

Marijuana Impaired Driving: Toxicological Testing in Washington State



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Introduction

In November 2012, Washington voters passed Initiative-502 (I-502), legalizing retail cannabis sales and recreational cannabis use for adults 21 years and older. As with alcohol, the law provides two options for prosecuting impaired drivers: 1) demonstrating impairment through detailed observation notes, field test results, witness observations, or Drug Recognition Expert assessments; and 2) determining the suspect’s blood level for the drug is above the legal "per se" limit. I-502 established a *per se* level of 5ng/mL of active delta-9-tetrahydrocannabinol (Δ^9 -THC) in blood for cannabis-impaired driving. Δ^9 -THC is a psychoactive and impairing compound in cannabis.

The objectives of these analyses were to describe the estimated time to blood draw under real world conditions, and examine the relationship between estimated time to blood draw and the level of Δ^9 -THC detected.

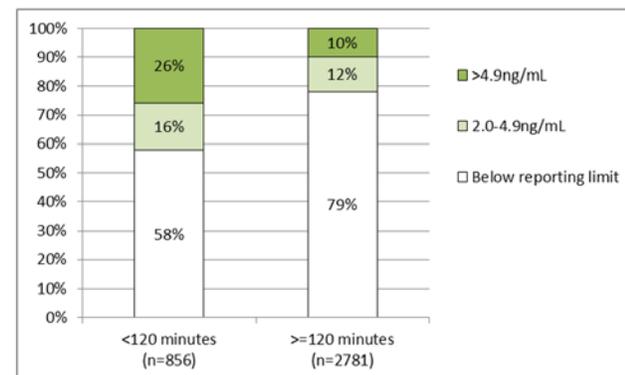
Methods

Data from the Washington State Patrol’s toxicology laboratory and dispatch were linked. An estimated time to blood draw (ETBD) variable was created from data in the computer automated dispatch system. The relationship between the estimated time of blood draw and measured Δ^9 -THC level was tested.

Main Results

- The median time to blood draw for all cases was 165 minutes.
- The median estimated time to blood draw for Δ^9 -THC-positive drivers (among collisions and non-collisions) was 139 minutes. Estimated time to blood draw was significantly longer for those positive for the metabolite carboxy-THC, but not Δ^9 -THC, at the time of testing (175 minutes).
- The measured Δ^9 -THC blood level for the population studied declined 5ng/mL on average during the first 120 minutes from contact with police.
- The proportion of those with an ETBD of less than 2 hours who had a Δ^9 -THC blood level ≥ 5 ng/mL was 26% compared to 10% for those with an ETBD of 2 hours or more.

Δ^9 -THC Level by Estimated Time of Blood Draw



Implications

It is likely that prolonged delays in blood testing routinely resulted in those who were above the 5ng/mL Δ^9 -THC *per se* limit at the time of a collision or driving violation were below this level at the time blood was drawn. Overall the average ETBD was 165 minutes. These findings indicate that Δ^9 -THC impaired driving is likely underestimated given the generally protracted time until a blood sample is obtained. Evaluating the impact of protracted time until blood testing is complicated by the lack of available standardized law enforcement data on the time of testing. These findings highlight the challenges in enforcing drugged driving laws, particularly with a *per se* component, in the absence of point-of-contact testing modalities and in the presence of logistical delays in obtaining blood samples. Detailed study procedures and findings are provided in the following pages.

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DETAILED STUDY PROCEDURES AND FINDINGS

Cannabis and Driving – Legislation and Evidence Base

To address cannabis-impaired driving, Washington State's Initiative-502 set a *per se* level of 5 ng/mL of delta-9-tetrahydrocannabinol (THC) in whole blood for driving under the influence (DUI). The main psychoactive and impairing component of cannabis is Δ^9 -THC. Δ^9 -THC is generally measureable in blood for several hours following consumption and metabolism varies widely by route of administration, potency, and user characteristics⁸⁻¹⁴. Some consensus exists on 2-4 hours of effects after smoking, decreasing quickly after maximum impairment at 20-40 minutes, but higher Δ^9 -THC -content smoke has longer effects^{10,11,15-17} and mild effects have been documented at 6 hours or more post dosage^{13,17}. Slower absorption of oral doses (e.g. edibles), particularly in presence of other food, creates a delayed and longer-lasting peak blood level^{13,18} that is typically much lower than results from smoking. Metabolism and neurological effects of Δ^9 -THC also depend upon the levels of other cannabinoids in the consumed substance¹⁵. The presence of Δ^9 -THC in blood at levels above 1 ng/mL is generally an indication of recent cannabis consumption for occasional users. Carboxy-THC is a readily detected non-psychoactive metabolite of cannabis. The metabolite carboxy-THC may remain measureable for several days following occasional use, and longer with more frequent use.

