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Journal of Road Safety

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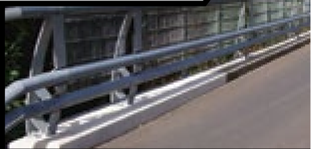

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5. Correct loading of vehicle and caravan to meet safety requirements
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Cover image

Subjectivity can play a role in road designs and audits. See the Perspective on Road Safety article: Harris, P. (2020). "Subjectivity in Road Safety and Traffic Engineering". *Journal of Road Safety*, 31(4), 62-64. Photo: Peter Harris, CPEng | NER | RPEQ | SRSA | BE (Civil) | BB (Admin)

The Journal of Road Safety (ISSN 2652-4252 (Online); ISSN 2652-4260 (Print); DOI:10.33492/JRS (formerly **The Journal of Australasian College of Road Safety (JACRS)**, ISSN 1832-9497, DOI:10.33492/JACRS between 2005 and 2019 and **RoadWise** between 1988 and 2004). Published quarterly (February, May, August, November) by the *Australasian College of Road Safety*.

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All papers submitted to the JRS undergo a peer-review process, unless the paper is submitted as a Contributed Article or *Correspondence (Letter to the Editor)*. Peer-review Papers and Contributed Articles can take the form of the following articles types: *Original Road Safety Research; Road Safety Data, Research & Evaluation Methods; Road Safety Policy & Practice; Road Safety Case Studies; Road Safety Evidence Review; Road Safety Best Practice Guidance; Road Safety Theory; Road Safety Media Review; Perspective on Road Safety*.

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ACRS office contact details
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Peer-reviewed papers

Original Road Safety Research

Risk Perceptions of Crash Related Traffic Rule Violations

Praveena Penmetsa[1], Srinivas S. Pulugurtha[2]

[1]*University of Alabama, Tuscaloosa, USA*
[2]*The University of North Carolina at Charlotte, Charlotte, USA*

Corresponding Author: Praveena Penmetsa, 248 Kirkbride Ln, 3014 Cyber Hall, Tuscaloosa, AL, 35487; ppenmetsa@ua.edu +1 (919) 666-7549

Key Findings

- Disregarding traffic signal was perceived the riskiest traffic rule violation;
- Exceeding speed limit by 10 to 20 mph is the least perceived violation in terms of risk;
- Except for two violations, female drivers' risk perception is greater than their counterparts.

Abstract

The objective of this paper is to evaluate drivers' risk perception toward crash related traffic rule violations and identify violations that are perceived as low risk to better educate drivers. Risk perceptions on crash related traffic rule violations was gathered from 3,593 participants as a part of Naturalistic Driving Study. The variations in risk perceptions by driver characteristics such as age, gender, education, and household income were studied. The risk perception of violating traffic rules was observed to increase with an increase in drivers' age, except for driving under the influence of alcohol and drugs. Drivers older than 25 years perceive disregarding traffic signals as the riskiest traffic rule violation. Exceeding speed limit by 10 to 20 mph is perceived as the least risky among the considered traffic rule violations, irrespective of age, gender, education, and income level of the driver. The risk perception of disregarding traffic signals and following vehicle closely are statistically the same for both male drivers and female drivers. For all other traffic rule violations, female drivers' risk perception is greater than male drivers' risk perception. Participants with lower education level perceive violating traffic rules as not risky, except for DUI. Graduates or professionals with no advanced degree perceive risk of violating traffic rules greater than the average risk for the entire sample population. Dissemination of risk perception information as well as enhanced educational programs are necessary to increase awareness about the risk associated with violating traffic rules that are perceived as low risk by drivers.

Keywords

Drivers, Risk, Perception, Traffic, Violation, Crash.

