Evaluation of an Increase in Roadside Drug Testing in Victoria Based on Models of the Crash Effects of Random and Targeted Roadside Tests

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This peer-reviewed paper was first submitted as an Extended Abstract and an Oral Presentation was recommended by two reviewers at the 2021 Australasian Road Safety Conference (ARSC2021) held in Melbourne, Australia 28-30 September 2021. The two Reviewers also recommended that the Extended Abstract be expanded into a 'Full Paper' and undergo further peer-review as a journal submission by three independent experts in the field. The Extended Abstract is published in the ARSC2021 Proceedings. This 'Full Paper' version is being reproduced here with the kind permission of the authors and will only be available in this edition of the JRS. Furthermore, the original methods of this paper were included in MUARC's submission to the Inquiry Into the Increase in Victoria's Road Toll during 2019, conducted by the Economy and Infrastructure Committee of the Parliament of Victoria. Updated results were presented to the Committee in oral evidence and a PowerPoint presentation. MUARC's submission and evidence were published on the Committee's website and are protected by parliamentary privilege. The investigation of hospital drug testing of seriously injured drivers was added in response to the reviewers' comments on a draft of this paper.

Key Findings

- The annual number of roadside drug tests in Victoria increased from 42,000 to 100,000.
- Reductions in the prevalence of tetrahydrocannabinol (THC) and methamphetamine in fatally and seriously injured drivers were found to be significantly related to increases in the numbers of random and targeted tests, and their offence detection rates.
- The increase in roadside drug tests is estimated to have saved 33 fatal crashes and at least 80 serious injury crashes per year. Road trauma benefits out-weighed costs by 9.4 to 1.
- Further increase in roadside drug testing in Victoria is warranted, based on economic criteria.

Abstract

Drug driving continues to be overrepresented in both fatal and serious injury crashes in Victoria. As an enforcement countermeasure, preliminary oral fluid tests to detect drug driving were introduced in Victoria, Australia in December 2004. Recent research has modelled the relationships between prevalences of THC and methamphetamine in fatally and seriously injured drivers and (a) the annual numbers of random and targeted drug tests during 2010-2016 and (b) the positive detection rates from these tests. The increase in roadside drug tests in Victoria from 42,000 in 2013 (1% of licensed drivers) to 100,000 per year (2.2% of drivers), particularly targeted tests, is estimated to have saved 33 fatal crashes (13.7% reduction) and at least 80 serious injury crashes (1.4% reduction) per year. Based on the findings from this research, further increases in targeted and random roadside drug tests are warranted, up to at least 390,100 total tests per year, which are estimated to save a further 46 fatal crashes and at least a further 134 serious injury crashes per year.

Keywords

roadside testing, drugs, cannabis, THC, methamphetamine

Received: 21/09/2020; **Final revised form received:** 19/12/2021; **Accepted:** 20/02/2022; **Available online:** 11/05/2022

Suggested citation: Suggested citation: Cameron, M., Newstead, S., Clark, B. and Thompson, L. (2022). "Evaluation of an Increase in Roadside Drug Testing in Victoria Based on Models of the Crash Effects of Random and Targeted Roadside Tests". *Journal of Road Safety*, 33(2), 17-32. https://doi.org/10.33492/JRS-D-20-00272

Introduction

Drug driving is a serious road safety issue with 41% of drivers/motorcycle riders killed in Victoria identified as having drugs (legal and illegal) in their system (TAC, 2018). To address this serious road safety issue, roadside drug testing was introduced in Victoria in December 2004. These Preliminary Oral Fluid Tests (POFTs) screen for the presence of three drugs (Tetrahydrocannabinol [THC], methamphetamine and MDMA) in saliva samples taken from drivers stopped at roadside testing sites operated by Victoria Police. Following the detection of a positive POFT drug result, drivers then undergo a subsequent Oral Fluid Test (OFT) specifically administered for formal evidence purposes.

In its introductory year (2004/05), Victoria Police allocated around eight thousand roadside drug tests, principally for operations in the city of Melbourne. Initially POFTs were predominantly administered at bus-based testing stations in conjunction with random alcohol breath testing. However, over its first decade the roadside drug testing program gradually increased to approximately 42,000 tests per year by 2013 and an increasing number of POFTs were carried out by Highway Patrols (HP) and the Heavy Vehicle Unit (HVU). These tests were more targeted with time and locations identified as drug driving events and hotspots Anderson et al., (2021) describe targeted roadside drug testing in Queensland; Victorian practice is similar). However, the majority of testing still occurred from bus-based operations within the Melbourne metropolitan area.

In recognition of its likely beneficial effects on road fatalities and serious injuries, in November 2014 the Transport Accident Commission (TAC) funded an expansion of the Roadside Drug Testing Program. This expansion aimed at increasing roadside drug testing in Victoria to 100,000 per year by 2017, through two mechanisms. First, through training more police members in conducting drug tests to support the increased roadside testing projections and second, a focus on training HP members to increase the roadside drug testing in rural areas not frequented by bus-based operations.

Understanding the impacts that these changes have on road trauma outcomes is important for optimising the benefits of drug testing, as well as for setting appropriate strategic targets aimed at meeting road trauma savings goals. Comprehensive evaluation of changes in drug enforcement in Victoria is critical to providing this understanding.

The aim of this paper is to evaluate the effects associated with the expansion of the Roadside Drug Testing Program and the increase in roadside drug tests on fatal and serious injury crashes. The study focused on the two most frequently detected roadside drug testing substances, THC and methamphetamine. MDMA is also a proscribed drug included in the roadside drug test.

Data

Investigations were undertaken in conjunction with Victorian Road Policing Command to identify and obtain the most suitable data sources to support the conduct of this evaluation. Due to existing data collection limitations, data were obtained from several sources and matched to provide the necessary variables to conduct this analysis.

Roadside Drug Testing data

Detailed operational data pertaining to roadside drug testing shifts for the years 2004 to 2018 were obtained from Victoria Police. These data included the following variables: shift date and time, Police Work Unit, number of drug driving POFTs conducted, number of Oral Fluid Tests (OFTs) conducted following a positive POFT, and Police Region in which the testing occurred.

Traffic Incident System data

The Victoria Police Traffic Incident System (TIS) data containing drug and alcohol test results, for persons involved in fatal and serious injury crashes reported to police, were extracted for the years 2006 to mid-2018.

Victorian Road Crash Information System data

The Road Crash Information System (RCIS) is an online database containing information from Victorian road crashes. The information contained is derived from crash data collected by Victoria Police from crashes resulting in at least one person being injured and recorded in TIS. These data is subsequently transferred to VicRoads and enhanced to become RCIS, the official database of road crash information within Victoria. The Transport Accident Commission (TAC) then matches information from lodged insurance claims to validate the severity of all injuries sustained by persons recorded in RCIS, particularly hospital admission. Data from the TAC enhanced RCIS data containing the injury severity variables were extracted for the years January 2000 to December 2016.

Victorian Coronial Data System

Data were extracted from the Victorian Coronial Data System to match the RCIS data (2006-2018). These data contained toxicology results that identified the presence of drugs and alcohol in fatally injured crash-involved drivers. Coronial blood samples were provided by the Victorian Institute of Forensic Medicine (VIFM).

Summary of Key Data

Planned and actual numbers of roadside drug tests

The target of increasing POFTs to 100,000 per year occurred in stages, dependent on resources such as increasing the number of police members trained to conduct the tests. Figure 1 depicts the planned increase in test allocation for each financial year, together with the actual number of POFTs conducted each year, 2004/05 to 2018/19.

