Evidence Brief: Driving Under the Influence of Cannabis – Risk Factors and Preventive Interventions

Key Messages

- Self-reported driving under the influence of cannabis (DUIC) was consistently associated with:

  - lower perceived risk from DUIC;
  - lower perceived disapproval of DUIC by friends (normative beliefs);
  - higher cannabis use; and
  - cannabis dependence.

- Natural experiments suggest that the introduction of legislated legal limits (*per se* laws) was followed by increased testing for DUIC and THC test-positivity rates.

- Graduated driver licensing and increased roadside testing may act as deterrents against DUIC.

September 2017

Background

An estimated 2.5% of Canadian drivers[1] and 2.7% of Ontario drivers[2] reported driving under the influence of cannabis in 2012. Four meta-analyses[3-6] have consistently showed an increased risk of motor vehicle collisions (MVC) from DUIC, although there is a wide range in the estimated magnitude of the increase (range: 20-266%).

Evidence suggests that the burden from cannabis-related MVCs is considerable. According to a recent economic analysis,[7] cannabis-attributable MVCs were estimated to have caused 75 deaths, 4407 injuries and 7794 collisions involving only property damage in Canada in 2012. The total cost of cannabis-related MVCs that year was in excess of one billion dollars, with the highest costs being borne by younger people (under 35 years old).[7]

In comparison, 707 people died in an alcohol-related MVC in 2012 in Canada (excluding British Columbia), and younger people (under 35 years old) represent the majority of individuals killed or seriously injured.[8]

Cannabis legalization and DUIC

In its December 2016 report, the Canadian Task Force on Cannabis Legalization and Regulation specifically identified driving impairment as an important consideration.[9]

At present, enforcement of drug-impaired driving legislation is based on the assessment of functional impairment using a Standardized Field Sobriety Test (SFST).[10] Drivers who demonstrate impaired performance on the SFST must undergo evaluation by an officer trained in the Drug Evaluation and Classification (DEC) program.[10] The validity and reliability of current methods for assessing functional impairment from cannabis use have been called into question.[11]

Legislated legal limits, also known as *per se* laws,[9] have the potential to facilitate the enforcement of drug-impaired driving legislation and have been established in a few jurisdictions. However, the Task Force noted several technical issues that complicate the development and implementation of legislated legal limits for cannabis.

In light of these issues, the Task Force recommended[9] the federal government invest in research to better link THC levels with impairment, determine whether to establish a legal limit, support the development of roadside screening devices, and invest in surveillance of DUIC.

Proposed DUIC legislation

The Government of Canada has stated that it is committed to legalizing cannabis no later than July, 2018.[12] On April 13, 2017, the Government of Canada introduced the Cannabis Act (Bill C-45),[13] which aims to legalize, regulate, and restrict access to cannabis.[14] An Act to amend the Criminal Code (Bill C-46),[15] which includes measures to discourage DUIC, was introduced concurrently with the Cannabis Act.

The Act to amend the Criminal Code (Bill C-46) would enable police to demand an oral fluid sample for drug screening at the roadside when they suspect a driver of being intoxicated.[15] If a person refused to provide an oral fluid or blood sample, they could be charged with the offence of failure to comply.[15] The proposed legislation would also provide police with the option to pursue drug recognition evaluation or a blood sample in situations where they have reasonable grounds to believe an offence has occurred.[15]

The *per se* limits of THC in whole blood proposed in the Act to amend the Criminal Code (Bill C-46) are:

- ➤ 2 ng/mL to less than 5 ng/mL for the offence punishable by a fine;
- ➤ 5 ng/mL or higher of THC alone, or 2.5 ng/mL or higher combined with 50 mg/100 mL or more of alcohol, for the offence punishable by a fine or imprisonment depending on the number of offences.[15]

Public Safety Canada, in collaboration with law enforcement agencies across the country, led a pilot project to assess various roadside drug testing devices on drivers.[15] This pilot project will help inform the development of national roadside testing standards.[15] The pilot ended in March 2017, and results released in June 2017 indicated "that with the proper training and standard operating procedures, these devices are a useful additional tool for Canadian law enforcement to better detect individuals who drive under the influence of drugs." will be made public in the coming weeks.