Laboratory studies of cannabis and driving simulator studies have repeatedly demonstrated that Δ^9 -THC use is associated with impairment in driving related behaviors. Recent cannabis use diminishes virtually every driving-related capacity, generally in a non-linear dose-response fashion: psychomotor functions, cognition, attention, vigilance, tracking, reaction time & coordination^{10,11,15,16,19,20}. Cannabis affects automated/routine driving more than that requiring cognitive effort^{14,16}. Effects depend on dose, potency, absorption, time since peak blood level, individual tolerance and skill/task^{16,18,19}.

However, real world studies examining the association between cannabis use (THC presence and level) with collision risk have been inconsistent. A recent case-control study compared oral fluid and blood test results of more than 3,000 drivers involved in a collision with over 6,000 control drivers recruited from the same location, traveling in the same direction, and at the same time of day. All drivers voluntarily participated in the study. In multivariable analyses controlling for the presence of alcohol or other intoxicating drugs, investigators found no significant association between collision risk and cannabis use after adjusting for demographic variables²¹.

Epidemiologic studies exploring crash risk factors have relied on the Fatal Accident Reporting System (FARS). For instance, a study examined the presence of marijuana metabolites reported in the FARS system in Colorado to states without widespread medical marijuana to test for the impacts on fatal accidents and found increases "in the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive" in Colorado but not in non-medical marijuana states.²² However, the FARS system utilizes the presence of carboxy-THC, an inactive metabolite of Δ^9 -THC, as a proxy for "marijuana involvement" or Δ^9 -THC impairment²³. Carboxy-THC can reflect recent marijuana use, but it is also present in the blood of chronic users of marijuana even in the absence of acute marijuana use, and can be detected days after marijuana use in some individuals²⁴. As a consequence, relying upon carboxy-THC as a proxy for cannabis-impaired driving may overestimate the proportion of cases with "recent" cannabis consumption or "impairment" due to cannabis. An additional challenge with fatal cases is that metabolism essentially stops at the time of death, so blood levels among those who have died will on average be much higher than those who live and whose time to a blood test may be several hours late^{25,26}.

METHODS

Analytic data sources

1. Toxicology (TOX) data from the WSP Forensic Laboratory Services Bureau measure levels of different drugs or their metabolites: carboxy-THC, Δ^9 -THC, ethanol, and other intoxicating drugs. The laboratory tests toxicological evidence for all Washington state and local law enforcement jurisdictions. Cases involving suspected DUI or serious motor vehicle collisions are included for 2005-2014.
2. Computer Automated Dispatch (CAD) data from the WSP provide a time stamped progression of a case from initial dispatcher involvement onwards. Of specific interest for these analyses were: a collision indicator variable, the beginning time of the case, and an estimate of when a blood draw was obtained.

Methodological approach and analyses

Analysis of estimated time of blood draw and Δ^9 -THC levels

Graphs displaying the level of Δ^9 -THC versus carboxy-THC by the estimated time of blood draw (ETBD) obtained from computer automated dispatch (CAD) data were created to show the distribution of cases by estimated blood times. We conducted Wilcoxon rank-sum test tests of differences in median blood draw times for Δ^9 -THC versus carboxy-THC. A scatter plot with locally weighted regression lines was created to examine the relationship between ETBD and Δ^9 -THC level. Linear regression analyses were conducted to test the relationship between ETBD and Δ^9 -THC level and whether the relationship differed for those with an ETBD of less than two hours compared to two to four hours using a piecewise regression analysis (with a priori 2-hour cut point).

Variables

Drug types and blood level coding

Drug types and blood levels were obtained from the Washington toxicology (TOX) dataset¹. The laboratory indicates that they can detect approximately 125 substances². Δ^9 -THC was coded as present or absent based on Δ^9 -THC levels being at or above 2ng/mL for time trend analyses.

