1: Introduction

What is the aim of this fact sheet series?

The aim of this fact sheet series is to review the scientific evidence on cannabis and driving to provide objective information and inform the development of legislation to manage cannabis-impaired driving. The International Council on Alcohol, Drugs & Traffic Safety (ICADTS) aims to address road safety, with a focus on preventing and reducing traffic crashes caused by driving under the influence of cannabis. This approach demands a different approach from drug control strategies designed to reduce illicit cannabis use in the general population.

In jurisdictions where cannabis is entirely illicit, drug control might be prioritized over road safety. That is, a positive result on a biological test may result in a penalty for driving under the influence, regardless of the degree of impairment. However, as an increasing number of jurisdictions no longer prohibit cannabis use, we need to develop effective road safety policies that distinguish between cannabis-impaired driving and the prior use of cannabis only. This is especially pertinent with the increasing use of cannabinoid products as prescription medicines (i.e., medical cannabis).1,2

What do we mean by cannabis?

Cannabis refers to products including and derived from the flowering and fruiting tops of the Cannabis sativa plant. These herbal and resinous products have many names, including marijuana, sinsemilla and hashish. Cannabis sativa comprises over 140 unique cannabinoids, but scientific knowledge of them is limited.3 The quantity of each cannabinoid can vary greatly depending on plant variety and growing technique. The two most abundant of these are the non-psychoactive tetrahydrocannabinolic acid (THCA) and cannabidiolic acid (CBDA). When these cannabinoid acids are decarboxylated through heating, such as smoking, vaporizing, or baking into edibles, they are converted into the psychoactive compounds tetrahydrocannabinol (THC) and cannabidiol (CBD).4,5

Although CBD can be considered psychoactive, there is no evidence that CBD impairs when consumed alone. It is unclear whether the sedative effect of CBD would help generate impairment when cannabis is consumed in combination with alcohol or other drugs. According to a recent systematic review and meta-analysis, consumption of THC can impair driving ability.6 Limited evidence indicates that consumption of CBD does not appear to impair driving ability.7,8 Driving under the influence of cannabis should therefore be interpreted as driving under the influence of THC. This is an important consideration with respect to impaired driving legislation as low-THC cannabis and CBD products are increasingly promoted globally for their supposed wellness properties.9,10
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How is driving performance measured?

Driving is a complex and demanding task that involves a wide range of cognitive, perceptual, and motor functions. The most common measure of driving performance is the standard deviation of lateral position (SDLP), a measure of lane weaving, swerving, and overcorrecting. It is very sensitive to alcohol and drug effects. The change in SDLP associated with a blood alcohol concentration (BAC) of .05 is widely used as the benchmark for clinically relevant driving impairment as this is the legal driving limit in many jurisdictions. Other common measures include reaction time, speed, and headway (the distance a driver leaves between their vehicle and the vehicle ahead).

Since individuals have a different baseline level of driving performance, experimental studies generally examine how driving performance changes under different conditions. Researchers do this by comparing a driver’s normal level of performance (e.g., after receiving a placebo or before being given alcohol or cannabis) to their performance after being given a particular dose of alcohol or cannabis or being deprived of sleep.

The most realistic way to assess driving performance is by conducting an on-road study in which participants drive while supervised under real-world conditions. However, these designs are not often used because of the ethical and logistical challenges that they entail. Driving simulators are commonly used instead. In addition to their practicality, a key advantage of using a driving simulator is that investigators can control every aspect of the driving environment, including weather and road conditions, vehicle dynamics, and other vehicle behaviours. This makes it possible to simulate scenarios and conditions that would be impossible to control, and thereby ethically test, in the real world.

How much does cannabis impair driving?

Cannabis impairs driving, although the degree of impairment it produces varies substantially depending on the dose and the individual.

A series of on-road studies conducted in the Netherlands in 2000 established that smoked cannabis (100 and 200 μg/kg THC) significantly increases a driver’s SDLP. This finding has been confirmed by most studies since, including a study which used the highly advanced driving simulator at the University of Iowa. In a very recent on-road study, participants vaporized several types of cannabis that contained different ratios of tetrahydrocannabinol (THC) to cannabidiol (CBD). Regardless of the
CBD content, cannabis containing THC produced driving impairment at 40 min that was similar in magnitude to that typical of drivers with a BAC of .05. At 4 hours, it was closer in magnitude to what is typical among drivers with a BAC of .02. By contrast, CBD, when taken alone, did not produce any driving or cognitive impairment.

In another on-road study investigating driving performance in occasional and chronic frequent cannabis consumers, only occasional consumers were substantially impaired. Among chronic frequent consumers, neither 10 nor 20 mg THC produced clinically relevant driving impairment. This does not mean THC is harmless for chronic frequent consumers; rather, it indicates that people who use cannabis regularly develop a tolerance to some of its impairing effects. Chronic consumers may also consume higher doses of THC to overcome their tolerance and achieve a high. When they do their driving may then also be impaired.

Some studies have shown cannabis increases headway, meaning drivers leave a larger gap between them and the vehicle ahead. This, like slower driving speeds, is thought to be a compensatory mechanism drivers use when they think their driving might be impaired. Reaction times while driving were slowed in one simulator study but unaffected in a separate on-road study. In this latter study, a low dose of THC (100 μg/kg) did not impair city driving performance; highway driving performance was also relatively unaffected but worsened considerably with higher doses, especially when combined with alcohol.

In order to make sense of discrepant findings, Simmons and colleagues (2022) conducted a rigorous systematic review and meta-analysis. They found that although cannabis led to slower driving speeds, it nonetheless negatively affected lateral control of the vehicle, such that drivers under the influence of cannabis tended to weave more within their lane. However, there was insufficient evidence that “cannabis reliably changes rates of crashes, hazard reaction time (RT), headway, variability, time out of lane, speed variability, speed exceedances or time speeding.” Overall, this meta-analysis indicates cannabis does impair driving, even despite slowed driving speeds, but more research is required to fully characterize how cannabis affects driving.