Preventing DUIC

In addition to *per se* limits, other evidence-based policies used to address alcohol-impaired driving[16] that may also be adaptable to DUIC include lower *per se* limits for young or inexperienced drivers,[17] and publicized sobriety checkpoint programs.[18]

Issue and Research Question

To better inform the development of interventions to prevent DUIC, this Evidence Brief asks two questions:

1. What are risk factors for cannabis-impaired driving?
2. What interventions have been shown to prevent or reduce DUIC?

An accompanying Evidence Brief, *Driving Under the Influence of Cannabis and Risk of Motor Vehicle Collision*, reports the prevalence of DUIC in Ontario and Canada, the impact of cannabis legislation changes on the prevalence of DUIC, and the risk of MVC from DUIC. It was beyond the scope of this Evidence Brief to quantify the burden of harms from DUIC or assess the effectiveness of interventions to prevent or reduce alcohol-impaired driving and their potential application to DUIC.

Methods

Literature search

Four databases (MEDLINE, EMBASE, CINAHL, PsychINFO) were searched by a PHO Library Information Specialist on January 27, 2017 for articles published between 2006-2017; the search was updated on June 5, 2017. The following search terms were used: "cannabis", "marijuana", "THC" and related terms, in combination with terms related to "driving". References from the included articles were hand searched for additional relevant studies. The full search strategy can be obtained from PHO upon request.

Eligibility criteria

Studies were eligible for inclusion if they were published in English or French, between 2006 and 2017.

For research question #1 on risk factors:

Eligible study designs included any analytic observational study design; eligible exposures were risk or protective factors; the outcome of interest was DUIC.

For research question #2 on interventions:

Eligible study designs included experimental and observational studies; eligible exposures

were interventions meant to reduce or prevent DUIC; the outcome of interest was DUIC.

For research questions #1 and #2:

Eligible study settings were limited to countries similar to Canada, i.e., a member-country of the Organisation for Economic Co-operation and Development (OECD).[19]

Article screening, data extraction, and quality appraisal

Title and abstracts, followed by full-text articles, were screened for eligibility independently by two reviewers using DistillerSR. Relevant information was extracted from each included study by one reviewer; and a 20% random sample of the data extraction was verified by the other reviewer. Both reviewers independently appraised the quality of the included studies using a tool appropriate for the study's design, i.e., AMSTAR[20] for systematic reviews, the Health Evidence Quality Assessment Tool[21] for non-systematic narrative reviews, the Newcastle-Ottawa scale adapted for cross-sectional studies,[22] and the EPHPP[23] for experimental designs, including natural experiments. Disagreements were resolved through discussion.

Main Findings

The literature search identified 1,354 unique articles. A total of 124 articles underwent full-text screening. Seventeen primary research studies[24-39] were included to answer research question #1 on the risk factors for DUIC; our search did not identify any reviews. Ten articles[24,40-48] were included to answer research question #2 about interventions to reduce or prevent DUIC; of which two articles[47,48] were identified only by hand-searching the reference lists of other included articles. A PRISMA flow diagram is available from PHO upon request.

Risk factors for DUIC

A total of 17 included studies sought to identify risk factors or correlates of DUIC.[24-39,49] All 17 studies used a cross-sectional design, which does not allow for causal inference. The quality of these studies was rated between 4-7 stars out of a possible 10 stars on the Newcastle-Ottawa Scale adapted for cross-sectional studies. In 11[24,28-34,36] of the 17 studies, the study population comprised adolescent or young adult drivers. The outcome was self-reported DUIC in all 17 studies.