Dataset linkage processes

The dataset linkage was a multi-step process. The TOX dataset included Washington drivers suspected of a DUI infraction or drivers involved in a traffic collision. The CAD dataset was linked to the TOX dataset by the WSP agency number and date of offense and was retained if there was at least one reference to blood in the CAD dataset. The CAD dataset did not contain time stamped entries related to the exact time of the blood draw. Rather, data entries in the CAD dataset typically referenced a specific evidence number connected to the process of arranging for a blood sample and a time stamp was associated with this reference. An algorithm was developed based upon text string searches of the CAD to create an ETBD. For 10% of cases, the word “blood” was not specifically associated with an evidence number and after a careful review of the data we determined that for this subset of cases we would utilize the time stamp associated with the first reference to “blood”. As an initial assessment of the validity of the ETBD we pulled 25 random cases where the driver was positive for carboxy-THC but not for active Δ^9 -THC and an additional 25 cases where the driver was positive for Δ^9 -THC. We reviewed the complete sequence of activity reported in CAD for these 50 cases. Specifically, we looked in CAD for references to arriving and leaving the hospital (where the vast majority of blood draws occur) and found that using the first reference to blood coincided closely

¹ For most years the level of reporting was 1 ng/mL, however there was a period from December 3, 2012 through May 8, 2014 where the reporting limit for Δ^9 -THC was 2 ng/mL and 10 ng/mL for carboxy-THC.

² http://www.wsp.wa.gov/forensics/docs/toxicology/Measurement_Uncertainty/drug_list_uncertainty_values.pdf

with the mid-point between hospital arrival time and hospital discharge time and therefore was a reasonable proxy to use for ETBD.

The University of Washington human subjects division reviewed and approved all study procedures.

RESULTS

An overview of a common DUI traffic stop is provided below to give a sense of the variability and complexity of procedures.

Abbreviations - DUI flow diagram

EBT = Evidentiary Breath Test-Machine used for estimating blood alcohol concentration from a breath sample

DOL = Washington State Department of Licensing

DUI = Driving Under the Influence

DRE = Drug Recognition Expert

FSTs = Field Sobriety Tests (not standardized)

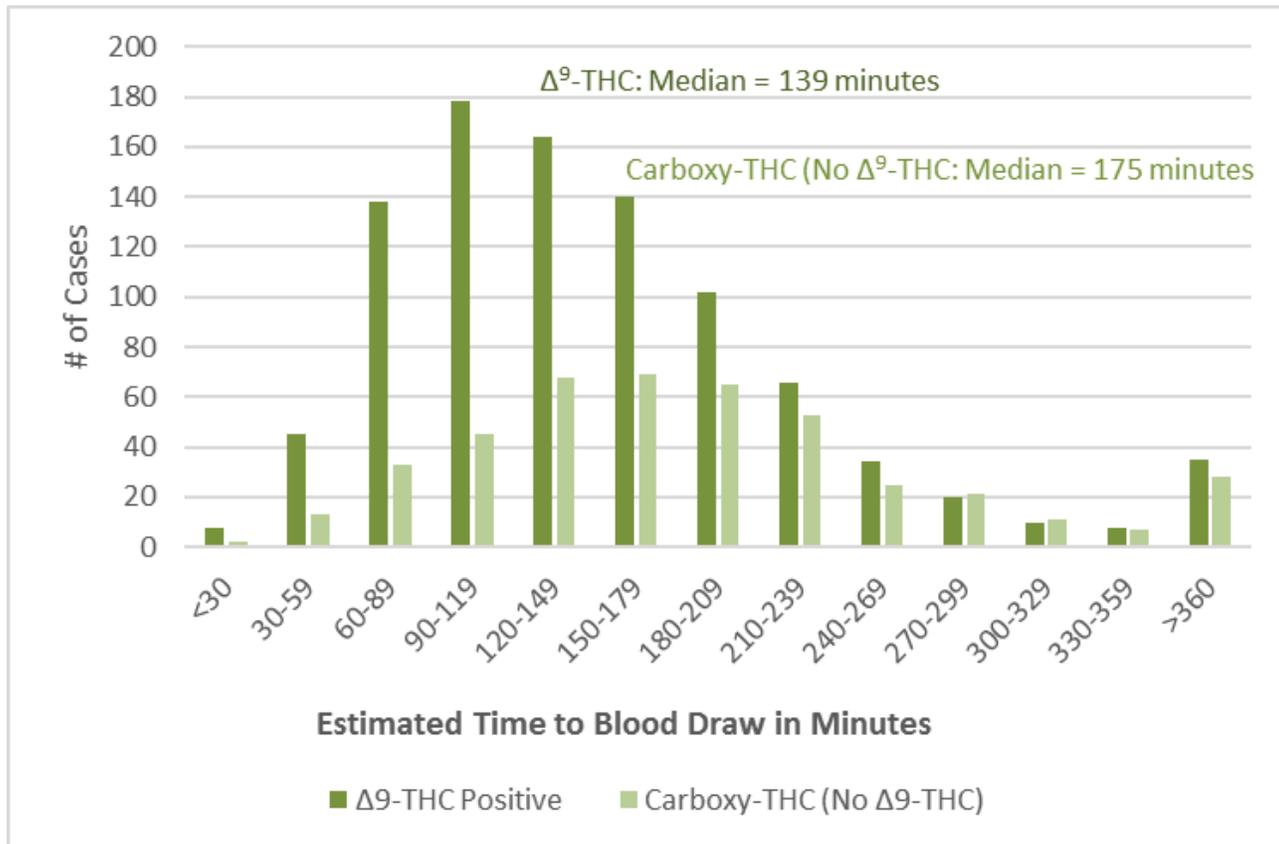
PBT = Portable/Preliminary Breath Test instrument for estimating blood alcohol concentration from a breath sample.