**How long after using cannabis are drivers safe to drive?**

Unfortunately, there is no definite period of time after which it is safe to drive after using cannabis. Cannabis affects different people in different ways, and the time needed to recover from cannabis intoxication varies. Generally speaking, for a given THC dose, someone who uses cannabis more frequently and has a greater tolerance for THC can safely drive sooner than someone who uses cannabis occasionally. However, this tolerance effect may be negated if the person with a higher tolerance uses a higher THC dose to achieve a similar effect to someone with a lower tolerance who uses a lower THC dose.

The length of time needed to recover from cannabis intoxication is not fixed and depends on various factors, such as biological characteristics of consumers, type of cannabis consumed, dose, and method of ingestion.

In a recent on-road driving study involving occasional cannabis consumers, participants who vaporized 13.75 mg THC were, on average, safe to drive by 4-5 hours. This was confirmed by a recent review which showed impairment typically passes within ~5 hours of inhaling 20 mg THC and ~8 h after ingesting 20 mg THC. Importantly, impairment recovery times may be shorter or longer depending on the THC dose, the experience of consumers, and how they consume it. When cannabis is ingested, impairment lasts longer and it takes longer to recover because of the way THC is absorbed and metabolized compared with when it is inhaled.

**If a driver tests positive for THC, does that mean they are impaired?**

No; it depends on the dose, the route of administration, and the frequency of use among individuals, as well as whether cannabis has been consumed alone or in combination with alcohol or other substances.

There is a weak, negative correlation between THC concentration and driving performance (i.e., individuals with higher THC concentrations in their system exhibit poorer driving performance). However, at the individual level, it is impossible to reliably
infer level of impairment from THC concentrations alone. Peak THC concentrations occur while smoking or vaporizing and decrease rapidly after inhalation ceases. Intoxication, on the other hand, is typically greatest between 30 min and 1h after smoking. This means that individuals experience the strongest impairing effects of cannabis after THC concentrations have already peaked and begun to decline.

THC may be detectable in blood at low concentrations in chronic frequent cannabis consumers long after acute impairment has subsided. In fact, THC can remain at detectable concentrations for weeks, especially among chronic consumers. When cannabis is consumed orally (e.g., edibles), intoxication typically peaks around 2 hours and may last for up to 6 or more hours. Even with much higher doses, THC concentrations after ingestion are an order of magnitude lower than when cannabis is smoked or vaporized because of differences in the way THC is absorbed in the body. These issues are discussed in more detail in ICADTS Cannabis-Impaired Driving Detection & Toxicology.

How does cannabis compare with alcohol?

There are similarities in the effects of alcohol and cannabis on driving, such as increased SDLP (i.e., greater lane weaving), but the two drugs produce distinct behavioural effects. Unlike cannabis, alcohol tends to decrease inhibition, inflate self-confidence, and increase risk-taking behaviour, such as speeding and risky driving manoeuvres. While cannabis does impair several important driving-related skills, it is often associated with slower driving, increased headway, and a reduced willingness to drive. These results suggest cannabis consumers have a heightened awareness of their impairment and engage in potential compensatory mechanisms but results do not preclude cannabis use impairing driving performance.

In comparing the effects of cannabis to those of alcohol on driving performance and behaviour, Simmons and colleagues (2022) also observed the effect of cannabis was deemed similar to low levels of alcohol (e.g., a BAC up to .05).

Alcohol and cannabis produce different patterns of impairing effects.

The combined effect of alcohol, even in low concentrations, and cannabis is particularly dangerous for driving.

The effect of combining alcohol and cannabis is additive, producing greater impairment than that caused by either drug alone. In one on-road study, low (100 μg/kg) and moderate (200 μg/kg) THC doses combined with a .04 BAC produced road-tracking impairment similar to BACs of .09 and .14, respectively.

What are the limitations of experimental studies of cannabis and driving?

All study methods have strengths and limitations. A notable advantage of experimental studies is the ability to measure the effects of cannabis on driving performance and behaviour while an individual is actually under its influence. As discussed in this fact sheet, testing positive for THC does not necessarily mean an individual is impaired by cannabis while driving, which creates a notable limitation for epidemiological studies which aim to quantify the crash risk associated with cannabis. However, experimental studies do have important limitations. A systematic review and meta-analysis noted findings from experimental studies may not generalize well to the entirety of the cannabis-using population of drivers. Specifically, experimental studies have historically excluded older drivers, teen or novice drivers, medical cannabis consumers, individuals who are using cannabis for the first time, and heavier cannabis consumers with higher THC tolerances. Additionally, participants are often self-referred (rather than randomly selected) and became unblinded to their status as individuals in either the active cannabis group or the control group. This can lead to biased outcomes.
What research is still needed?

Research is needed to address several remaining questions. Most experimental studies involve standard doses of THC administered through smoking or vaporization with the goal of achieving measurable and substantial impairment in an individual. Much less is known about the effects of cannabis on driving in patients using medical cannabis in the real world and using individually tailored doses of THC or CBD. Further research is also needed to better understand how different doses of cannabis affect driving in new, occasional, and chronic or frequent consumers.

Finally, cannabis is often taken in combination with other substances. There is a body of research examining the combined effects of THC and alcohol but much less is known about the effects of using THC and CBD with other commonly prescribed medications such as opioids, sedating antidepressants, Z-drugs, and benzodiazepines.

More research is needed to understand how medical cannabis affects driving.

References


About ICADTS

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What is the prevalence of cannabis use in randomly selected drivers in traffic?

In roadside surveys, THC is typically the most commonly detected recreational drug after alcohol.