The various risk factors and correlates of DUIC assessed in the 17 included studies can be grouped into seven categories: 1) socio-demographic factors, 2) school performance, truancy, and extracurricular activities, 3) sensation-seeking and risk behaviours, 4) DUIC risk perception, 5) perceived consequences of DUIC, 6) normative beliefs about DUIC, and 7) substance use and dependence. Only results from multivariate analyses adjusted for confounders are presented in this Evidence Brief.

1) Socio-demographic factors

Age: The association between age and DUIC was reported in nine included studies, with mixed results.[24-26,32,33,36-39] Among all ages, three studies reported no effect of age on DUIC,[32,37,39] while one study reported that adolescent and young adult drivers (age 16-24) were more likely to report DUIC than older drivers.[25] Among the five studies that focused only on adolescent or young adult drivers,[24,26,33,36,38] two studies found that older drivers in this group (age analyzed as a continuous variable, age ranged from 16 to 30 years) were more likely to report DUIC,[26,36] while three found no effect.[24,33,38]

Gender: The association between gender and DUIC was reported in twelve included studies.[24-26,28-31,34,36-38,49] Five studies reported that male drivers were more likely to report DUIC,[25,29-31,49] while seven studies found no effect.[24,26,28,34,36-38]

Race or ethnicity: The relationship between race or ethnicity and DUIC was reported in five

studies.[29,30,36,39,49] Studies found lower reported DUIC among White students compared with students who identified as Aboriginal,[49] African-American,[29] or non-White.[36] Another study found lower DUIC among those who identified as Hispanic compared to White students.[30;49] One study found no effect of race/ethnicity on self-reported DUIC.[39]

Household composition: The link between high-school students' household composition and DUIC was assessed in three studies.[29,30,36] The only significant effect was found in one nationally-representative, annual survey of American high school seniors which found that students living in a two-parent household were less likely to report DUIC than those living in a household with no parent (e.g., living with a relative).[32, 33]

Employment: The association between employment and DUIC was reported in four studies.[29,30,36,39] Three studies of US high school students found no association,[29,30,36] while one study among adults found those employed/self-employed were more likely to report DUIC than their unemployed counterparts.[39]

Geographic location: A study using data from the 2014-2015 Canadian Student Tobacco, Alcohol, and Drug Use Survey found that students in Saskatchewan, Nova Scotia, Prince-Edward Island, and Newfound and Labrador were more likely to report DUIC than those in Ontario.[49] Three other studies found no association between geographic location and DUIC.[29,30,39]

There was no significant association between DUIC and several other socio-demographic factors: education,[39] parental education,[29,30] or population density (e.g., urban versus rural),[29,30,49] in all studies that investigated those associations.

2) School performance, truancy, and participation in extracurricular activities

School performance: The association between US high school students' school performance and DUIC was examined in three studies.[29,30,36] Two found that students with a lower grade-

point average (GPA) were more likely to report DUIC, [29,30] while one found no association.[36]

Truancy: Two studies using a nationally-representative, annual survey of American high school seniors found that students who reported truancy (i.e., staying away from school without good reason) were more likely to report DUIC.[29,30]

Extracurricular activities: The link between extracurricular activities and DUIC was assessed by three studies of US high-school students.[29,30,36] One found no association between self-reported DUIC and participation in any of five extracurricular activities (i.e., band, theater, sports, student council, clubs).[36] Two found a dose-response relationship between the number of evenings out for fun/recreation in the past week and DUIC[29,30]

3) Sensation-seeking and risk behaviours

Sensation-seeking: Two studies found a positive association between sensation-seeking and DUIC.[24,32] A study of Quebec male drivers found a positive association between impulsivity and DUIC.[32] Another study found no association between risk-taking propensity and DUIC.[33]

Riding in car with an impaired driver: One survey of college students found that those who had ridden in a car with a cannabis-impaired driver were themselves more likely to report DUIC.[28] However, the study found no association between riding in a car with an alcohol-impaired driver and DUIC.[28]

Risky driving behaviours: The association between self-reported risky driving and DUIC was reported in three studies.[24,28,33] These found a positive association between DUIC and high-risk driving (e.g., speeding),[33] joyriding,[24] and driving under the influence of alcohol (DUIA),[28] but no association with street racing.[24]