Introduction

Traffic fatalities are one of the leading cause of deaths in the United States (Heron, 2015). The behaviour of drivers is considered as one of the major reasons for the occurrence of these traffic fatalities (Sabey and Taylor, 1980). The deviant driving behaviour of humans can be either unforced errors or intended violations (Reason et al., 1990). The errors depend on the cognitive process of the individual, whereas violation "can only be described with regard to a social context in which behaviour is governed by operating procedures, codes of practice, rules, norms, and the like" (Reason et al., 1990).

There are several factors that affect the driving behaviour of a driver; cognitive processing, risk perception, driving skill, etc. are a few. While performing a maneuver, drivers' risk perception play a crucial role; higher the risk perception towards a maneuver, lower the likelihood of performing that maneuver. For example, if a driver perceives driving under the influence (DUI) as risky, he/she might not be willing to take the risk of DUI. Recently, Rhodes and Pivik (2011) studied the association between risk perceptions and risky driving behaviours. Their study identified that positive affect (liking for risky driving behaviours) and risk perceptions are independent predictors of risky driving behaviour. Carter et al. (2014) found that risk perception, among other factors including parents' distracted driving behavior, was predictive of adult's distracted driving behaviour. Harbeck and Glendon (2013) and Yao and Wu (2012) further emphasized the role of risk perception on risky behaviors.

A few researchers in the past concentrated on analyzing the differences in risk perceptions in association with socio-demographic and cultural factors. Sivak et al. (1989) carried out a study to assess cross-cultural differences on drivers' risk perception. Spanish drivers reported the highest risk, while United States drivers reported the lowest risk. Further, younger drivers reported lower risk than middle-aged and older drivers. Young drivers basically underestimate the probability of specific risks caused by the traffic situations (Brown and Groeger, 1988). The risk perceptions of novice drivers are relatively lower in specific driving situations compared to other groups of drivers (Milech et al., 1989; Deery, 1999; Glik et al., 1999). Moyano-Diaz (1997) examined the differences in behaviour between male and female drivers, and young and adult drivers. The participants judged a few traffic rule violations as serious, which are the first four major causes of crashes in Chile, while they perceived other traffic rule violations as less serious. Yagil (1998) surveyed students to observe age and gender related differences toward compliance with traffic rules. Female drivers were observed to be more willing to follow traffic rules compared to male drivers. Hallett et al. (2012) evaluated the risk perception of drivers and observed that young drivers are more likely to engage in text messaging while driving. In a study by Machado-Leon et al. (2016), socio-economic variables were found to have a significant influence in perceptions of risky driving behaviours.

While performing a maneuver, drivers do take decisions depending on how they perceive the risk of that maneuver. Numerous studies have been carried out on how the risk perceptions vary by gender, age and other demographic factors. Penmetsa and Pulugurtha (2017a, 2017b) examined the risk factors associated with violating traffic rules to educate drivers and increase the compliance of drivers towards traffic rule violations. However, to the best of the authors knowledge, traffic rule violations were not compared with each other based on drivers' risk perception to identify traffic rule violations that are perceived to be of low risk or high risk. Hence, the objective of this research is to compare crash related traffic rule violations by drivers' risk perceptions. Since demographic factors were known to influence the risk perceptions, the authors considered them in the analysis while making comparisons. Identifying traffic rule violations that are perceived as low risk will help in better educating drivers about the higher risk associated with these traffic rule violations.

Data

As a part of the Naturalistic Driving Study (NDS) under Strategic Highway Research Program (SHRP) 2, data such as driving behaviour, characteristics of the driver (age group and gender), risk perceptions, etc. were gathered from drivers who voluntarily participated in the study. The information pertaining to participant (driver) characteristics and their risk perception toward violating traffic rules were requested and obtained. The readers are encouraged to refer to "The SHRP2 Naturalistic Driving Study" to understand further on data collection and sampling methods (Campbell, 2012).

The data received from Virginia Tech Transportation Institute (VTTI, 2016) consisted of 3,593 rows, each row indicating the response of a participant. The NDS was carried out in six states in the United States; Washington, Pennsylvania, North Carolina, New York, Florida, and Indiana. The participants who possess a vehicle (passenger car, pickup truck, SUV/crossover, and/or van/minivan) were only encouraged to participate in the study through incentives and advertisements.