The prevalence of Δ⁹ tetrahydrocannabinol (THC) positive drivers varies from country to country, depending on the legal status of medical and/or recreational cannabis, the availability of cannabis, prevalence of cannabis use in the general population, traffic laws and their enforcement, and driving culture. A recent systematic review indicates those who use drugs and drive – and in particular, those who use cannabis and drive – are more likely to be younger and male.¹ Findings from several recent roadside surveys in Europe and North America are summarized in Table 1 below.

### Table 1. Prevalence of cannabis / alcohol use in randomly selected drivers in traffic (recent research).

<table>
<thead>
<tr>
<th>Country (year)</th>
<th>THC positive (country, year)</th>
<th>Alcohol positive (country, year)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td></td>
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<tr>
<td>Norway (2016-17)³</td>
<td>1.3%</td>
<td>0.2%</td>
<td>BAC&gt;.02</td>
</tr>
<tr>
<td>Spain (2018)⁴</td>
<td>5.1%</td>
<td>4.7%</td>
<td>BAC&gt;.01</td>
</tr>
<tr>
<td>Europe (2007-2009;13 countries)⁵</td>
<td>1.3%</td>
<td>3.5%</td>
<td>DRUID project; &gt;50,000 drivers BAC&gt;.01</td>
</tr>
<tr>
<td>North America</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Columbia, Canada (2018)⁶</td>
<td>6.0%</td>
<td>4.4%</td>
<td>BAC&gt;0; non-weighted values; evening and nighttime drivers</td>
</tr>
<tr>
<td>Ontario, Canada (2017)⁷</td>
<td>8.6%</td>
<td>4.9%</td>
<td>BAC&gt;0; non-weighted values; evening and nighttime drivers</td>
</tr>
<tr>
<td>US Roadside Survey (2013/14)¹⁰,¹¹</td>
<td>8.9% daytime 12.5% nighttime</td>
<td>1.1% daytime 8.3% nighttime</td>
<td>Nationally representative sample; weighted values</td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland (2006 – 07)¹³</td>
<td>1.7%</td>
<td>Not reported</td>
<td>Oral fluid testing with Cozart® Rapiscan device.</td>
</tr>
</tbody>
</table>
What is the prevalence of cannabis use in crash-involved drivers?

Findings from recent studies of crash-involved drivers from different regions are summarized in Table 2. Variation between these studies is explained by cultural and legal factors that influence how often drivers in different countries use drugs or alcohol and by differences in study design. For example, substances are more commonly detected in seriously injured drivers than in drivers involved in minor crashes and different studies use different detection thresholds for reporting THC and/or alcohol.

The prevalence of cannabis and of alcohol are generally higher in crash-involved drivers than in roadside surveys.

Table 2. Prevalence of cannabis / alcohol in crash-involved drivers (recent research).

<table>
<thead>
<tr>
<th>Country (year)</th>
<th>THC positive</th>
<th>Alcohol positive</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Europe</strong> (Past year use of cannabis in adults = 7.4%)(^2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway (2015-18)(^4)</td>
<td>9.9% (THC&gt;1.3ng/mL)</td>
<td>16.3% (BAC&gt;.02)</td>
<td>Fatally injured car/van drivers</td>
</tr>
<tr>
<td>EU (2007-2010)(^5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium, Denmark, Finland, Italy, Lithuania, the Netherlands</td>
<td>2.7% (THC&gt;1ng/mL)</td>
<td>24.5% (BAC&gt;.01)</td>
<td>Seriously injured drivers (DRUID study)</td>
</tr>
<tr>
<td>Italy (2017-2018)(^6)</td>
<td>1.5% (THC&gt;2ng/mL)</td>
<td>17.3% (BAC&gt;.05)</td>
<td>Crash-involved drivers</td>
</tr>
<tr>
<td>Italy (2012-2015)(^7)</td>
<td>3.7% (THC&gt;2ng/mL)</td>
<td>Not reported</td>
<td>Drivers treated in an Emergency Department</td>
</tr>
<tr>
<td><strong>North America</strong> (Past year use of cannabis in US adults = 17.9%; in Canadian adults = 27% (unweighted))(^8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada (2018-20)(^9)</td>
<td>18.8% (THC &gt;0.2 ng/mL) 7.6% (THC&gt;2ng/mL)</td>
<td>15.5% (BAC&gt;.01)</td>
<td>Injured drivers treated in fifteen trauma centres.</td>
</tr>
<tr>
<td>Canada (2015-2019)(^10)</td>
<td>21.8% (THC greater or equal to 0.01 ng/ml)</td>
<td>31.8% (BAC greater or equal to .01)</td>
<td>Fatally injured drivers of highway vehicles</td>
</tr>
<tr>
<td>USA (2019-2020)(^11)</td>
<td>20.8-32.7% (THC&gt;1ng/mL)</td>
<td>21.8-28.3% (BAC &gt;.02)</td>
<td>Injured drivers in five Level 1 Trauma Centers pre/post COVID-19 periods</td>
</tr>
<tr>
<td>USA (2011-12)(^12)</td>
<td>7.6% (THC&gt;2ng/mL in oral fluid or THC&gt;1ng/mL in blood)</td>
<td>5.0% (BAC&gt;.01)</td>
<td>Mostly minor injuries (Virginia Beach Study)</td>
</tr>
<tr>
<td><strong>Australia</strong> (Past year use of cannabis in Australian adults = 11.6%)(^13)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Victoria (2013-18)(^14)</td>
<td>11.1% (THC&gt;1ng/mL)</td>
<td>15.8% (BAC&gt;.01)</td>
<td>Injured drivers treated in hospital</td>
</tr>
<tr>
<td>Victoria (2006-16)(^15)</td>
<td>13.1% (THC&gt;0.01ng/mL)</td>
<td>18.4% (BAC&gt;.05)</td>
<td>Fatal crashes</td>
</tr>
<tr>
<td>Queensland (2011-15)(^16)</td>
<td>15.5% (THC&gt;1ng/mL)</td>
<td>31.8% (BAC&gt;.00)</td>
<td>Fatal crashes</td>
</tr>
</tbody>
</table>

*> means greater than; *< means less than
What is crash risk and how is it measured?