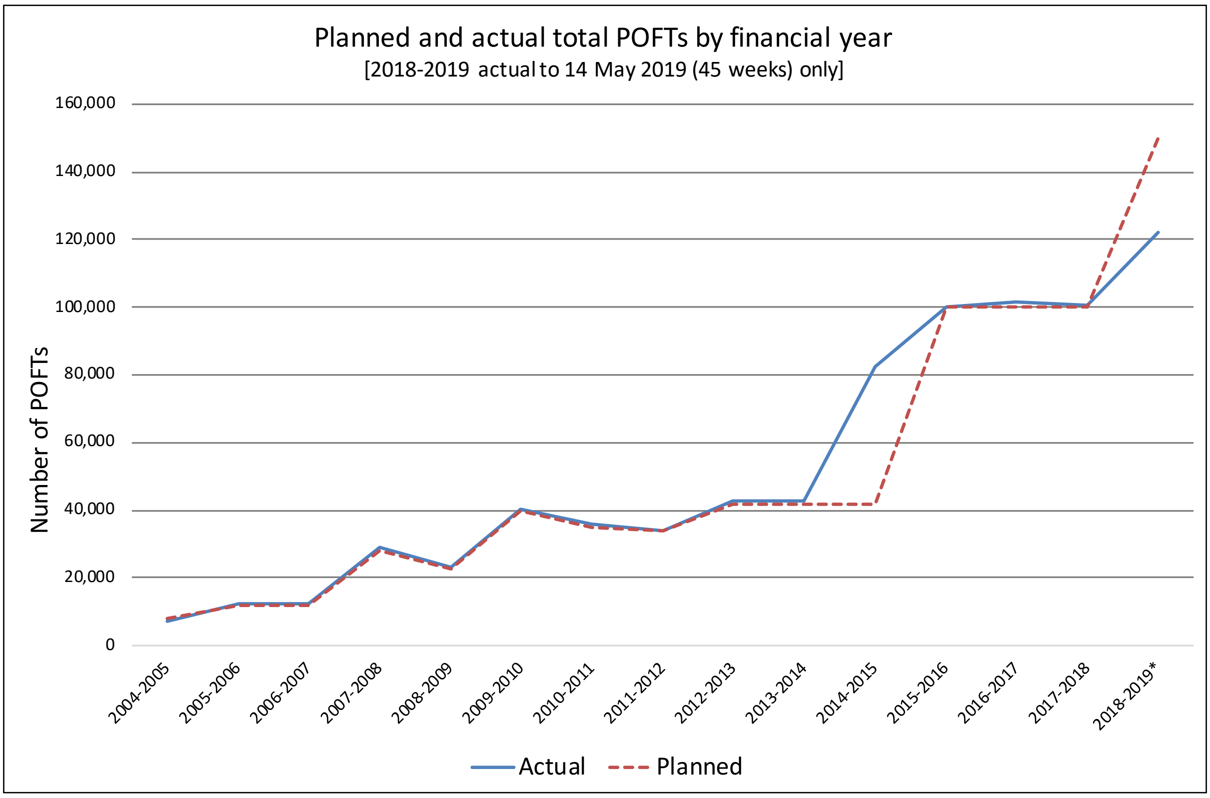
As shown, the actual number of roadside drug tests conducted closely followed the planned increases, from 2004/05 up until 2012/13. Similar to the 2012/13 target, there had been 42,000 tests allocated for each of the following two years (2013/14 and 2014/15). However, in 2014/15 the number of POFTs rose to 82,383, nearly doubling the number of tests undertaken during the previous two years. The planned expansion to 100,000 tests per annum (or greater) was achieved during each of the following three financial years (2015/16 to 2017/18).

Trends in preliminary oral fluid tests (POFTs) and detection rates

The numbers of POFTs conducted per year during 2004/05 to 2018/19 by operation unit, in the Melbourne metropolitan (Metro) and rural police divisions, are shown in Figure 2. The positive POFT detection rates are shown in Figure 3. From 2010/11, the detection rate from the HP/HVU targeted operations increased more rapidly than from RPDAS operations which were mainly random drug tests at bus-based stations. The increases in detection rates during 2010/11 to 2014/15 support the increase in the prevalence of methamphetamine use by drivers identified by DiRago et al (2019).

Trends in driver fatalities involving drugs

The role of drugs in fatally injured drivers was based on the Victorian Coronial Data System blood samples. Confirmation of the increased role of methamphetamine in drug driving is shown in Figure 4. The presence of methamphetamine in fatally injured drivers increased between 2006 and 2016 from a rate of 5% to over 18% respectively, while the presence of THC varied between 12% and 18% with an overall small upward trend.



Note: * part year (first 45 weeks of 2018-2019)

Figure 1. Planned total allocation of POFTs and actual numbers achieved, 2004/05 to 2018/19

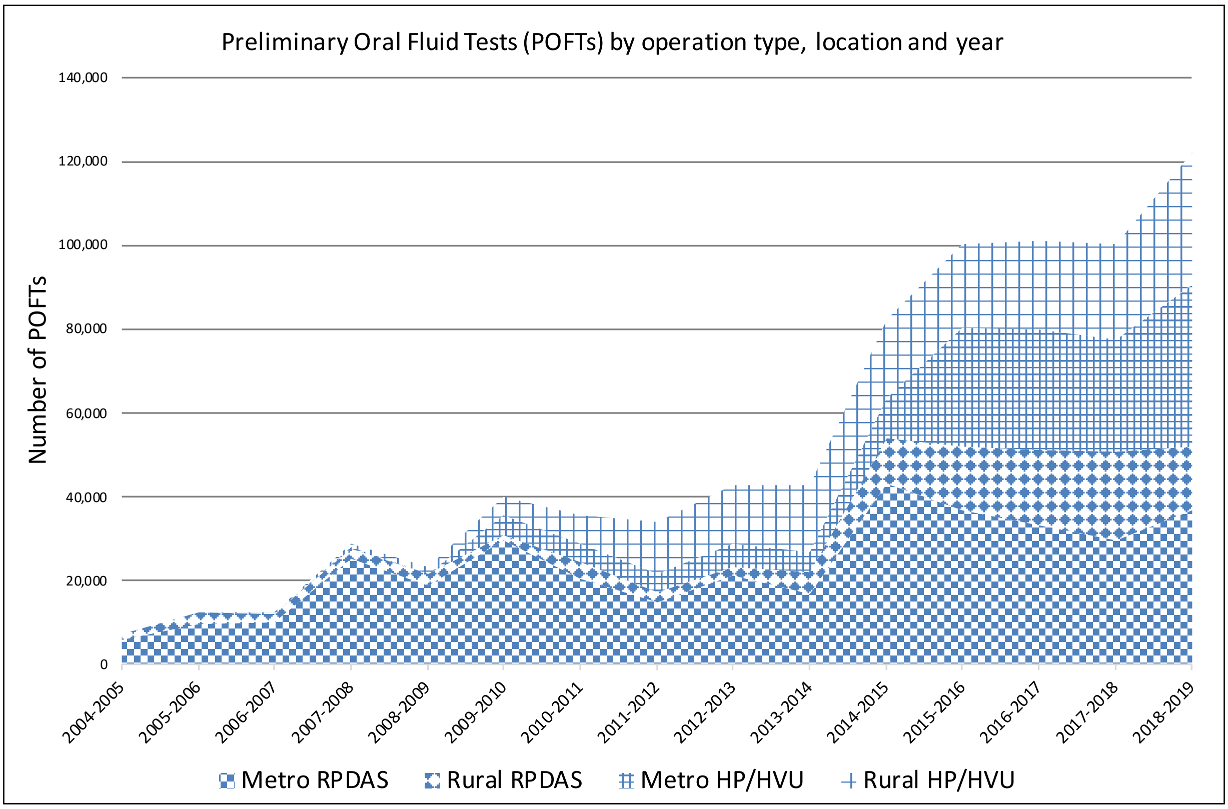


Figure 2. Roadside drug tests conducted by operation type, location and year, Victoria 2004/05 to 2018/19