SFSTs = Standardized Field Sobriety Tests

Relationship btw estimated time to blood draw (ETBD) and Δ^9 -THC and carboxy-THC detection and levels

The number of cases positive for any Δ^9 -THC (with or without carboxy-THC or other substances) and those positive for carboxy-THC (no Δ^9 -THC), are displayed in the Figure 2 below for the period from April 2013 through December 2014. There are many more cases positive for Δ^9 -THC (n=948) than carboxy-THC (no Δ^9 -THC) (n=440). There is a significant difference in the median ETBD with Δ^9 -THC positive cases having a significantly shorter median time of 139 compared to 175 minutes for carboxy-THC, no Δ^9 -THC ($p < 0.001$).

Figure 2. Estimated Time to Blood Draw for Collisions and Suspected DUI



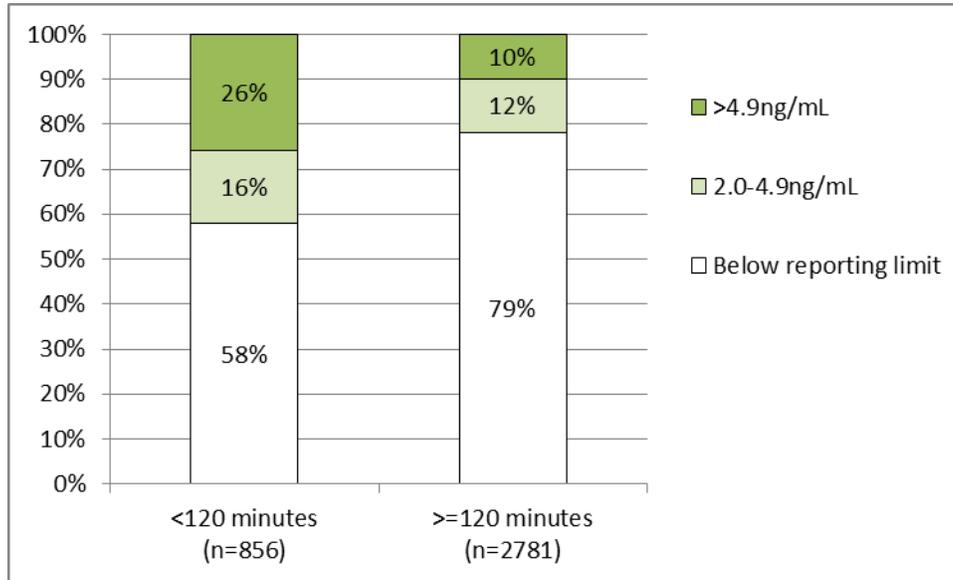
The median ETBD and statistical tests of differences are displayed in Table 1 below. The median ETBD for all other substances was 174 minutes, statistically no different than cases positive for carboxy-THC (no Δ^9 -THC), while the median for Δ^9 -THC positive cases was 139 minutes, much less than for other substances.