Crash risk is an odds ratio (OR) which measures relative risk of rare events such as drug-impaired driving. It expresses the likelihood that drivers who test positive for cannabis will be involved in a crash compared with drivers who test negative for cannabis. Most epidemiological studies of crash risk associated with cannabis are either case-control designs (which compare cannabis use in crash-involved drivers with that of non-crash-involved drivers), or responsibility (i.e., culpability) analyses which include only crash-involved drivers and compares cannabis use in drivers who were deemed responsible for the crash versus in drivers deemed not to be responsible.

What is the risk of crashing after using cannabis?

Cannabis, when consumed alone, is associated with a modest increase in crash risk at the population level according to most studies which compared the presence versus the absence of cannabis.

The increase in crash risk varies between studies, but the average increase is 30% to 40% in the latest meta-analysis. This means drivers who test positive for cannabis are approximately 1.3-1.4 times more likely to be involved in a crash than drivers who test negative for cannabis. Since this meta-analysis, two high-quality responsibility analyses were completed. A Canadian study of 1,825 injured drivers linked to police reports demonstrated no statistically significant increased risk in THC-positive drivers.

Limited data suggest that risk increases for drivers with whole blood THC ≥ 5ng/mL.

Two recent high-quality studies investigated crash risk at different THC concentrations. A Canadian study reported no evidence of increased crash risk responsibility for drivers with THC < 5 ng/mL. The estimated risk of crash responsibility was increased (OR=1.74) in drivers with THC ≥ 5 ng/mL. This was not statistically significant (perhaps due to the small number of drivers with THC > 5 ng/mL) and so may have been due to chance. Fortunately, most drivers do not drive while impaired by cannabis, so epidemiological studies can analyze only a limited range of relatively low THC concentrations.

A large Australian study found a significantly increased responsibility risk (OR=3.2) for drivers with THC ≥ 5ng/mL. For drivers with 1 ng/mL < THC < 5 ng/mL, the estimated risk was increased (OR=1.6) but this result was not statistically significant meaning it may have been due to chance. These responsibility analysis designs used different analytic approaches which may have contributed to their different findings. The Australian study excluded drivers who used more than one substance and compared risk in drivers who used cannabis alone (THC positive, all other substances negative) with the risk in drivers who were negative for all substances. In contrast, the Canadian study included drivers with polysubstance use and compared risk in drivers who used cannabis versus those who did not use cannabis, while statistically adjusting for the presence of other substances.

How does crash risk vary with THC concentration?

The crash risk associated with alcohol is much higher than cannabis.

Large case-control studies with low test refusal rates showed drinking drivers are at high risk of crashing. For example, a large U.S. study showed drivers with BAC>.08 had 6.63 times the likelihood of crashing (OR=6.63) compared to non-drinking drivers. Similarly, large increases in risk in drinking drivers were reported in the recent responsibility analyses from Canada (OR=4.2 for BAC>0; OR=6.0 for BAC>.08) and Australia (OR=16 for BAC>0).

What happens to risk when drivers combine alcohol and cannabis?

Drivers who combine cannabis and alcohol are at a very high risk of crashing.

In the recent Canadian responsibility analysis, drivers who tested positive for both alcohol and cannabis were approximately 7 times more likely to cause a crash than drivers who did not use either substance (OR=7.3 for BAC>0 and 0<THC<2ng/mL; OR = 6.8 for BAC>0 and THC≥2). Similarly, the Australian study found an odds ratio of crash responsibility of 14 (OR = 14) in drivers who combined alcohol and cannabis compared to use of neither substance. These findings are consistent with those observed in experimental studies (see ICADTS Cannabis Recent Experimental Evidence for more information). An American study demonstrated the combined use of even low doses of alcohol (i.e., BAC <.05) and cannabis significantly increased crash risk (i.e., OR=3.2).
What are the major limitations of epidemiological studies?

The four most common study limitations are described below.

Failure to measure recent cannabis use or impairment.

In older studies, cannabis exposure was often based on the presence of THC-COOH. This is an inactive THC metabolite that does not indicate either recent cannabis use or impairment. A number of studies of fatally injured drivers relied on post-mortem THC concentrations that are difficult to interpret because THC undergoes unpredictable post-mortem redistribution-up and down, but most data shows less post-mortem distribution than expected. THC concentrations in post-mortem blood correlate poorly with THC concentrations at time of death. More recent studies have defined cannabis exposure using the presence of THC in blood or oral fluid but the presence of THC in blood or oral fluid does not necessarily indicate acute impairment or intoxication, or even recent use of cannabis. This is partly due to the complex pharmacokinetic profile of cannabis (see ICADTS Cannabis-Impaired Driving Detection & Toxicology for more information). As a general rule, higher concentrations of a drug are more likely to indicate impairment, but the relationship varies greatly from person to person. A low-THC concentration may not be associated with noticeable impairment in frequent, heavy consumers but could be associated with substantial impairment in people who use cannabis occasionally.

Delays in obtaining blood to measure THC.

Many studies suffer from substantial delays between the time a crash occurs and the collection of a blood sample. THC levels decline rapidly after smoking cannabis, so concentrations measured hours after a crash are substantially lower than at the time of the crash. Conversely, in chronic heavy cannabis consumers, THC can be detected at low levels many hours after using cannabis, so detection of THC at low concentrations does not indicate drivers were high or intoxicated at the time of the crash. In studies of drivers who used cannabis more than 3-4 hours before a crash, the calculated crash risk is biased downwards (i.e., under-estimated) compared with the crash risk in the first 2-3 hours after cannabis use.