The characteristics of the participant collected in the survey are gender, age group, ethnicity, birth country, education, marital status, household, type of house living, work status, household income level, miles driven last year, and the age at which they procured their license. Table 1 shows the descriptive statistics of the data with respect to participant demographics.

Thirty-two questions were asked to assess the risk perception of each participant (VTTI, 2016). Two sample questions from the survey are listed next.

- The participant's associated risk with driving under normal speed during bad driving conditions such as road construction, rain, snow or ice.
- The participant's associated risk with driving shortly after drinking alcohol or using recreational drugs.

In all the risk perception questions, the participants were given 7 options to choose from and assess the risk of the activity and/or the potential to get involved in a crash; 1 indicating no greater risk, 4 indicating moderately greater risk, and 7 indicating much greater risk.

As mentioned earlier, participants provided risk response for 32 different questions. Not all 32 questions are related to traffic rule violations. For example, one of the survey questions is related to "the participant's associated risk with driving to reduce tension". In addition to studying individual traffic rule violations' risk perceptions, examining the overall risk perception of drivers towards various driving situations is important. Therefore, the overall risk perception was estimated by averaging all the 32 responses.

Table 1. Descriptive Statistics of Participants Demographic Characteristics

Variables	Categories	Frequency
Age group	16-19	550
	20-24	748
	25-29	284
	30-34	172
	35-39	138
	40-44	125
	45-49	154
	50-54	174
	55-59	149
	60-64	157
	65-69	216
	70-74	176
	75-79	269
	80-84	157
	>85	70
	Unknown	54
Education	Advanced degree	611
	Some graduate or professional school, but no advanced degree	370
	College degree	956
	Some education beyond high school	1,025
	High school diploma	328
	Some high school	283
	Unknown	20
Household Income	<29000	597
	30,000-40,000	410
	40,000-50,000	337
	50,000-70,000	595
	70,000-100,000	638
	100,000-150,000	529
	>150,000	258
	Unknown	229
Gender	Male	1712
	Female	1,878

To reduce the number of traffic rule violations to be studied, the most severe and frequent traffic rule violations were identified so only those can be selected for this research. Hence, the North Carolina crash data from 2012 to 2013 was gathered, processed, and evaluated. Each row in the North Carolina crash database indicates the characteristics of the vehicle involved in the crash and their corresponding contributing factor along with additional information such as time, day, month and year of the crash, crash location, weather condition, pavement condition, and occupant details. A total of 549,023 vehicles were involved in crashes during those two years.

A driver can be convicted of multiple traffic violations, but such occurrences are very rare (do not even contribute to 1% of the total vehicle crashes). Therefore, only the

Table 2. Traffic Violations % Contribution to Total Fatalities and Total Vehicles Involved in Crashes in North Carolina

Traffic Violations	% to Total Fatalities	% to Total Vehicles Involved in Crashes
No Contributing Factor	18.67%	49.20%
Alcohol Use*	13.79%	1.32%
Crossed Center Line/Going Wrong Way	11.74%	1.26%
Exceeded Authorized Speed Limit*	11.17%	0.49%
Operated Vehicle in Erratic, Reckless, Careless, Negligent or Aggressive Manner*	8.13%	1.54%
Exceeded Safe Speed for Conditions*	6.22%	3.48%
Failed to Yield Right of Way*	4.95%	7.07%
Overcorrected/Oversteered	4.74%	1.44%
Disregarded Stop Sign	2.76%	0.55%
Inattention	2.76%	6.26%
Failure to Reduce Speed	2.48%	13.79%
Disregarded Traffic Signals*	1.20%	1.30%
Operated Defective Equipment	1.13%	0.54%
Drug Use*	0.21%	0.18%
Followed Too Closely*	0.07%	0.86%

Note: * indicates variables that are considered in this research.

primary contributing factor of the driver responsible for the crash was considered. Table 2 shows the percentage contribution of different traffic violations to fatalities and to total vehicles involved in crashes.