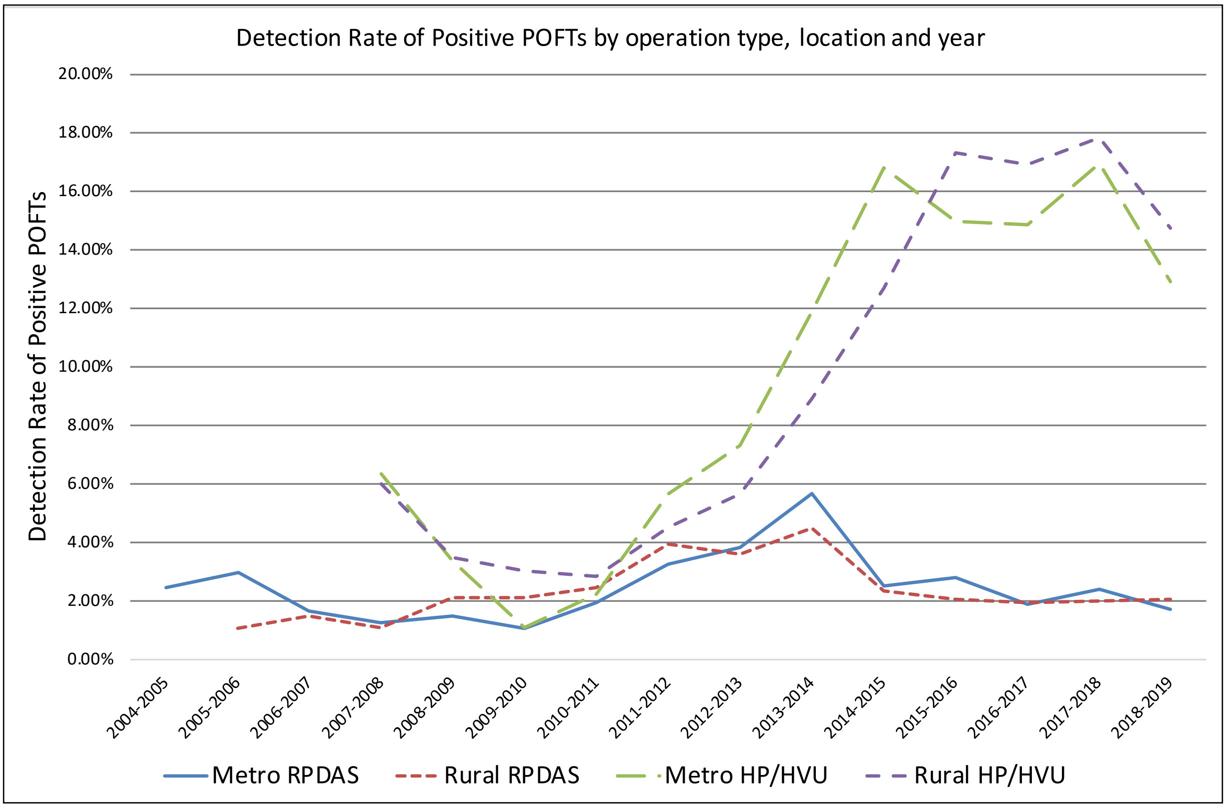


Figure 3. Positive roadside drug tests (detection rates) by operation type, location and year, Victoria 2004/05 to 2018/19

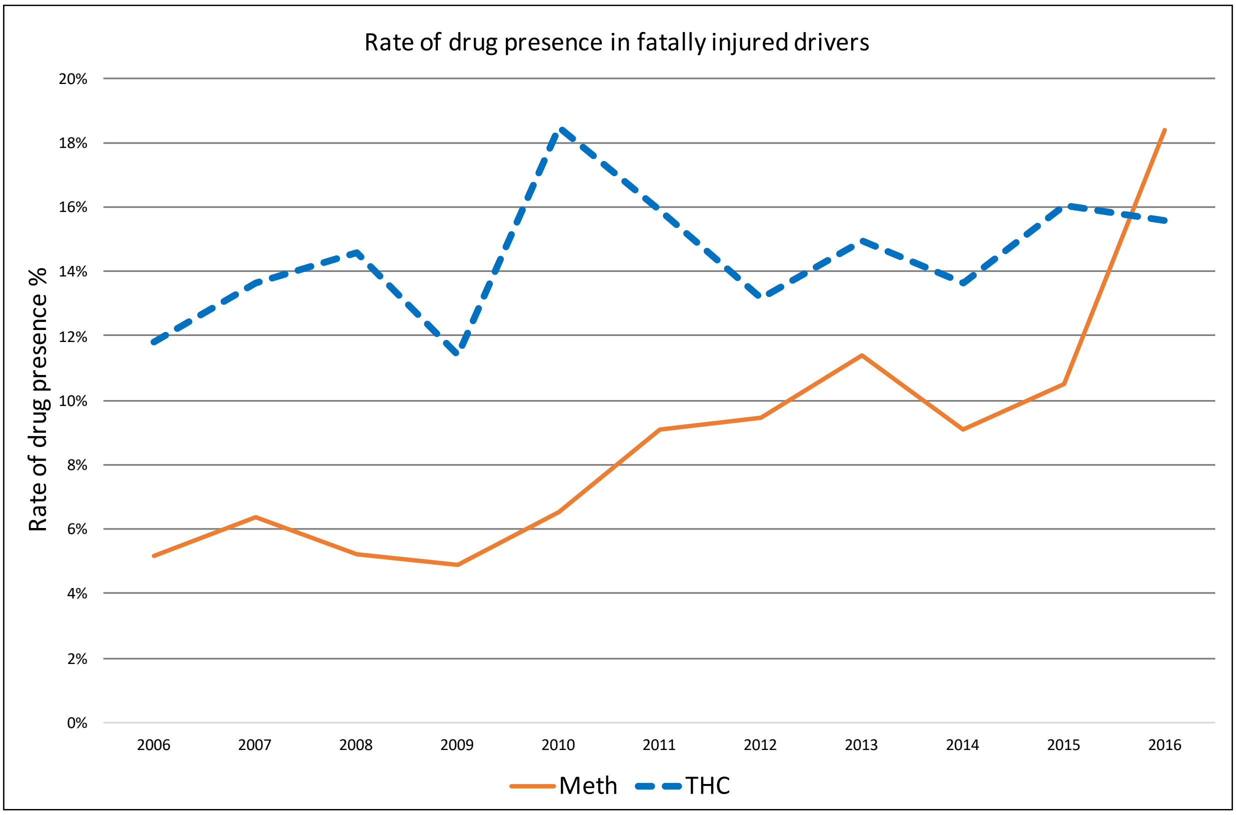


Figure 4. Rate (%) of THC and methamphetamine presence in fatally injured drivers in Victoria, 2006-2016

Data on driver serious injuries involving drugs

The involvement of drugs in seriously injured drivers was based on data from two merged Victoria Police files, one containing hospital obtained drug test results (TIS) and the other containing details of crashes (RCIS).

Traffic Incident System (TIS) file of drug test results for persons involved in crashes

In these data, one case corresponds to one alcohol or drug test result for one person involved in a crash (43,864 records). Vehicle drivers (including motorcyclists) detected with multiple drugs (including alcohol) in their system result in multiple data entries (39,496 records). For example, for one driver there were eight separate records, with each case corresponding to a different drug detected in that driver's system. The multiple-drug records were merged to form 35,170 unique records of drivers with one or more alcohol or drug test result.

Cases that did not contain any positive drug or alcohol test result were retained in the TIS data file, for the analysis reported in this paper, in order to examine the overall rates of drug testing. Initially in the study, it had been assumed that all seriously injured drivers admitted to hospital would have had a blood sample taken and been tested for alcohol or drugs (as per Victorian legislation).