Previous traffic collisions or offenses: The link between previous traffic collisions or offenses and DUIC was reported in two studies.[37,38] One found no association between previous cannabis-related accidents and self-reported DUIC,[37] while one found that higher-frequency

DUIC was associated with ever being checked by police for impaired driving, involved in a MVC as driver, or involved in a MVC as a driver where cannabis played a role.[38]

4) DUIC risk perception

The association between the perception that DUIC is unsafe/dangerous and self-reported DUIC was examined in seven studies.[26,31,34,35,37-39] Five studies found that increased perception that DUIC is unsafe/dangerous was associated with lower odds of self-reported DUIC.[26,31,34,37,39] Among two other studies, DUIC was more likely among individuals who perceive that they are not at increased risk of accident from DUIC,[35] and among those who perceive their own driving ability not to be impaired by cannabis use.[38]

5) Perceived consequences of DUIC

The association between the perceived consequences of DUIC and self-reported DUIC was reported in four studies.[26,34,37,38] There was no association found between self-reported DUIC and perceived negative consequences of DUIC (i.e., being stopped by police, being drug tested, being arrested, and having an accident)[26,34] or beliefs about the likelihood of being caught by the police for DUIC.[37] Among individuals with prior self-reported DUIC, those who reported more frequent DUIC had a high expectancy of getting ticketed/charged in next twelve months.[38]

6) Normative beliefs about DUIC

The relationship between normative beliefs and self-reported DUIC was examined in two studies.[26,34] Both found a negative association between DUIC and higher scores on two items combined: 'how many of your three closest friends disapprove of using marijuana and driving' and 'how many of your three closest friends would refuse to ride with a driver who had used marijuana'.[26,34]

7) Substance use and dependence

Cannabis use: The link between cannabis use and DUIC was reported in six studies.[28,31,34,36,38,39] Five studies found that

increased cannabis use was positively associated with DUIC,[31,34,36,38,39] while one found no association between frequency of cannabis use and DUIC, but did not ask about quantity of cannabis used.[28]

Age of onset of cannabis use: The relationship between age of onset of cannabis use and DUIC was reported in four studies.[27,28,35,36] Two studies found that persons who starting using cannabis at an earlier age were more likely to report DUIC than those who started using cannabis later,[27,28] one found the same relationship among women, but not men,[35] and one found no association.[36]

Cannabis dependence: Three studies found a positive association between self-reported cannabis dependence and DUIC.[24,35,37]

Alcohol use: The link between alcohol use and DUIC was examined in five studies.[24,33,36,37,49] Among four studies involving students or young drivers, DUIC was associated with 'problem drinking' on the Alcohol Use Disorders Identification Test (AUDIT),[24] binge drinking (i.e., consuming five or more drinks in one occasion), [36,49] and higher alcohol intake (among males).[33,49] Another study based on a convenience sample of recent cannabis users found no association between alcohol intake and DUIC.[37]

Other drug use: The relationship between the use of drugs other than cannabis and DUIC was investigated in three studies.[35,37,38] Among recent cannabis users, one study found a dose-response relationship between the number of different drug types used and self-reported DUIC,[35] while another found no association with other drug use.[37] An Ontario study of persons who reported prior DUIC found that those who reported more frequent DUIC were more likely to report other drug use.[38]

Interventions to prevent or reduce DUIC

A total of eight primary research studies assessed the impact of preventive interventions on DUIC.[24,40,42,44-48] Three studies were randomized trials,[40,44,47] three were pre-post natural experiment,[42,45,48] one used another type of experimental design,[46] and one was a cross-sectional study.[24] Two reviews[41,43] assessing the impact of preventive interventions on DUIC were also identified; however, only a minority of the studies included in these reviews measured DUIC as an outcome. All eligible primary research studies[24,40,45,47,48] cited in either of the two reviews[41,43] had already been included, so we excluded the two reviews[41,43] themselves.