The contributing factors mentioned in Table 2 were found to be the most frequent and severe in the considered crash data. They are listed by the percent of total fatalities. Out of the total vehicles involved in the crashes, 50% have committed some kind of traffic rule violation, but they contributed towards 81% of the total fatalities. The risk perception related to disregarding stop sign, failure to reduce speed, going wrong way, overcorrected/oversteered, inattention, and operating defective equipment are not available in the data provided by SHRP 2. Therefore, these six traffic rule violations were not further analyzed even though they lead to a considerable number of crashes and fatalities. The remaining eight traffic rule violations were found to be frequent and severe at the same time, has risk perceptions data in SHRP 2 data, and, hence, were considered for analysis in this research. Exceeding authorized speed limit was divided into two categories; exceeding speed limit by greater than 20 mph and exceeding speed limit by 10 mph to 20 mph. Driving under the influence of alcohol and drugs was combined into one question for assessing the risk perception using SHRP 2 data.

Methodology

To study the gendered differences in risk perceptions by traffic rule violation, the authors used simple t-test. This test helped study the significant difference between the means (risk perception) of two groups (male and female). While the t-test helps evaluate the difference between two groups, ANOVA is useful when there are more than two groups. Since, the education level variable in this study has 6 levels, ANOVA was used to analyze the statistically significant differences in risk perceptions among people from different education levels. Further, contrasts were estimated to make pairwise comparisons among the many education levels. SAS software was used to estimate the contrasts.

Results

The risk perception varies by age, gender, education, and income. Ignoring these participant characteristics while comparing traffic rule violations by risk perception will mask the variations. Hence, traffic rule violations are compared along with these participant characteristics.

Risk Perceptions by Age

Figure 1 compares different traffic rule violations by age and risk perception; the mean of the age group was plotted on the x-axis. For each participant, an overall risk perception was computed by simply averaging the response for all 32 questions. This is called as the average risk perception towards risky driving behaviors in this research. For each age group, the average risk perception was computed by estimating the mean of the responses.

The risk perception toward following vehicle closely, failing to yield the right-of-way, exceeding speed limit by greater than 20 mph, DUI, and disregarding traffic signals are above the average risk perception for almost all the age groups. Exceeding speed limit by 10 to 20 mph, operating vehicle aggressively, and exceeding safe speed limit for conditions related risk perceptions are less than the average risk perception.

Among all the considered traffic rule violations, exceeding speed limit by 10 to 20 mph has the least risk perception for all the age groups. Participants with age less than 25 years perceived DUI to be more risky than disregarding traffic signals; vice versa, for participants greater than 25 years. For all traffic rule violations, the trend can be clearly seen between the risk perception and age, except for DUI.

Equation 1 shows the linear best fit for DUI. The slope is almost equal to zero, implying that the risk perception for DUI does not change with an increase in the age. Each age group perceived DUI risk in almost a similar manner.

$$Risk\ Perception_{DUI} = 0.0004 * Age + 6.13 \quad (1)$$

Participants greater than 40 years of age perceived disregarding traffic signals as the riskiest traffic rule violation (Figure 1). Participants with age greater than 70 years perceived lower risk towards disregarding traffic signals than participants between 40 to 70 years.