TIS drug test results matched with persons recorded on Police crash reports

In the RCIS data, one case corresponded to one person involved in a crash (666,807 records), of whom 437,594 were identified to be drivers or motorcyclists (hereafter "drivers"), and retained in the final data set.

For subsequent analysis, the driver records in RCIS were merged with the TIS records of crash involved drivers with an alcohol or drug test result (positive or negative) during 2006 to mid-2018. In the absence of personal identifiers in either file, the cases were matched by Incident number, Incident date, Gender, and Age of the driver. This match resulted in the following data. There were 413,199 records of drivers in crashes during 2000 to 2016 recorded in RCIS, of which 199,322 drivers had no injury, and 3,327 who were fatally injured and likely died in hospital because in most cases their coronial blood test for drug presence was not included. No drug test results were available in TIS for 88,461 injured drivers recorded in RCIS from crashes during 2000 to 2005. There remained 122,089 drivers with serious injury (admitted to hospital) or minor injury from crashes during 2006 to 2016.

Table 1. Drug testing rates of seriously injured drivers (admitted to hospital) and percentage positive for THC and methamphetamine

Year	Tested for drugs	Total seriously injured drivers	Per-cent tested	THC pos-itive	Meth pos-itive	THC pos of tested drivers	Meth pos of tested drivers	THC pos of involved drivers	Meth pos of involved drivers
2006	32	4388	1%	8	3	25.0%	9.4%	0.2%	0.1%
2007	58	4820	1%	9	10	15.5%	17.2%	0.2%	0.2%
2008	50	4546	1%	3	12	6.0%	24.0%	0.1%	0.3%
2009	752	4504	17%	80	27	10.6%	3.6%	1.8%	0.6%
2010	1299	3967	33%	139	62	10.7%	4.8%	3.5%	1.6%
2011	1314	4208	31%	162	77	12.3%	5.9%	3.8%	1.8%
2012	1217	3894	31%	139	122	11.4%	10.0%	3.6%	3.1%
2013	1218	3955	31%	91	135	7.5%	11.1%	2.3%	3.4%
2014	1362	4238	32%	90	150	6.6%	11.0%	2.1%	3.5%
2015	1481	4243	35%	93	195	6.3%	13.2%	2.2%	4.6%
2016	1511	4460	34%	109	190	7.2%	12.6%	2.4%	4.3%
Total	10294	47223	22%	923	983	9.0%	9.5%	2.0%	2.1%

Methods

Modelling the relationships between roadside drug testing and drug involvement in fatally and seriously injured drivers, 2010-2016

Relationships were modelled between the probability of drug presence in fatally injured drivers and in all seriously injured drivers, separately, and (a) increased POFTs during 2010-2016 and (b) the positive drug detection rates from these tests (rate of OFTs per POFT). The analysis made use of the information in Figures 2 to 5 within each Police Region, thus allowing greater sensitivity to establish the relationships.

Two measures of drug enforcement were defined as independent (predictor) variables in the analysis model:

- total number of POFTs (representing the drug testing rate)
- total number of Oral Fluid Tests (OFTs) per 100 POFTs (representing the offence detection rate)

The total number of POFTs delivered per year and Police Region was used as a measure of input associated with *general deterrence* from the roadside drug testing. This methodology parallels research on the general deterrence associated with roadside alcohol testing, where the number of preliminary breath tests delivered has been found to correlate most strongly with crashes that are likely to involve illegal alcohol levels (Cameron, Newstead and Diamantopoulou, 2016).

The total number of OFTs per 100 POFTs, the offence detection rate, was used as a measure of input associated with *specific deterrence* from the drug testing program. This provides a measure of the proportion of drivers detected for drug use, subsequently prosecuted, and likely to be specifically deterred from re-offending. The proportion of OFTs per POFT conducted was used in preference to the number of OFTs as, together with POFTs, they represent two independent measures of enforcement effort; this also supported simpler interpretation of the analysis results.

Logistic regression analysis was used to model the association between the proportion of injured drivers (serious or fatal) detected with drugs in their system and (a) the number of POFTs and (b) the rate of OFTs per POFT. 'Year of crash' was also included in the model to control for possible changes in driver drug use prevalence (unrelated to enforcement) over time.

The form of the model was as follows:

$$logit(p_{yr}) = \alpha + \beta_y + \gamma \, POFT_{yr} + \delta \left(\frac{OFT}{POFT}\right)_{yr}$$

(Equation 1)

In the model:

p_{yr} is the proportion of injured (serious or fatal) drivers detected with the drug in year γ and region *r*

logit(p) = $\log_e$[p/(1-p)], i.e. natural logarithm of the odds ratio of p

$POFT_{yr}$ is the number of POFTs delivered in year γ and region r

$(\frac{OFT}{POFT})_{yr}$ is the rate of drug detection per POFT in year γ and region r

β_y is the categorical year effect parameter for year γ (2010, 2011, ..., 2016)

α, γ and δ are model parameters

The association between the rate of drug detection in injured (serious or fatal) drivers and annual POFTs delivered per region is measured by parameter γ in the model, with exponential of γ being the estimated change in odds of drug use in an injured (serious or fatal) crash involved driver per POFT delivered. Statistical significance of the association and confidence limit on the estimated odds can be calculated from the standard error of the parameter estimated in the model. Similarly, δ measures the association between injured (serious or fatal) drivers and annual average drug detection rate per region, with exponential of δ representing the change in odds of drug involvement in the injured (serious or fatal) driver per percentage-point increase in detection rate.

Traffic Enforcement Resource Allocation Model (TERAM)

TERAM was developed for Victoria Police to assist them with planning levels of enforcement of speeding, drink- and drug-driving, and unlicensed driving (Cameron et al 2016). The new relationships obtained from the analysis method outlined above (see Table 3 in the Results section) were then included in TERAM. They allowed the savings in fatal and serious injury crashes to be modelled as functions of increases in the total number of POFTs. The role of the targeted POFTs in the total has been included, including their effect on overall detection rates because of the much higher detection rate of the targeted (HP/HVU) operations compared with the mainly random (RPDAS) operations.

Results

Drug testing rates and drug prevalences in seriously injured drivers

The numbers of seriously injured drivers tested for drugs and found positive for THC and methamphetamine during 2006 to 2016 are shown in Table 1. These data allowed calculation of the drug testing rates for seriously injured drivers recorded on the official crash record. The prevalence of each drug in the tested drivers and also in all involved seriously injured drivers are shown.

The prevalence of THC and methamphetamine in seriously injured drivers was calculated based on the assumption that all drivers admitted to hospital had a blood sample taken which was tested for drugs. This estimated prevalence is given in the last two columns of Table 1. During 2006-2008 (and also 2009), the numbers of hospital tests for drugs was low, so the estimated prevalences during those years are probably under-estimated. New legislation in 2009 affected this situation.

Table 2. Drivers and motorcycle riders presenting at hospitals (estimated 80% of total) and persons admitted to hospital in Victoria during 2013 to 2018

Year	Hospital emergency presentations* (estimated 80%)	Estimated total emergency presentations	Hospital admissions**
2013	8101	10126	3937
2014	8257	10321	4295
2015	7934	9917	4746
2016	8052	10065	5412
2017	7168	8960	5782
2018	7650	9562	6241
Average per year	**7839**	**9799**	**4940**

Source: Victorian Injury Surveillance Unit, Monash University Accident Research Centre

* Victorian Emergency Minimum Dataset (VEMD)

** Victorian Admitted Episodes Database (VAED)

DiRago et al (2019) stated that "Victorian law requires a blood specimen to be taken from each driver admitted to a hospital (includes attendance at emergency units at hospitals) as a result of road traffic collision for analysis of the presence of alcohol and the three proscribed drugs. Blood samples were taken by a medical practitioner or registered nurse at each hospital ...". Drummer et al (2020) made a similar statement. This legislative requirement was introduced in mid-2009. The blood specimens are analysed by the Victorian Institute of Forensic Medicine (VIFM) for the presence of alcohol, THC, methamphetamine and MDMA.