With respect to study quality, the randomized trials were rated as weak[40,47] or moderate[44] on the EPHPP scale, the natural experiments[42,45,48] and the other experimental study[46] were all rated as weak on the EPHPP scale, and the cross-sectional study[24] scored 7/10 on the modified NOS.

The various interventions to prevent or reduce DUIC assessed in the eight primary research studies[24,40,42,44-48] can be grouped into four categories: 1) legislated legal (*per se*) limits, 2) roadside testing and penalties, 3) graduated driver licensing, and 4) motivational interviewing. The first three categories are policy interventions, whereas the last one is an individual-level intervention.

1) Legislated legal (per se) limits

The impact of introducing legislated legal limits on DUIC was assessed in three pre-post natural experiments in Washington State, Denmark and Norway.[42,45,48] All three studies reported significant increases in the proportion of suspected impaired driving cases that tested positive for cannabis (also known as test-positivity rate) after the introduction of *per se* limits.[42,45,48] Other factors that may partially explain in Washington State was that THC testing of suspected DUI cases changed from discretionary to universal, and a different toxicology analytical method went into effect.

2) Roadside screening and penalties

The impact of theoretically increasing roadside screening for DUIC and increasing DUIC penalties on willingness to DUIC was assessed in one experimental study from Australia. The low certainty and low severity of punishment conditions were designed to reflect current legislation.[46] Multivariate regression analyses showed that the participants were less likely to indicate willingness to drive in the high certainty of punishment scenario (including random road side testing) (OR=0.2; p<0.001), while punishment severity (e.g., doubling fines, licence disqualification) had no significant effect.

3) Graduated driver licensing

The impact of a graduated driver licensing policy on DUIC was examined in one cross-sectional study among students in Ontario[24] The study found that students with a G1 license (with several restrictions, including maintaining a zero BAC) were less likely to report DUIC than those with a G2 (fewer restrictions) or G license (no restrictions).

4) Motivational interviewing

The impact of brief interventions using motivational interviewing techniques on DUIC was assessed in three randomized trials among at-risk youths in the United States.[40,44,47] One study found self-reported DUIC was significantly decreased with therapist-delivered motivational interviewing in primary care,[40] but not with motivational interviewing In the emergency department at three months compared with controls.[47] Further, among substance-using incarcerated adolescents, there was no difference between motivational interviewing or relaxation therapy on DUIC at 3 months post-release.[44]

Discussion

Risk factors for DUIC were assessed in 17 primary research studies.[24-39] Persons who perceived DUIC as risky or dangerous were consistently less likely to report DUIC.[26,31,34,35,37-39] Greater sensation-seeking,[24,32] riding in a car with a cannabis-impaired driver,[28] high-risk driving,[33] joyriding,[24] and drunk driving[28] were all positively associated with DUIC. Persons who believed that their closest friends disapproved of DUIC were significantly less likely to report DUIC.[26,34] As expected, higher cannabis use[31,34,36,38,39] and cannabis-dependence[24,35,37] were positively associated with DUIC. In contrast, DUIC was not significantly associated with perceived consequences (e.g., being stopped by police, being drug tested, being arrested).[26,34,37,38] Among socio-demographic characteristics, study findings were mixed on age, gender, household composition, employment, geographic location. DUIC was associated with ethnicity in four of five studies, with religious commitment in two studies. There was no association with education, parental education, or population density. When other risk factors were taken into account (e.g., risk behaviours), socio-demographic factors were no longer significant.

The effect of preventive interventions on DUIC was examined in eight primary research studies.[24,40,42,44-48] Drivers with a restricted license were less likely to report DUIC.[24] Implementation of legislated legal limits led to an increase in the number of suspected DUI drivers tested for THC as well as the THC test-positivity rate.[42,45,48] Higher certainty of punishment (i.e., increased roadside testing) was associated with lower willingness to DUIC; in contrast, higher severity of punishment had no significant effect.[46] Therapist-delivered motivational interviewing was found to reduce self-reported DUIC among cannabis-using adolescents and young adults in one RCT[40].