Participants with age less than 50 years perceived DUI to be more risky than exceeding speed limit by 20 mph; vice versa, for participants with age greater than 50 years. Participants greater than 40 years perceived DUI and exceeding speed limit by 20 mph almost similarly; with very less difference than participants with age less than 40 years. The average risk perception for exceeding speed limit by 10 to 20 mph and DUI is 4.5 and 6.2, respectively for participants less than 35 years. Participants perceived exceeding speed limit by 20 mph as 25% times (from Table 2, 6.14/4.88) more risky than exceeding speed limit by 10 to 20 mph. Exceeding safe speed limit for conditions is the second least traffic rule violation in terms of perceived risk. The slope for exceeding speed limit between 10 to 20

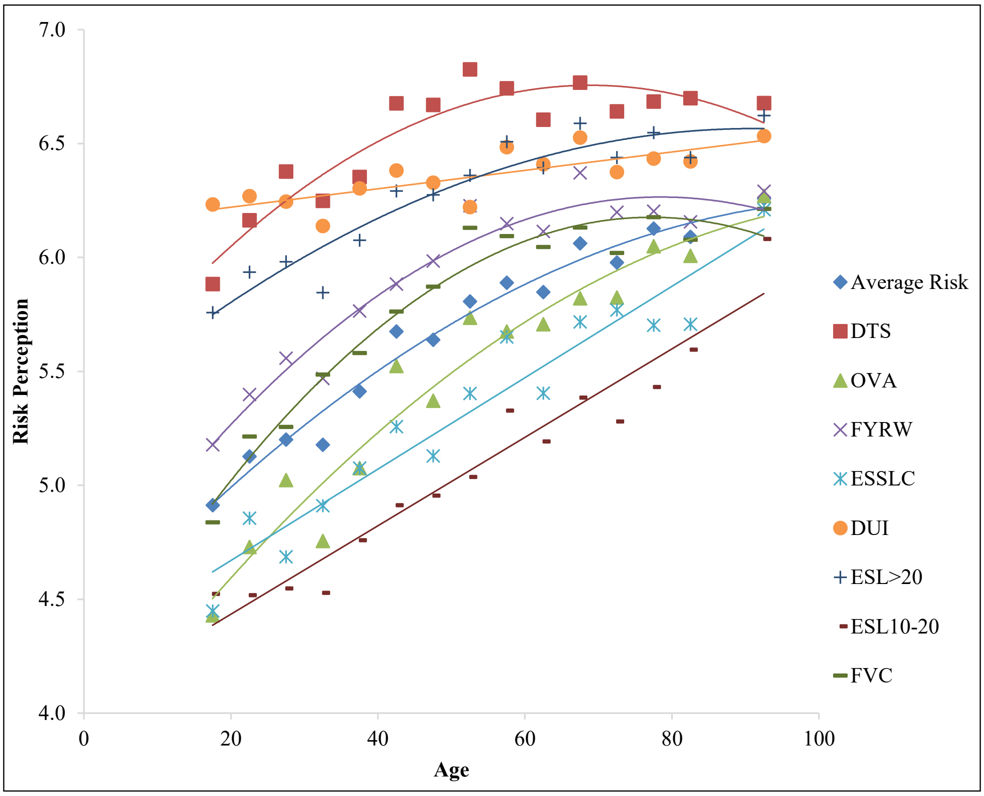

Figure 1. Relationship between Traffic Violations and Age

Note: Disregarding traffic signals - DTS; Operating vehicle aggressively - OVA; Failing to yield the right-of-way - FYRW; Exceeding safe speed limit for conditions - ESSLC; Driving under the influence of alcohol and drugs - DUI; Exceeding speed limit by greater than 20 mph - ESL>20; Exceeding speed limit by 10 to 20 mph – ESL10-20; Following vehicle closely - FVC.

Table 3. Average Risk Perception for Different Traffic Violations

Traffic Violation	Average Risk Perception			t-test p-value
	All	Male	Female	
Disregarding Traffic Signals	6.39	6.38	6.40	0.63
Driving under the Influence of Alcohol or Drugs	6.32	6.19	6.44	<0.01*
Exceeding Speed Limit by 20 mph	6.14	6.02	6.25	<0.01*
Failing to Yield the Right-of-Way	5.73	5.67	5.79	0.02*
Following Vehicle Closely	5.56	5.54	5.57	0.65
Operating Vehicle Aggressively	5.20	5.08	5.31	<0.01*
Exceeding Safe Speed Limit for Conditions	5.10	4.90	5.29	<0.01*
Exceeding Speed Limit by 10 to 20 mph	4.88	4.70	5.04	<0.01*
Average Risk Perception	5.48	5.37	5.58	<0.01*

Note: * Difference is statistically significant at a 95% confidence level.

mph and exceeding safe speed limit for conditions is 0.02, implying that the increase in risk perception with age is same for both these traffic rule violations.