However, while the legislation requires a hospitalised driver to provide a blood sample if requested, it is *not* legislatively mandated that a sample of a crashed driver's blood must be taken at hospital. Advice from Victoria Police officers responsible for the transfer of the blood samples from hospitals to VIFM during 2010 to 2016, indicated a number of reasons why a blood sample may not be taken:

- doctors or nurses deeming that a sample is not necessary/relevant, refusing to take the sample, or deeming it contrary to the care of the patient

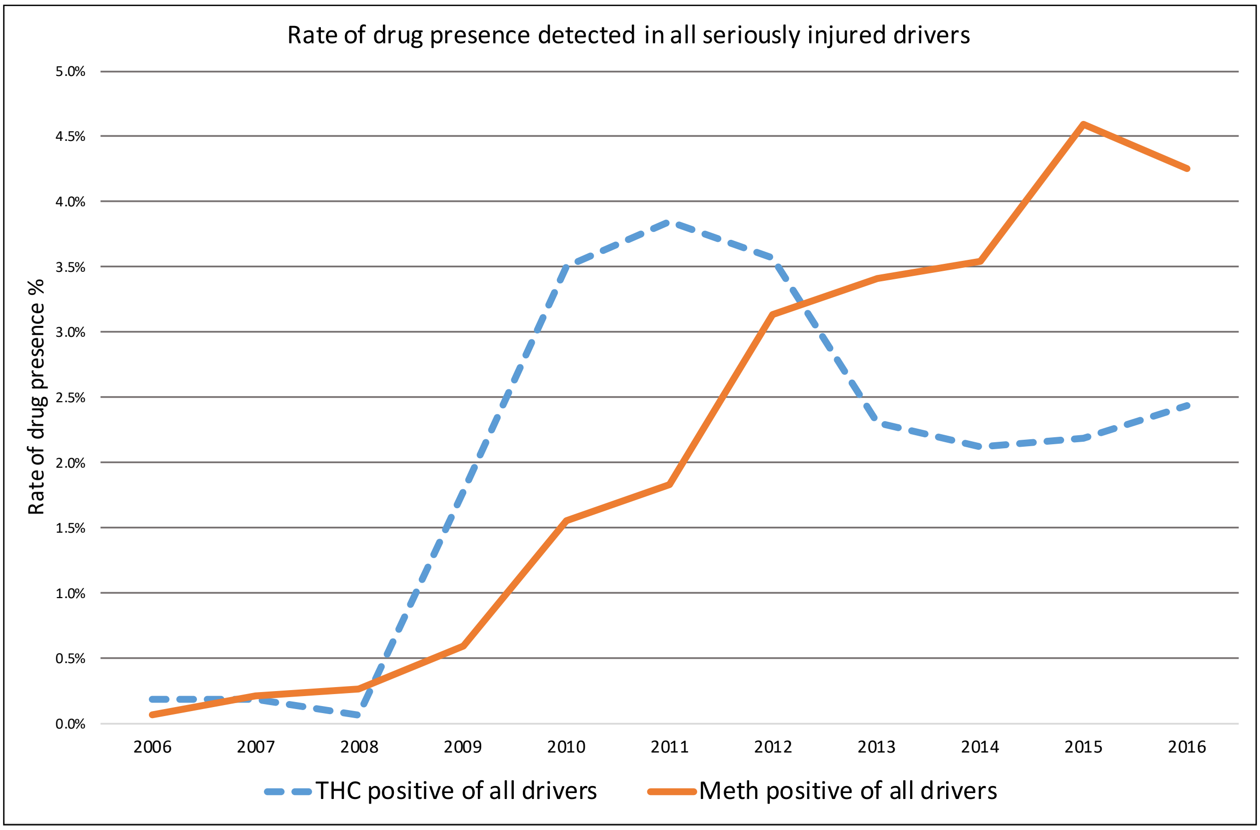


Figure 5. Rate (%) of THC and methamphetamine presence detected in seriously injured drivers, Victoria 2006-16

- the injured person hiding the fact that they were in a crash
- injured drivers transferred from one hospital to another, and neither hospital taking a sample
- air-lifted drivers not having a sample taken, due it being detrimental to their health
- the injured person refusing to have a sample taken on some occasions
- in 2010, early in the legislative requirement, Police telling hospital staff that a blood sample was not required because a Preliminary Breath Test (PBT) of the injured driver was negative.

Advice from VIFM indicated that all blood test samples received from hospitals via Victoria Police were tested for THC, methamphetamine and MDMA, and the result returned to Police for entry into the TIS record of each driver injured in crashes. Two authors of this paper have independently matched each TIS record with the RCIS record of drivers in crashes and found the two merged files to be in agreement.

Comparison with DiRago et al's sample

DiRago et al (2019) took a sample of 1,000 driver blood tests per year during the five fiscal years 2013/14 to 2017/18. These came from an average of 3,458 driver blood samples taken from around 9,800 hospital emergency presentations per year (see Table 2). RCIS data shows that on average 4138 drivers were admitted per year during 2010 to 2016 (see Table 1), so clearly not all of them could have a blood sample analysed by VIFM. It is likely that some of the samples analysed by VIFM also came from the non-admitted driver presentations.

A comparison can be made between the drug prevalence levels of drivers admitted to hospital, being tested and included in the merged RCIS/TIS data for 2010-2016 and that reported by DiRago et al (2019). DiRago's principal results were prevalences of THC and methamphetamine levels above the laboratory testing levels, namely 11.1% for THC above 1ng/mL and 12.8% for methamphetamine above 0.01mg/L. However, they also provided prevalences of tested drivers for drug levels above those prosecuted by Victoria Police, namely 7.3% for THC above 2.6ng/mL and 11.7% for methamphetamine above 0.026mg/L. It can be seen that there is reasonable agreement between DiRago et al's (2019) prevalences based on the higher thresholds and those for drivers admitted to hospital during 2010-2016, shown in Table 1. The comparison cannot be exact because DiRago's sample was taken from the set of hospitalised drivers during a five year period ending 18 months later.