Limitations

A major limitation of this Evidence Brief is the low quality of the studies included. All 17 studies that assessed risk factors of DUIC used a cross-sectional design, which prevents causal inference. Nine studies used a convenience sample[26,31,32,34-39] and are therefore subject to selection bias. The outcome of DUIC and a majority of the risk factors were self-reported in all 17 studies, which make these vulnerable to social desirability bias. There was also

considerable variation in how DUIC was defined, which makes these studies susceptible to measurement error. Eight studies' findings were likely confounded by the opportunity to engage in DUIC; only nine studies adjusted their analyses for the amount of driving done,[29,30,32,35,38] access to or ownership of a car,[31,38] or possession of a driver's license.[24,36] Adjustment for other confounders was highly variable across studies.

Evidence of the effectiveness of policy interventions for preventing DUIC was scarce. Whereas *per se* laws have been implemented in a few jurisdictions, studies assessing their effect sampled only suspected DUI cases, but not the population-level impact or deterrent effect of *per se* laws on DUIC. Evidence of the effectiveness of individual-level interventions to prevent DUIC was also scarce, but generally of higher quality.

Knowledge gaps and need for future research

High-quality evidence about risk factors for DUIC is needed to help identify the types of interventions that are likely to be effective, and the higher-risk groups for whom interventions may be targeted or tailored. The population-level impact of policies to reduce DUIC could be evaluated with a natural experiment involving roadside testing of a representative sample of drivers before-and-after implementation of the *per se* law, both in the jurisdiction with the *per se* law and in a 'control' jurisdiction.

Implications for Practice

The existing burden of cannabis-related MVCs and the lack of clarity on whether legalization will lead to increased DUIC support public health interest in this topic. The Ontario Public Health Standard (OPHS) on the 'Prevention of Injury and Substance Misuse' requires local Boards of Health to engage in assessment and surveillance, health protection, and health promotion and policy development activities related to road safety generally, and drunk (or drugged) driving specifically.[50] The evidence

summarized in this Evidence Brief can help inform the public health response to DUIC.

Evidence about risk factors for DUIC can help inform health promotion efforts. For example, studies found that persons who perceive DUIC as more risky or dangerous are less likely to engage in DUIC. Similarly, normative beliefs were found to be associated with DUIC. Therefore, behaviour change and social learning theories could be used to develop interventions to address DUIC. Finally, the finding that higher cannabis use and cannabis dependence are both linked to DUIC highlights the need for public health to work together with addiction services to address DUIC.

Local public health units may also use the 'Lower Risk Cannabis Use Guidelines for Canada' (LRCUG) as a tool for informing the development of population-based interventions. For example, the LRCUG recommends a 3-4 hours minimum waiting period after cannabis use before driving.[51] In the upcoming 2017 version of the LRCUG, the recommended waiting period before driving is expected to increase to 6 hours.[52]

It may also be possible to adapt some of the preventive strategies used to address alcohol-impaired driving, keeping in mind the important distinctions between cannabis and alcohol. For example, multicomponent interventions with community mobilization,[53] school-based instructional programs,[54] and mass media campaigns,[55] which are evidence-based public health interventions to reduce drunk driving recommended by CDC's Community Guide, may be adaptable to DUIC. In fact, the Task Force for Cannabis Legalization and Regulation recommended that the federal government work with the provinces and territories to develop a national, comprehensive public education strategy about DUIC.[9]

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Specifications and Limitations of Evidence Briefs

The purpose of this Evidence Brief is to investigate a research question in a timely manner to help inform decision-making. The Evidence Brief presents key findings, based on a systematic search of the best available evidence near the time of publication, as well as systematic screening and extraction of the data from that evidence. It does not report the same level of detail as a full systematic review. Every attempt has been made to incorporate the highest level of evidence on the topic. There may be relevant individual studies that are not included; however, it is important to consider at the time of use of this brief whether individual studies would alter the conclusions drawn from the document.

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