For participants with age less than 19 years, the average risk perception of operating vehicle aggressively is lower than exceeding speed limit by 10 to 20 mph. For other age groups, risk due to operating vehicle aggressively is greater than exceeding speed limit by 10 to 20 mph. Following vehicle closely trend-line is slightly above the average risk perception. Participants less than 20 years perceived following vehicle closely slightly less than the average risk perception. As the age increased, the difference between the average risk perception and following vehicle closely increased up to a certain limit and then the difference decreased. Following vehicle closely is almost equal to the average risk perception for participants greater than 85 years. Failing to yield the right-of-way is perceived to be slightly of greater risk than the average risk perception. Polynomial curve best fitted failing to yield the right-of-way, and as age increased the risk perception toward failing to yield the right-of-way also increased.

For young participants, the risk perception ranged from a minimum of 4.43 to a maximum of 6.23. Participants with age greater than 85 years had the range from 6.08 to 6.68. The difference between the maximum and minimum averages reduced with an increase in the age and the same can be observed in Figure 1.

Table 4. Risk Perceptions by Education Level

Traffic Violation	Education Level						ANOVA p-value
	1	2	3	4	5	6	
Disregarding Traffic Signals	6.58	6.47	6.49	6.35	6.13	6.02	<0.01*
Driving under the Influence of Alcohol or Drugs	6.24	6.39	6.26	6.39	6.31	6.32	0.24
Exceeding Speed Limit by 20 mph	6.19	6.28	6.17	6.13	6.08	5.84	<0.01*
Failing to Yield the Right-of-Way	5.96	5.86	5.71	5.72	5.67	5.30	<0.01*
Following Vehicle Closely	5.80	5.67	5.61	5.56	5.41	4.92	<0.01*
Operating Vehicle Aggressively	5.46	5.57	5.21	5.15	5.06	4.53	<0.01*
Exceeding Safe Speed Limit for Conditions	5.23	5.28	5.14	5.07	5.22	4.53	<0.01*
Exceeding Speed Limit by 10 to 20 mph	4.83	4.92	4.88	4.87	5.09	4.68	0.06
Average Risk Perception	5.62	5.61	5.50	5.48	5.47	5.02	<0.01*

Note: 1-Advanced degree, 2-Some graduate or professional school, but no advanced degree, 3- College Degree, 4-Some Education beyond High School but not Degree, 5- High School Diploma, 6- Some high school.

Note: * Difference is statistically significant at a 95% confidence level.