High refusal rates in case-control studies.

Most case-control studies have high refusal rates (>15%). This introduces potential selection bias if, as is likely, drivers who refuse to participate have higher rates of drug use. In addition, many case-control studies used different methods to measure cannabis exposure in cases versus in controls (e.g., blood THC in cases and saliva THC in controls). Another common problem is the use of non-comparable controls (e.g., patients visiting hospitals for medical problems) to estimate the prevalence of THC use in the general driving population.

Difficulty assigning responsibility in responsibility analyses.

In a responsibility analysis design, all drivers are involved in a crash. This minimizes differential ascertainment of THC in cases versus controls and eliminates bias due to refusals by using routine THC testing done by police, hospitals, or coroner investigations. Responsibility analyses nonetheless face major challenges in retrospectively determining who was responsible for a crash in a sample of drivers who failed to avoid crashing. As a result, non-responsible drivers may differ from the general driving population.

References


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3: RECENT EPIDEMIOLOGICAL EVIDENCE |
CANNABIS & DRIVING
Are THC concentrations in blood predictive of driver impairment?

At the population level, the higher the Δ⁹-tetrahydrocannabinol (THC) concentrations in blood, the greater the fraction of cannabis consumers who show impairment.¹ This association is clearest in occasional cannabis consumers and may differ in chronic frequent cannabis consumers who develop partial tolerance to the effects of THC. However, at the individual level, it is difficult to predict impairment in individual drivers.

At the population level, the fraction of cannabis consumers who show any degree of impairment increases with higher tetrahydrocannabinol (THC) concentrations in blood.¹

At the individual level, the association between THC concentration and driving performance is difficult to measure.¹² A dissociation between blood THC concentrations and impact on psychomotor function and cognition exists for several reasons. These include:

1. Peripheral blood THC concentrations do not represent THC in the brain.³
2. Individuals may develop partial tolerance after repeated exposure to the impairing effects of THC.⁴,⁵
3. After chronic daily cannabis intake, THC (above 1 ng/mL) can be detected in the blood of some consumers for many days, sometimes in the absence of impairment.⁶
4. In road traffic practice, THC concentrations are usually detected in blood up to 1-8 h after a traffic crash or stop. These do not represent THC concentrations at the time of the crash (i.e., blood THC concentrations decrease approximately 74% in the first 30 min and by 90% in the first 1.4 h).⁷
5. THC concentrations widely vary after the intake of different THC formulations while producing similar levels of impairment (e.g., THC peak concentrations are low after oral formulation intake and initially high after vaping or smoking).⁸
Are THC concentrations in oral fluid predictive of driver impairment?

Positive oral fluid test results may indicate recent cannabis use because test sensitivity is usually limited to a few hours after smoking (the time depending upon the detection threshold of the device). THC in oral fluid primarily represents coating of the mouth after inhalation of drug-laden smoke or vapour. It is not associated with THC concentrations in blood or driver performance. Two to four hours after cannabis intake, coating of the oral fluid dissipates and oral fluid THC concentrations approximately parallel blood THC concentrations, but not at the same levels. We cannot accurately predict blood concentrations of THC from oral fluid concentrations because of high intra-subject and inter-subject variability.

We cannot accurately predict blood concentrations of THC from oral fluid concentrations because of high intra-subject and inter-subject variability.

Is there a specific (per se) THC limit that allows differentiation of impaired and non-impaired drivers?

No; while impairment from THC increases at the population level, THC concentrations do not predict impairment at the individual level.

Can behavioural standardized field sobriety tests (SFSTs) alone reliably detect THC-induced driver impairment?

Current standardized field sobriety tests include horizontal gaze nystagmus (HGN), one leg stand (OLS) and walk and turn (WAT). They were developed to identify alcohol-impaired driving and do not adequately detect THC-induced driver impairment.

THC does not produce HGN. However, of these three behavioural tests, the OLS is the most sensitive at detecting THC effects. The Drug Evaluation and Classification Program (DECP) was later developed to improve the detection of impaired driving following the use of seven classes of drugs drug in addition to alcohol. The DECP captures physiological measures, pupil size/light reaction, and performance on psychophysical tests including the OLS, WAT, Finger to Nose (FTN), and Modified Romberg Balance (MRB). These are assessed in a highly standardized exam conducted by specially trained police officers. Cannabis significantly increased pulse, systolic blood pressure, and pupil size, with documented errors on the FTN and WAT, eyelid tremors on the MRB, sway on the OLS, and pupil rebound dilation. THC impairment was identified in ≥96.7% of THC-impaired driving cases if two of these four test criteria were met, ≥3 FTN misses, MRB eyelid tremors, ≥2 OLS clues, and/or ≥2 WAT clues. False negative rates of the DECP are unknown because these procedures are only applied by police to drivers who are suspected of drug-impaired driving.

Many jurisdictions are developing other behavioural tests to detect THC-induced impairment. The major challenge is in distinguishing THC-related impairment from an individual’s driving performance when not drug-affected. Such reference data can be collected in laboratory settings but cannot be collected at the roadside. Without such normative data, standards of cannabis impairment are difficult to define for behavioural tests performed on drivers suspected of drug-impaired driving at the roadside.
Are urine drug concentrations alone appropriate to assess impairment in drivers suspected of driving under the influence of cannabis?

No, urine concentrations of cannabis metabolites simply identify past cannabis exposure and in no way identify THC impairment. Urine drug/metabolite concentrations should not be used to interpret the effect of a drug or a chemical on human behaviour.16

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How do jurisdictions address driving under the influence of cannabis?

It depends on the road safety objectives of the jurisdiction.

Driving under the influence of alcohol defined by a specified (per se) blood alcohol concentration (BAC) in many jurisdictions, even though not all drivers will be impaired at this level. Other offences, such as dangerous driving, fatigued driving or distracted driving, are less clearly defined. Determinations are left to the judgement of road safety authorities, experts, and the judicial system. Cannabis-impaired driving may be defined using either approach.