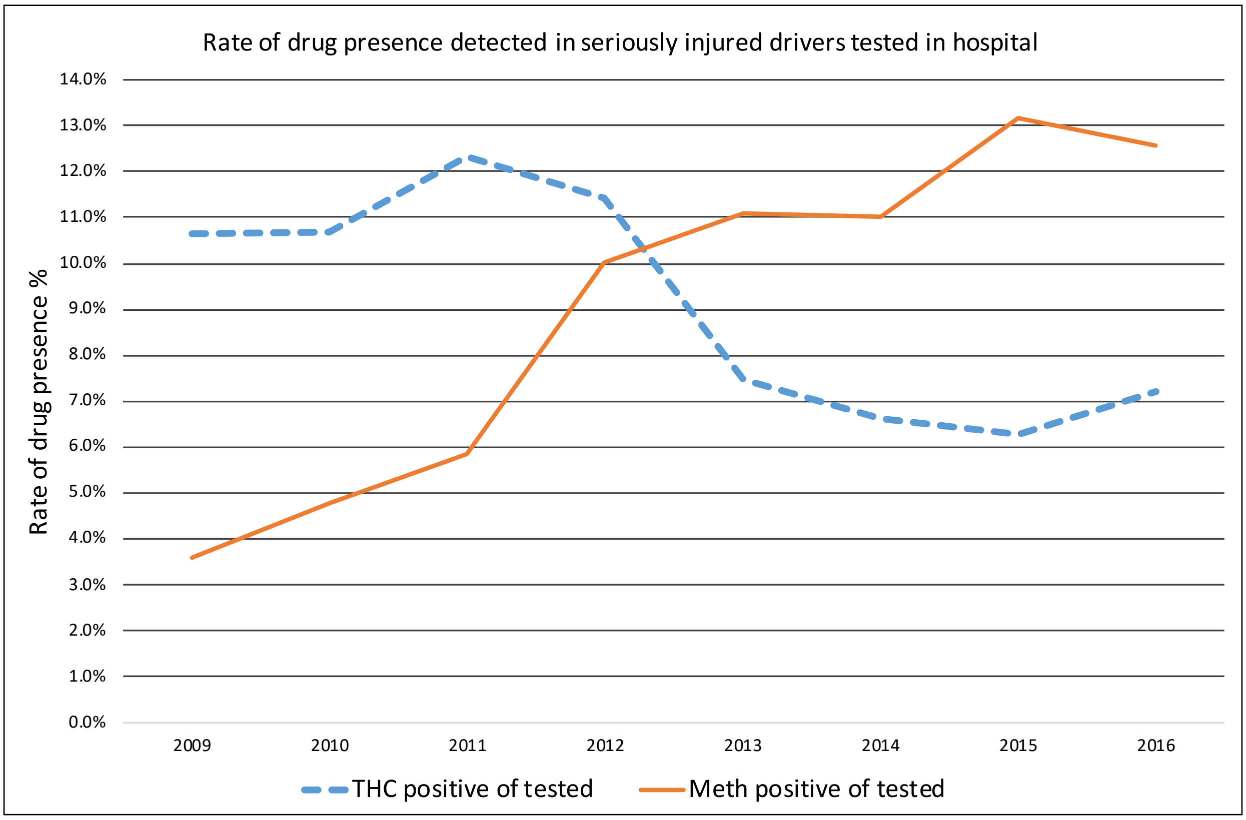


Figure 6. Rate (%) of THC and methamphetamine presence detected in seriously injured drivers who were tested in hospital, Victoria 2009-16

Drug prevalence in all seriously injured drivers

For the purpose of this analysis, the prevalences for seriously injured drivers shown in the last two columns of Table 1 were used. Only about one-third of seriously injured drivers were tested for drugs during 2010-2016 and hence the estimated prevalences of drugs in all seriously injured drivers are very conservative.

An alternative would have been to base the estimated prevalences of seriously injured drivers on those drivers who were tested for drugs. However, the test rate varied from 31% to 34% during the period (see Table 1). Other analysis showed that the test rate varied by Police Region, ranging from 21-25% in one Police Region to 37- 43% in another region. There were also substantial differences between Melbourne and the rest of Victoria. These differences in test rates may introduce biases in estimating the drug prevalences for all seriously injured drivers.

The drug prevalences based on the seriously injured drivers in Table 1 are shown in Figure 5. The presence of methamphetamine in seriously injured drivers increased consistently whereas, after an initial increase (2008 to 2011), the presence of THC decreased. However, the rates of THC and methamphetamine associated with seriously injured drivers are likely to be conservative indicators of the prevalence of these drugs in all drivers admitted to hospital in Victoria during 2010-2016.

Drug prevalence in seriously injured drivers who were tested in hospital

The trends in the drug prevalences, in the sub-set of seriously injured drivers who had a blood sample taken in hospital and tested by VIFM, are shown in Figure 6. Only the years 2009 to 2016 are shown because it was during this period that legislation required a hospitalised driver to provide a blood sample. The trend in prevalence for both THC and methamphetamine was very similar to the corresponding trend in Figure 5, except that the prevalences based on the tested drivers were about three times higher than those based on all seriously injured drivers.

Confirmation of the similarity of the corresponding trends is indicated by the Pearson correlation coefficient (R). This was 0.992 for the pair of THC prevalence trends and 0.990 for the pair of methamphetamine prevalence trends during 2010 to 2016, the years in which the drug test rates were approximately constant in the range 31- 35% (Table 1).

Table 3. Relative odds of THC and methamphetamine involvement in driver casualties related to POFTs and detection rates (statistically significant relative odds are shown in bold and with 95% confidence limits in brackets below)

Drug	Input variable	Statistical significance in fatally injured drivers	Relative Odds Per Unit Input Change	Reduction in fatalities per Unit Input (%)	Statistical significance in seriously injured drivers	Relative Odds Per Unit Input Change	Reduction in seriously injured per Unit Input (%)
THC	Number of POFTs (1000s)	**0.047**	**0.958** (0.919, 0.999)	**-4.18%** (-8.1%, -0.1%)	**<0.0005**	**0.962** (0.934, 0.980)	**-3.81%** (-5.6%, -2.0%)
THC	Detection rate (percent points)	*0.099*	*0.877*	-12.26%	0.818	1.008	NA
Meth	Number of POFTs (1000s)	*0.088*	*0.957*	-4.29%	0.474	1.007	NA
Meth	Detection rate (percent points)	**0.007**	**0.790** (0.666, 0.938)	**-20.99%** (-33.4%, -6.3%)	**0.021**	**0.934** (0.882, 0.990)	**-6.55%** (-11.8%, -1.0%)

Relationships between roadside drug testing and drug involvement in fatally and seriously injured drivers, 2010-2016

The modelling analysis found that:

- Relative odds of THC involvement in fatally injured and seriously injured drivers decreased with increased total POFTs (random and targeted)
- Relative odds of methamphetamine involvement in fatally injured and seriously injured drivers decreased with the increase in the positive detection rate of any of the proscribed drugs (THC, methamphetamine, MDMA) from the combined random and targeted POFTs.

The mathematical model (Equation 1) shown in the Methods section was fitted via logistic regression to the proportion of driver casualties found to have each specific drug in their system, to assess whether the number of POFTs and/or the detection rate was statistically significantly related to the proportion with the drug. The model was fitted to each of the following series across each Police Region during each year 2010 to 2016:

- Proportion of fatally injured drivers found to have THC in their system
- Proportion of fatally injured drivers found to have methamphetamine in their system
- Proportion of seriously injured drivers found to have THC in their system
- Proportion of seriously injured drivers found to have methamphetamine in their system.

The statistical significance, estimated relative odds, and the implied reduction in drug involvement per unit increase in enforcement level (POFTs or detection rate) are shown in Table 3 for each drug and driver injury severity. The relative odds of THC involvement in fatally injured drivers decreased by 4.18% (95% CI: 0.1% to 8.1%) per 1,000 annual POFTs in each Police Region. The relative odds of methamphetamine involvement in fatally injured drivers decreased by 20.99% (95% CI: 6.3% to 33.4%) per one percentage point increase in the percentage detection rate. Similar results for the involvement of THC and methamphetamine in seriously injured drivers can be seen in the right-hand side of Table 3.

Further details of the results of the modelling analysis are provided in Newstead et al (2020; Section 3.1.4). The results relevant to the new relationships added to TERAM are shown in Table 3. Only the statistically significant effects on the odds ratios were used in the additions to TERAM.