Table 1. Estimated time to blood draw for collisions and suspected DUI cases in Washington State, April 2013 – December 2014

	Cases	Median time in minutes	Time difference from carboxy-THC no Δ^9 -THC	p-value
Carboxy-THC (no Δ^9 -THC) ≥ 10 ng/mL	440	175	--	--
THC ≥ 2 ng/mL	948	139	36	<0.001
All other substances	2249	174	1	0.871
All cases	3637	165	10	...

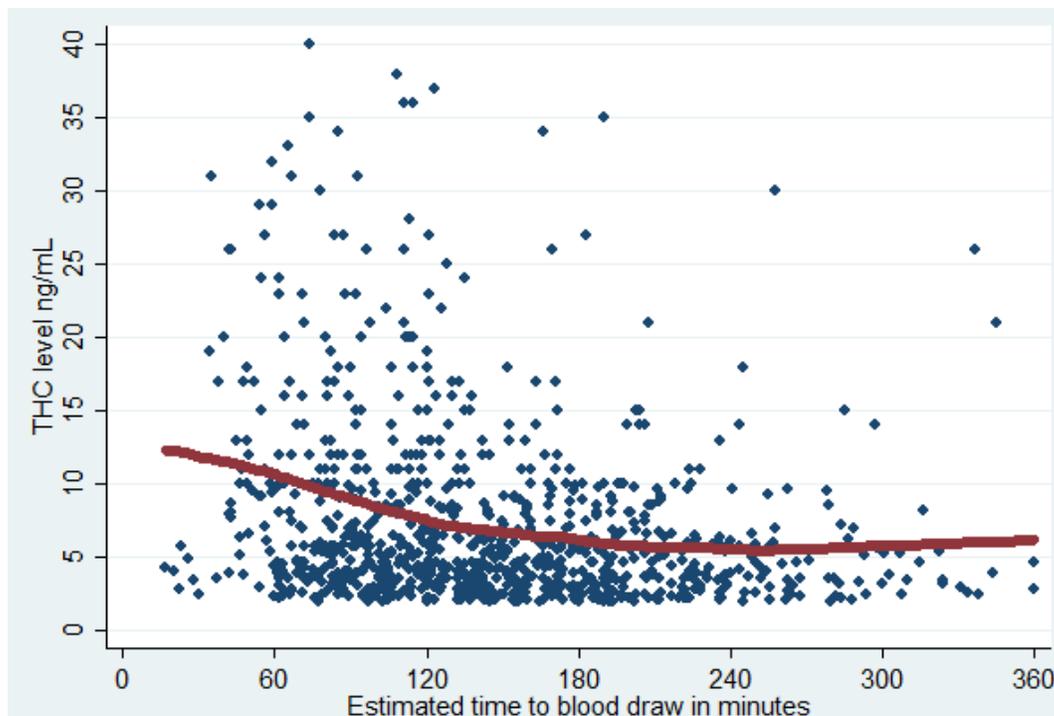
The proportion positive for Δ^9 -THC at a level $>4.9\text{ng/mL}$ is compared for ETBD less than and greater than two hours in Figure 3. The proportion of those with an ETBD of less than 2 hours who had a Δ^9 -THC blood level $\geq 5\text{ng/mL}$ was 26% compared to 10% for those with an ETBD of 2 hours or more ($p<0.001$).

Figure 3. Δ^9 -THC Level by Estimated Time of Blood Draw



Among drivers who had Δ^9 -THC present at a level of 2ng/mL or higher we examined the relationship between measured Δ^9 -THC level and ETBD. Figure 4 indicates that Δ^9 -THC levels are negatively associated with ETBD with a lower blood level of Δ^9 -THC on average the greater the ETBD, on average this would be expected at the population level because it is related to the phenomenon in humans that drugs are metabolized over time and blood levels therefore decline. The line displayed is a locally weighted regression line which fits the data better than a simple trend line which would assume that the relationship between the variables is constant over time. The changing slope of the line suggests that the relationship is different across time.