Understandably, law enforcement and road safety agencies would like to have a numerical concentration (per se) limit for tetrahydrocannabinol (THC) that is analogous to a BAC limit for alcohol. THC concentrations in the body, however, do not accurately reflect the magnitude of cannabis-related impairment (see ICADTS Cannabis Recent Epidemiological Evidence and ICADTS Cannabis-Impaired Driving Detection & Toxicology). Jurisdictions which give a priority to protecting drivers’ rights are generally reluctant to establish a per se limit because it is difficult to defend. Jurisdictions which place a greater emphasis on protecting the safety of the broader population have in some cases defined per se limits which they consider sufficiently evidence-based for their purposes. Policymakers will need to interpret the available scientific evidence in the context of their local societal and cultural values to decide how to balance these competing risks.

Jurisdictions may use toxicological or behavioural tests, or a combination of both (see ICADTS Cannabis-Impaired Driving Detection & Toxicology) to identify cannabis-impaired drivers. Extant per se limits for cannabis generally relate to THC concentrations in blood, with thresholds ranging from .5–5 ng/mL. Taking and testing blood is invasive and often requires justification (e.g., prima facie evidence of driver impairment). It also requires special training for those tasked with taking blood and for these reasons it is rarely done at the roadside. The severity of the offence (e.g., administrative, minor or major criminal, felony) may also affect testing procedures. Some countries have introduced graduated offences that impose:

- a lower penalty for low concentrations of THC;
- a higher penalty for a defined blood/oral fluid (OF) THC concentration; and/or,
- even greater penalties for higher THC concentrations or clear evidence of impaired driving.

As with alcohol, some countries impose per se restrictions on drug-impaired driving according to specific driver categories (novice or young drivers, heavy truck drivers). The severity of the offence may be reflected in the classification and in the severity of punishment (i.e., administrative offences, minor to more serious criminal offences, fines or prison sentences).
What about medical cannabis?

Medical cannabis consumers should not be subject to THC zero-tolerance laws that make it illegal to drive with any detectable level of THC, as is the case with some other types of impairing medications, but they should still be subject to impaired driving laws.

A different limit or threshold should be considered for medical cannabis consumers when drivers can provide evidence their cannabis use is legal and prescribed. It would be desirable to have ways for police to identify medical consumers for enforcement purposes. As with other medicines, a medical exemption does not protect drivers from impaired driving offences. Legislation regarding medical exemptions requires consideration of both the road safety context and regulatory protocols specific to the jurisdiction. Policymakers should be aware that legislation concerning medical cannabis use may influence limits for cannabis-impaired driving in the broader population.

Few studies have directly assessed the effects of medical cannabis use on driving. Some evidence suggests cannabis has few effects on driving ability when used therapeutically under medical supervision. This may be due to symptom improvement, a reduction in the use of other impairing medications, or reflect different patterns of use (e.g., frequency of use, type of product used, amount used) when compared with non-medical cannabis use.

In the Netherlands, medical use of cannabis is assigned to category II (not safe for driving). Medical consumers who are chronic, daily consumers, should not drive during the first two weeks; occasional consumers, should not drive in the first 15h after intake. The legal limit of 3.0 µg/L THC in blood also applies to medical cannabis. For more information, see the Medical Cannabis & Novel Psychoactive Substances fact sheet.

Should cannabis be treated like alcohol?

It may depend on the legal status of cannabis. It is more challenging to determine cannabis-related impairment than alcohol-related impairment.

As of 2022, the following countries have legalized cannabis for recreational use: Canada, Georgia, Malta, Mexico, South Africa, Uruguay, as well as other countries. In the United States, cannabis is legal in 19 states, 2 territories, and the District of Columbia. Many more jurisdictions have legalized medical cannabis. These trends are likely to continue. In jurisdictions where cannabis is still illicit, zero-tolerance laws may prohibit drivers from having any amount of cannabis in their system. This may be considered reasonable because it is illegal to consume cannabis under any circumstances. In jurisdictions where cannabis consumption is legal, however, zero-tolerance laws are less defensible because individuals who can legally consume cannabis may test positive for THC long after they last used cannabis, and when they are no longer impaired.

Alcohol is legal in most jurisdictions and for this reason, drivers are generally allowed to have some amount of alcohol in their system, although drivers exhibiting signs of impairment may still be charged with a driving offence below per se levels. How much constitutes some (i.e., the per se limit) depends on the level of risk that jurisdictions are prepared to accept. In most countries, this is a BAC of .05. In some countries it is lower (.02) and in some it is higher (.08), and some countries may further require retrograde extrapolation to determine BAC at the actual time of driving. Blood alcohol concentrations accurately reflect the amount of alcohol consumed, and therefore the level of impairment at the population level because increasing BACs increase impairment. Despite variations in impairment at similar BACs between subjects, BAC limits are effective and accepted in society. THC concentrations, on the other hand, do not accurately reflect the amount of cannabis consumed or the level of impairment. Due to the complexity of THC pharmacokinetics, a simple back-calculation of THC concentration in blood to determine the level at the time of the driving event is not feasible at this time. It is therefore much harder to establish impairment per se limits for cannabis than for alcohol. This issue is discussed in more detail in the ICADTS Cannabis-Impaired Driving Detection & Toxicology fact sheet.
In some countries such as Norway, the per se limits of cannabis detection aim to approximately parallel those for alcohol impairment. This eliminates the requirement for an individual evaluation of impairment of each driver, which is time-consuming and expensive. It also ensures more consistent handling of alcohol and cannabis-impaired driving cases. Most countries, however, retain a binary distinction between having committed an offence or not. Combinations of different drugs are also treated differently between countries. France and the Netherlands have established stronger punishments for driving after consuming a combination of different drugs and alcohol. Defined limits for individual substances are lowered for combinations. In Norway, an individual evaluation of the degree of impairment is conducted, based on all the detected drugs and observation of driver behaviour.