Effects of TAC-funded increased roadside drug testing

In late 2014, TAC funded an increase in roadside drug testing from the planned (and achieved) level of 42,000 POFTs per year (1% of licensed drivers) in 2012/13 and 2013/14 to 100,000 POFTs per year (2.2% of drivers). This new testing level was only partially achieved in 2014/15, but was fully achieved in each financial year 2015/16 to

Table 4. POFT increases associated with TAC funding during 2015/16 to 2017/18

Enforcement type	Base level 2012/13 & 2013/14 (*Tests* pa)	Base offence detection rate (% of POFTs)	Increase in level (%)	Increase (*Tests* pa)	Offence detection rate in the increased POFTs
RURAL					
Random POFT	*3,699*	4.23%	**384.1%**	*14,207*	1.41%
Targeted POFT	*14,708*	7.39%	**44.7%**	*6,581*	39.71%
Random + Targeted	*18,407*	**6.76%**	112.9%	***20,788***	13.53%
Increased total POFT				*39,194*	**10.35%**
METRO					
Random POFT	*18,953*	4.65%	**75.4%**	*14,286*	NA
Targeted POFT	*5,237*	9.52%	**435.9%**	*22,826*	16.98%
Random + Targeted	*24,190*	**5.70%**	153.4%	***37,112***	10.21%
Increased total POFT				*61,302*	**8.43%**
ALL VICTORIA					
Random POFT	*22,652*	4.58%	125.8%	*28,494*	0.40%
Targeted POFT	*19,945*	7.95%	147.4%	*29,406*	22.07%
Random + Targeted	*42,597*	**6.16%**	135.9%	*57,900*	11.40%
Increased total POFT				***100,496***	**9.18%**

2017/18. The assessment of the effects of the TAC funding was based on the estimated fatal and serious injury crash savings associated with the increased POFTs between the two base financial years (2012/13 and 2013/14), and the three financial years (2015/16 to 2017/18) when the more than a 100,000 POFTs per year were achieved.

The mainly random RPDAS operations were increased substantially in rural Victoria and the targeted HP/HVU operations were increased substantially in the Melbourne metro area (Table 4). Detection rates from RPDAS operations fell, as could be expected due to a general deterrence effect, and increased for the targeted operations. There was an increase in overall detection rates from the random and targeted operations combined, in part due to the greater growth in targeted operations compared with random.

Table 5 shows the results from the TERAM analysis based on the newly estimated relationships. The increase in the total number of POFTs (random or targeted) drives the savings in fatal and serious injury crashes, due to reductions in THC presence in fatally and seriously injured drivers. The increase in the detection rate from all testing operations (random or targeted) drives the savings in crashes, due to reductions in methamphetamine presence in the driver casualties.

TERAM estimated that more than 33 fatal crashes (13.7% reduction) and at least 80 serious injury crashes (1.4% reduction) were saved per year due to the increase in roadside drug testing from 2012/13 to 2017/18 associated with the TAC funding. The saving in serious injury crashes is a conservative estimate because the estimated prevalences of THC and methamphetamine in seriously injured drivers admitted to hospital are conservative, as outlined earlier in the Results section related to the investigation of hospital blood test rates.

The social cost savings, resulting from the savings in fatal and hospitalisation crashes, were valued based on the unit costs of crashes at each injury severity level, using the Human Capital Method (TIC, 2015). Each fatal crash was valued at $2.653 million and each serious injury crash was valued at $677,859. The cost of the additional POFTs and, where applicable, the secondary Oral Fluid Tests (OFTs) and laboratory processing, took into account the increased numbers of detected offences due to increases in targeted POFTs.

Table 5. Crash saving per year, cost savings, BCR and marginal BCR from POFT increases associated with TAC funding

Area	Fatal crashes saved per year	Serious injury crashes saved per year	Crash social cost saving per year ($m)	Total addit-ional cost ($m pa)	BCR (Increase benefits/ increase costs)	Marginal BCR
RURAL						
Crash savings due to reduction in odds of THC involvement	3.80	6.91				
Crash savings due to reduction in odds of Meth involvement	12.89	14.25				
Total rural crash saving	16.69	21.16	58.609	5.926	**9.89**	10.60
METRO						
Crash savings due to reduction in odds of THC involvement	6.12	29.62				
Crash savings due to reduction in odds of Meth involvement	10.50	28.82				
Total metro crash saving	16.62	58.45	83.702	9.194	**9.10**	13.33
ALL VICTORIA						
Crash savings due to reduction in odds of THC involvement	9.92	36.53				
Crash savings due to reduction in odds of Meth involvement	23.39	43.07				
Total Victoria crash saving	33.31	79.60	142.311	15.120	**9.41**	12.25

The benefit-cost ratio (BCR) is the ratio between the social cost savings and the costs associated with the increase in roadside drug tests from the annual base level to the increased annual level in 2015/16 to 2017/18. Note that it is <u>not</u> the BCR of the full roadside drug testing program at the level in 2015/16 to 2017/18; it is the BCR of the program expansion, i.e. the increase from 42,000 to 100,000 roadside tests per year.

The marginal BCR is the ratio of the benefits to costs, estimated for the next small (1%) additional increase, in each of the base levels of random and targeted POFTs, shown in Table 4. The estimates indicate that there would be additional social cost savings, well in excess of the additional costs, if the roadside drug testing program was increased beyond the annual level operated during 2015/16 to 2017/18.

Effects of further increases in roadside drug testing

The roadside drug testing program in Victoria has achieved substantial reductions in fatal and serious injury crashes, but could be expanded further. Further expansion is justified, not only by its potential savings in serious road trauma, but also because it would be a good economic investment up to a level where the social cost savings still exceed the costs at the margin. The extent of the additional investment depends on the method used to value the social cost savings from the reductions in fatal and serious injury crashes.

Social costs of crash savings valued by Human Capital Method

From the annual average base levels of POFTs in 2015/16 to 2017/18, a range of percentage increases in the random and targeted POFTs were considered until increases were found that produced a marginal BCR just below one (Tables 6 and 7). This maximum level was indicated if the random POFTs were increased by 190% and 175% in rural and metro Victoria, respectively, and the targeted POFTs were increased by 400% throughout the State. The total POFTs per year would increase by nearly 290% to 390,090. In the short term, the positive detection rate would increase from 9.2% to 11.2%, reflecting the greater percentage increase in the targeted operations.

Table 6. POFT increases to maximum level where marginal BCR falls below one

Enforcement type	Base level 2015/16 to 2017/18 *(Tests pa)*	Base offence detection rate (% of POFTs)	Increase in level (%)	Increase (*Tests* pa)	Offence detection rate in the increased POFTs
RURAL					
Random POFT	*17,906*	1.99%	**190.0%**	*34,021*	1.99%
Targeted POFT	*21,289*	17.38%	**400.0%**	*85,155*	17.38%
Random + Targeted	*39,194*	**10.35%**	304.1%	***119,175***	12.99%
Increased total POFT				*158,370*	**12.34%**
METRO					
Random POFT	*33,239*	2.39%	**175.0%**	*58,169*	2.39%
Targeted POFT	*28,063*	15.59%	**400.0%**	*112,251*	15.59%
Random + Targeted	*61,302*	**8.43%**	278.0%	***170,420***	11.08%
Increased total POFT				*231,722*	**10.38%**
ALL VICTORIA					
Random POFT	*51,145*	2.25%	180.3%	*92,190*	2.25%
Targeted POFT	*49,351*	16.36%	400.0%	*197,405*	16.36%
Random + Targeted	*100,496*	**9.18%**	288.2%	*289,595*	11.87%
Increased total POFT				***390,091***	**11.18%**

For the given percentage increases in random and targeted POFTs, TERAM estimated that 46 fatal crashes and at least 134 serious injury crashes would be saved per year (Table 7). The estimated saving in serious injury crashes is conservative, for reasons provided earlier.

Social costs of crash savings valued by Willingness-to-Pay Method

An analysis also considered the maximum level if the crashes were valued using the Willingness-to-Pay (WTP) method ($9.166 million per fatal crash and $611,718 per serious injury crash; TIC, 2015). In this case, the random POFTs could be increased by 265% and the targeted POFTs increased by 643%, to a total of 553,460 POFTs per year, an increase of 450% on the 2015/16 to 2017/18 level. TERAM estimated that this would save 53 fatal crashes and at least 157 serious injury crashes per year.