Figure 4. Δ^9 -THC level by Estimated Time to Blood Draw -- Scatter plot with locally weighted regression line



Regression analyses indicate that for every additional minute of time until blood draw the Δ^9 -THC level declines 0.0228 ng/mL on average (95% C.I. -0.0291 to -0.0164; p-value<0.0001). During the first two hours of ETBD, the regression coefficient can be interpreted as indicating that on average there is a decline in the Δ^9 -THC level detected of 5.328 ng/mL over 120 minutes.

We conducted stratified analyses to compare change in measured Δ^9 -THC blood levels in two periods: 0-2 hours ETBD, and 2-4 hours ETBD. For those with an ETBD less than 2 hours there was a significant negative association between ETBD and Δ^9 -THC level of -0.0444 (95% C.I. -0.0796 to -0.0165, p-value= 0.014). However, for those with an ETBD between 2-4 hours there was not a significant relationship between ETBD and Δ^9 -THC level -0.0077 (95% C.I. -0.0158 to 0.0004, p-value = 0.062).

For these analyses, cases with ETBD that were negative (n=4) or zero (n=5) were excluded. Scatterplots and regression analysis excluded cases with ETBD above 6 hours (4% of cases) and one case with an extremely high Δ^9 -THC level of 100.

Discussion of the importance of estimated time to blood draw

Analysis of the ETBD indicates that cases positive for Δ^9 -THC have a median ETBD that is 36 minutes shorter than for carboxy-THC (no Δ^9 -THC) present. These findings indicate the importance of time to blood draw and the fact that accounting for blood time would appear to be essential to properly conduct analyses of the presence of Δ^9 -THC in suspected DUI cases. Interpreting results across studies with different blood draw procedures and timing e.g. a roadside survey with a phlebotomist on site, should carefully account for ETBD.

Study Limitations

This study had a number of important limitations. First, because of the rapid metabolism of active Δ^9 -THC compounds and the challenges law enforcement officers face in timely obtainment of blood samples, an unknown proportion of carboxy-THC positive drivers at the time of the collision or traffic stop may have had quantifiable Δ^9 -THC levels well above 5ng/mL. Therefore estimates of Δ^9 -THC -impaired driving based upon blood toxicology results underestimate Δ^9 -THC levels at the time of first contact with police or the time of collision.

Second, multiple research studies indicate that regular users of cannabis become tolerant to some of the impairment associated with Δ^9 -THC ^{10,29}. At present there is no way to definitively identify whether a person is a regular, occasional or novice user from toxicological data alone. I-502 established a *per se* limit of 5ng/mL for Δ^9 -THC. Other states, such as Oregon, have chosen not to implement a *per se* level for cannabis focusing rather on evidence of impairment.

Third, the sample was limited to WSP cases for which the variables of interest were available and to cases that could successfully be linked. To the degree that these selected cases may not be representative of all DUI cases it may not be appropriate to generalize these to all WSP cases and is unlikely to be representative of local law enforcement cases given the different types of cases and locations with which they typically work.

CONCLUSION

The studies upon which the 5ng/mL blood level was selected as the *per se* level obtained blood soon after ingestion. Overall the average ETBD in this analysis was 165 minutes. Evaluating the impact of protracted time until blood testing is complicated by the lack of available standardized law enforcement data on the time of testing.

There remain significant and meaningful delays between the initial encounter with law enforcement and the collection of blood evidence. The median estimated time to blood draw for Δ^9 -THC positive cases was 139 minutes and the average decline in Δ^9 -THC levels was 5ng/mL during the first two hours following police contact. It is likely that the prolonged delay in blood testing routinely resulted in those who were above 5ng/mL at the time of a collision or driving violation being below this level at the time blood was drawn. These findings highlight the challenges in enforcing drugged driving laws, particularly with a *per se* component, in the absence of point-of-contact testing modalities and logistical delays in obtaining blood samples.

The results of the qualitative and quantitative analysis are of particular value in that the secondary data are real world data from the Washington State Patrol. Documenting the actual time of the blood draw in a standardized manner that can be readily obtained from secondary datasets would be tremendously beneficial for examining the impacts of laws, policies and practices as well as providing important data for epidemiological studies. The findings regarding the limitations of these data have implications for improving data systems to better understand the nature of impaired driving cases and collisions associated with cannabis and other substances.

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