Do laws relating to the presence of cannabis in drivers deter drug impaired driving and are they sufficient to change behaviour?

It is unclear whether cannabis zero-tolerance laws deter drug-impaired driving, although similar laws for alcohol have been effective. Some countries further specify different BAC levels for passenger vehicle drivers, heavy truck drivers, bus drivers and young drivers.

The aims of these laws include general and specific deterrence. Laws only deter drivers when they are actively enforced. In Australia, large-scale roadside drug testing for the presence of THC in oral fluid is used to detect and deter impaired drivers, with the goal of improving road safety. A positive test results in a punishment for the driver which is a specific deterrent. These aims affect police policy and operational philosophy.

Responses to drug-impaired driving may need to differ between first and repeat offenders, even though many first offenders may have driven impaired many times before detection. In practice, distinguishing the risk posed by drivers, and thereby their punishment, should be based on a validated risk assessment. Repeat offenders may have an underlying substance use problem that requires a targeted healthcare intervention. More research of the effectiveness of targeted responses is required, and better collaboration between the justice and healthcare systems is needed to adequately assess and reduce risk.

Most countries still consider punishment as the main form of deterrence (e.g., a fine or suspension of licence). Per se and zero-tolerance limits require less police training and are often considered simpler to enforce. As mentioned above, however zero-tolerance laws are inappropriate in the case of medical cannabis use. It has been difficult to measure the effects of enforcing per se limits on the prevalence of drug-impaired driving and rates of recidivism. Evidence that punishment is an effective deterrent is sparse. Prison sentences have not been found to consistently reduce the prevalence of impaired driving.

Countries that have successfully reduced drink driving in the community appear to share two key program components. Enforcement is one of the key strategies for effective change, with celerity and certainty of consequences more important than their severity. Longer-term change requires increasing cultural disapproval of drug-impaired driving that supports individual behaviour change. This approach has yet to be explored and evaluated for cannabis-impaired driving.

What tools are needed to enforce such laws and how efficient/effective are they?

\textit{Enforcement requires accurate and reliable technology to measure the presence of cannabis and/or behavioural assessment tests.}

Whatever legislative approach is applied to cannabis use and driving, it must be enforceable and actively enforced. Enforcement requires accurate and reliable technology to detect the presence of cannabis in drivers, similar to the use of breathalyzers to detect alcohol. Alternatively, it requires a capacity to conduct behavioural assessments, such as the Drug Recognition Expert program in the United States and Canada. Testing devices must be available in sufficient quality and quantity to enforcement agencies. This requires the road safety field to develop affordable fit-for-purpose technology.

For policymakers, cost-effective testing and sample analysis are essential given finite resources. Policymakers must consider cost-benefits of behavioural testing measures (e.g., Drug Recognition Expert program), blood concentration assessments, and oral fluid sampling, and their possible combinations. A commonly reported practice in some countries is to test first for alcohol and only test for other drugs if the alcohol test is negative or below specified BAC levels because this provides sufficient evidence for a conviction. This might not reveal if the driver has an underlying substance use problem; information that is highly relevant in assessing the risk of recidivism. Such an approach also precludes the collection of accurate data about drug use among drivers. Some consistency across jurisdictions in the tools used, and results recorded, would make it easier to pool data from several countries and produce more robust research on cannabis and drug-impaired driving.
More information about the penalties for drug-impaired driving across countries and the different types of tools and technologies used to detect drug-impaired driving by police services is available at:

https://druggeddriving.tirf.ca/module/laws-penalties/#5


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Does medical cannabis differ from recreational cannabis with respect to driving?

Defining medical cannabis.

Medical cannabis can refer to a wide variety of products and methods of preparation including herbal cannabis (the dried flowers of the cannabis plant) and cannabis extracts (e.g., oils, tinctures). In general, these products contain either THC or CBD as the primary active ingredient, or some combination of the two compounds. There is an ever-growing number of cannabis strains (varieties of the plant) which can vary substantially with respect to concentrations of THC, CBD, and other plant compounds. There are also several medical products with market authorization, such as Dronabinol and Sativex® (an oromucosal spray containing a 1:1 ratio of THC and CBD which is used to treat spasticity associated with multiple sclerosis).

An important issue in the provision of cannabis preparations for medical use is how it is consumed. Smoking is a common route of administration (and the traditional mode of consumption for recreational consumers) because it produces a rapid onset of drug effects. Safer and more precise methods of administration are available, however, such as vaporizing below the point of combustion (vaping) or ingesting oils or extracts. Smoking is not recommended as a route of administration because of its adverse health effects.

Relief of Symptoms

Individuals often use cannabis medically to treat conditions (e.g., pain, anxiety, stress) that can affect driver behaviour and performance. Relief of these symptoms by medical use of cannabis may offset driving impairment caused by the condition being treated under medically supervised conditions. A recent review identified six studies exploring the acute effects of THC on driving-related cognitive skills in individuals with diverse medical conditions such as Tourette syndrome, ADHD, and diabetic neuropathy. While therapeutic effects of THC were reported (e.g., reduced hyperactivity), only one of the six studies reported a significant impairing effect of THC on driving-related skills.

Tolerance

To date, most experimental studies of the effects of cannabis on driving have been conducted on healthy young drivers who use cannabis recreationally. By contrast, people who use cannabis medically typically use the drug more frequently than recreational consumers and, as a result, may develop pharmacological and behavioural tolerance to the effects of THC. In a study of occasional (less than once per week) versus heavy (primarily daily) cannabis consumers, there was no difference between groups in the subjective high experienced after a 10mg and 20mg dose of synthetic, medical THC. However, driving
performance was impaired only among occasional consumers. This suggests people who use cannabis more frequently may be less susceptible to its acute impairing effects. Chronic consumers may, however, consume higher doses of THC to overcome their tolerance and achieve a high, in which case cannabis-related driving impairment can occur.