Impacts on other traffic enforcement programs

Estimates of road safety benefits calculated in this analysis assume that the expansion of the roadside drug testing program has no negative impacts on the delivery of other police enforcement programs, such as roadside alcohol testing, due to constraints on overall human resources. This assumption is particularly pertinent given the requirement for high levels of targeted enforcement, which historically have been delivered by the Highway Patrols or the Heavy Vehicle Unit of Victoria Police.

Discussion

Crash statistics in Victoria show that drug involvement in crashes remains a major road safety problem. Most recent data available for this study showed 18% of fatally injured drivers in Victorian road crashes tested positive for methamphetamine whilst 16% tested positive for THC. Combined, proscribed illicit drugs were present in over 25% of fatally injured drivers. When considering seriously injured drivers, in the most recent data, methamphetamine was present in at least 4.3% of drivers compared to 2.4% of drivers recording the presence of THC. Over the past decade, methamphetamine has rapidly become the most common proscribed drug in fatally and seriously injured drivers, overtaking THC which was more predominant in earlier years.

Illicit proscribed drugs and alcohol, both known risk factors for serious crashes, remain commonly present in fatally injured and seriously injured drivers in Victorian road crashes, with methamphetamine use becoming a particular problem. Consequently, enforcement of drug-driving has significant potential to reduce exposure of these risk factors amongst drivers and hence reduce the

Table 7. Crash saving per year, Human Capital cost savings, BCR and marginal BCR from maximum POFT increases

Area	Fatal crashes saved per year	Serious injury crashes saved per year	Crash cost saving per year ($m)	Total addit-ional cost ($m pa)	BCR (Increase benefits/ increase costs)	Marginal BCR
RURAL						
Crash savings due to reduction in odds of THC involvement	13.74	25.91				
Crash savings due to reduction in odds of Meth involvement	8.43	8.29				
Total rural crash saving	22.16	34.20	*81.976*	33.242	**2.47**	0.99
METRO						
Crash savings due to reduction in odds of THC involvement	15.69	79.21				
Crash savings due to reduction in odds of Meth involvement	8.15	21.13				
Total metro crash saving	23.84	100.34	*131.260*	43.891	**2.99**	0.99
ALL VICTORIA						
Crash savings due to reduction in odds of THC involvement	29.43	105.12				
Crash savings due to reduction in odds of Meth involvement	16.58	29.42				
Total Victoria crash saving	46.00	134.54	*213.236*	77.133	**2.76**	0.99

incidence of crashes where use of these substances is a contributing factor. Commencing in late 2014, the TAC invested in a program to increase roadside testing of proscribed illicit drugs in Victorian drivers. Investment covered two aspects, namely the training of additional Victoria Police members to conduct roadside drug testing as well as funding an increase in the number of tests to be delivered to 100,000 per annum.

Drug enforcement and crashes

Analysis indicates clear associations between roadside drug testing and the rate of THC and methamphetamine presence in drivers injured, both seriously and fatally, in road crashes in Victoria. An important finding has been that the presence of different drug types in crash-involved drivers has corresponded to different aspects of the roadside drug testing enforcement program. The analysis showed that increases in the number of roadside preliminary oral fluid tests (POFTs) was associated with reductions in THC presence in driver casualties. As such, similar to that known about roadside alcohol testing, it appears that in relation to roadside drug testing a general deterrence model applies to deterring THC use by drivers. The absence of any association between methamphetamine presence in fatally or seriously injured drivers and the number of POFTs suggests that the general deterrence model does not apply to methamphetamine. THC users are apparently more deterred by the perceived threat of detection (general deterrence) based on the number of roadside POFTs conducted.

The offence detection rate from roadside drug testing had a strong association with methamphetamine presence in both fatally and seriously injured drivers. This suggests that roadside drug testing based on a specific deterrence model is more appropriate for reducing methamphetamine use by drivers on the road and their subsequent crash involvement. Deterring methamphetamine use appears to be associated with actually apprehending many affected drivers and the formal processes that follow apprehension (specific deterrence).

These results suggest a two-pronged approach to drug enforcement is optimal. An element of extensive testing, likely random, is required to deter THC use amongst drivers; the more tests delivered the greater the deterrence. To deter methamphetamine, a component of the roadside drug testing program aimed at targeting the interception of drug affected drivers is also required, with the increase in detection rates then leading to reductions in crash involvement. The increased detection rates could be achieved through incorporation of intelligence-based enforcement strategies targeting the time, locations and demographics most likely associated with methamphetamine use.

Interpreting the relationship between drug testing and THC involvement in serious crashes shows that the expansion in roadside drug testing has been associated with 4.2% reduction driver fatalities and 3.8% reduction in seriously injured drivers, per 1000 POFTs in each Police Region. These reductions can be directly attributed to the expansion program which produced the increase in drug testing from 42,000 to 100,000 tests per annum. In contrast, the increase in drug-driving offence detection rates between 2013 and 2017 has reduced driver fatalities by 21% and seriously injured drivers by 6.6%, for each percentage-point increase in detection rate. A greater emphasis on targeted testing by Police was apparently the key factor behind this improvement. It is likely that the expansion of the program, and in particular the training of additional Highway Patrol Officers to undertake drug testing, has increased the capacity for more targeted testing.

Identification of the relationship between the drug offence detection rate and methamphetamine involvement in crashes is a new finding that was not identified in previous relationships used to inform previous iterations of TERAM. Previous relationships between roadside drug testing and the presence of drugs in crash-involved drivers were calibrated from data prior to 2010. In this period, THC was the predominant detected drug, perhaps explaining why the relationship with enforcement was identified in relation to the number of roadside tests delivered (as also identified in this study). With the prevalence of methamphetamine being low during that time period, the association between offence detection rate and methamphetamine presence in crashes would not have been identifiable. This highlights the importance of the current evaluation in identifying effective enforcement strategies for proscribed illicit drugs as the drug landscape changes. It also identifies the need to modify enforcement strategies according to the mix of proscribed illicit drugs present in the community at any point in time.

Limitations

Compared to past research on roadside drug testing, this evaluation was able to assemble a wider range of data for analysis. Past research had focussed on bus-based operations, but for the first time, this evaluation was also able to access drug test data for car-based operations. Due to limitations with location recording of car-based operations, analysis of drug testing at a geographic level lower than the Police Region, such as the Police Division or LGA, was generally not possible.

A limitation in the serious injury data was the apparent limited blood sampling for testing of seriously injured drivers for drug presence, as indicated by the low prevalence recorded and the step increase in 2010. To overcome this, the decision to only use data from 2010 in the analysis was taken. Notwithstanding this, only about one-third of seriously injured drivers admitted to hospital had a blood sample taken and tested for drugs during 2010-2016.

Conclusions

The increase in roadside drug tests in Victoria from 42,000 to 100,000 per year, particularly targeted tests, is estimated to have saved 33 fatal crashes and at least 80 serious injury crashes annually. Road trauma benefits out-weighed costs by 9.4 to 1. Further increases in targeted and random roadside drug tests are warranted on economic criteria, up to 390,100 total tests per year (estimated 8.3% of licensed drivers). In achieving this further increase in annual tests, it is estimated that 46 fatal crashes and at least 134 serious injury crashes would be saved annually.

Acknowledgments

This paper is based on data provided by Victoria Police and analysis reported in greater detail in Newstead, Cameron, Thompson and Clark (2020). The provision of data on total numbers of hospital emergency presentations and admissions during 2013-2018 by the Victorian Injury Surveillance Unit is acknowledged. Detailed advice provided by Victoria Police and the Victorian Institute of Forensic Medicine regarding the taking, transfer, and analysis of hospital blood samples in Victoria during 2010-2016 is also acknowledged.

Funding

This work was funded by the Transport Accident Commision, Victoria, Australia. This body had no role in the study design; in the collection, analysis and interpretation of data; in the writing of this paper; and in the decision to submit this paper for publication.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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