massachusetts Department of Mental Health (DMH)

Massachusetts Executive Office of the Trial Court (EOTC)

Hampden County Sheriff's Department

Massachusetts and Rhode Island Regional Center for Poison Control and Prevention

Massachusetts State Police

New England High Intensity Drug Trafficking Area & Fusion Center

Worcester County House of Correction

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