Results from other studies likewise suggest individuals develop tolerance to the effects of cannabis over time. For instance, when cannabis naive patients received their first dose of medical cannabis, they showed poorer performance on a range of driving-related cognitive tasks. However, patients treated with cannabis for at least a few weeks with a stable dose showed no decline in neurocognitive performance and actually performed better in some cases than they did before commencing treatment. A recent review showed most multiple sclerosis patients using Sativex® exhibited either no change or an improvement in driving rather than a deterioration, although it is important to note that none of these studies assessed driving performance directly (i.e., by using a simulator or on-road driving).

**THC content**

Medical consumers may be more likely than recreational consumers to use cannabis products with lower THC content, potentially reducing their collision risk. Further population-level comparison of cannabis use patterns among recreational and medical cannabis consumers is needed.

Medical cannabis can refer to a wide variety of products and methods of preparation including herbal cannabis (the dried flowers of the cannabis plant) and cannabis extracts (e.g., oils, tinctures).

Should patients who are prescribed medical cannabis be given a medical designation for driving?

Those who use cannabis medically should do so under the supervision of a qualified medical professional. They are advised to titrate doses upward slowly as needed and as approved by a medical professional. They should refrain from driving in the first two weeks after initiation of cannabis use and after each increase in dose. They should also be made aware of legislation pertaining to medical use of cannabis in their jurisdiction.

**Does CBD affect driving performance and can it counteract the effects of THC?**

A recent on-road driving study showed CBD-dominant cannabis did not produce any driving impairment compared to placebo, although at least one study suggested CBD might be associated with impairment. Further, it seems that when consumed with alcohol, CBD can increase impairment and more research on this topic is needed. Cannabis containing mainly THC or a combination of THC and CBD, did cause driving impairment for up to four hours after inhalation. From this and another study, it can be concluded that CBD when consumed alone, does not impair driving performance nor does CBD reduce the impairing effects of THC.

**Do novel synthetic cannabinoids (SCs) pose a risk to traffic safety?**

Yes, novel SCs potentially pose a serious traffic safety risk.

While some medical cannabinoids have been synthetically manufactured for decades, novel SCs represent a large group of new psychoactive substances with 209 identified in the European Union (EU) over the 13 years between 1 January 2008 and 31 December 2020, including 11 identified for the first time in 2020. SCs are often sold as herbal smoking blends with names such as Spice, K2 and Kronic. SCs bind to the same receptors as tetrahydrocannabinol (THC) but often have far higher potency and efficacy. Controlled administration laboratory studies using low doses of one of the earliest SCs (JWH-018) demonstrated acute impairment of motor coordination, attention, response speed, and memory. It is expected that effects on psychomotor performance in consumers who use large amounts or overdose on SCs pose an even greater road safety risk than demonstrated in these studies.
What is the prevalence of SCs in traffic crashes?

To date, research suggests the prevalence of SCs in traffic crashes is relatively low.

A few cases of suspected impaired driving under the influence of SCs have been studied.\textsuperscript{20,21,22} The performance impairment was similar to that typically observed with cannabis use. However, overall, the prevalence of SCs in drug-impaired driving cases is low. In a retrospective analysis of novel psychoactive substances (NPS) in blood samples of German drivers suspected of drug-impaired driving, synthetic cannabinoids were detected in only 1.4\% of cases.\textsuperscript{23} This is likely because fewer people use SCs than natural cannabis. It may also partially be explained by a large variety of SC products on the market and the analytical challenges in detecting them in biological samples. On the other hand, in a Japanese study examining a sample of vehicle collisions attributed to illicit drugs, indirect evidence suggested that 93 of 96 drivers had used SCs,\textsuperscript{24} but SCs were identified in blood or urine only in a minority of cases, again suggesting prevalence is low.

How do the effects of synthetic cannabis differ/compare to natural cannabis?

SCs produce much stronger and more unpredictable effects than cannabis.

Both THC and SCs bind to the same cannabinoid receptor (CB1). Whereas natural THC acts as a relatively weak CB1 partial agonist, most SCs are full agonists. As a result, SCs are often much more potent (up to 85 times more potent than THC).\textsuperscript{17} SCs can also induce psychotomimetic (i.e., producing an effect similar to a psychotic state) more often and more strongly than natural cannabis.\textsuperscript{25}

A major issue is that SCs have unpredictable effects on consumers.\textsuperscript{26} There is a large variety of available SCs, and the specific type of SCs used in a mixture are not indicated on product packaging.\textsuperscript{27} The active ingredients in SC products also change regularly, and there is a large degree of variability in the active ingredient(s) and their distribution within the products.\textsuperscript{28} By comparison, natural cannabis produces more predictable effects and can be administered in controlled doses.

Can standard roadside tests detect SCs?

Current roadside tests have limited ability to detect SCs.

Standardized Field Sobriety Tests (SFSTs) have been developed to detect impairment caused by alcohol (see ICADTS Cannabis-Impaired Driving Detection & Toxicology). In the absence of alternative tools, SFSTs are also used in some jurisdictions to detect impairment caused by cannabinoids. Research has, however, demonstrated that SFSTs have limited sensitivity to detect the impairing effects of natural cannabis or Dronabinol (synthetic THC used to treat HIV/AIDS-related anorexia and chemotherapy-induced nausea and vomiting).\textsuperscript{4,29} SFSTs also appear to have limited sensitivity in detecting the impairing effects of SCs. SCs are not detectable in standard drug tests because they are present in very low concentrations in blood and oral fluid. A very sensitive Liquid chromatography–mass spectrometry (LC-MS/MS) analysis capable of detecting all SCs is required for testing purposes.

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