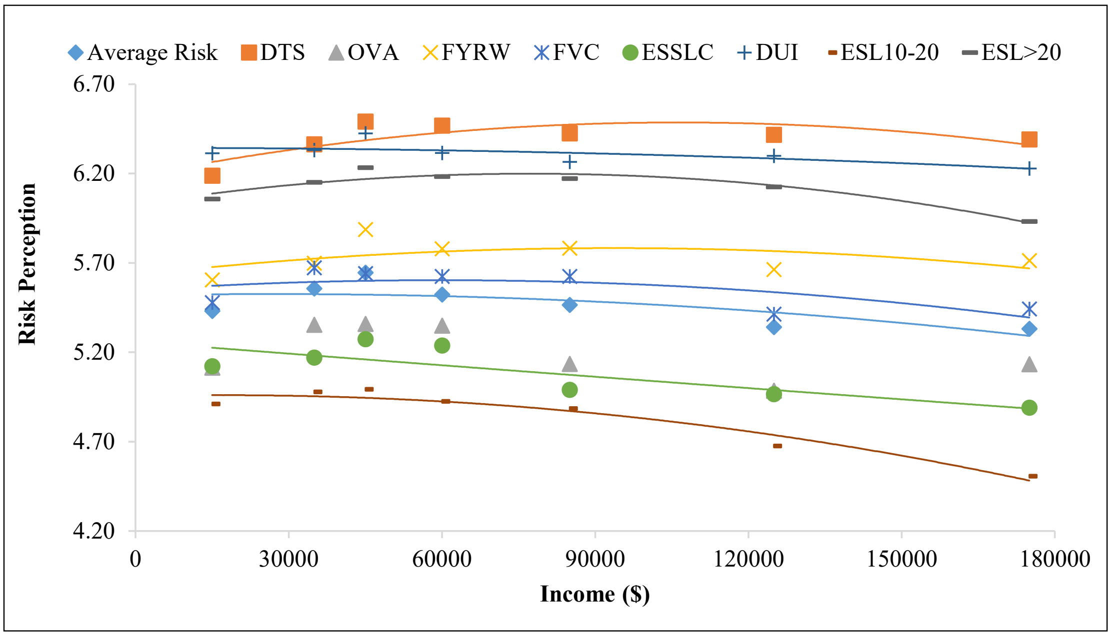

Figure 2. Risk Perceptions by Income

Note: Disregarding traffic signals - DTS; Operating vehicle aggressively - OVA; Failing to yield the right-of-way - FYRW; Exceeding safe speed limit for conditions - ESSLC; Driving under the influence of alcohol and drugs - DUI; Exceeding speed limit by greater than 20 mph - ESL>20; Exceeding speed limit by 10 to 20 mph – ESL10-20; Following vehicle closely - FVC.

Risk Perceptions by Gender

Table 3 shows the average risk perception for both male and female drivers, for different traffic rule violations. Female drivers' risk perception of operating vehicle aggressively, failing to yield the right-of-way, exceeding safe speed limit for conditions, DUI, exceeding speed limit by 20 mph, and exceeding speed limit by 10 to 20 mph are significantly different at a 95% confidence level (using t-statistic test) than male drivers' risk perception. Female drivers perceive disregarding traffic signals and following vehicle closely same as male drivers. Overall, female drivers perceive traffic rule violations as slightly riskier than male drivers, which is consistent with the findings from the past literature (Moyano-Diaz, 1997; Yagil, 1998; Hallett et al., 2012). The maximum difference in risk perception between female and male drivers is observed for exceeding safe speed limit for conditions, followed by exceeding speed limit by 10 to 20 mph. Both, male and female drivers perceive the risk towards different traffic rule violations in the same order as it was perceived overall.

Risk Perceptions by Education

Table 4 shows the risk perception of the participants by the education level. The results from the ANOVA test are also shown in the table. Except DUI and exceeding speed limit by 10 to 20 mph, rest all traffic rule violations have strong association with participant's education level. Contrasts were estimated to make pair wise comparisons across education levels for only those violations that are significant in Table 4, and were presented in the Appendix.

Participants having advanced degree perceived disregarding traffic signals to be more risky than other traffic rule violations. As the education level increased, the risk perceived for disregarding traffic signals increased. Advanced degree holders risk perception toward DUI is slightly less than the risk perception of participants with some high school degree. Irrespective of the education level, the risk perception is high for DUI. Participants with high school degree perceived DUI to be more risky than disregarding traffic signals.

Participants with high school diploma perceived exceeding speed limit by 10 to 20 mph to be of greater risk than other education level participants. Following vehicle closely had the highest difference in risk perception between participants with advanced degree and high school degree. The least difference between these two education levels was observed for exceeding speed limit by 20 mph. A difference in the risk perception between high school diploma and high school degree holders was observed for following vehicle closely, exceeding speed limit by 10 to 20 mph, exceeding safe speed limit for conditions, and operating vehicle aggressively.

Comparing the average risk of traffic rule violations provided in Table 3 with Table 4, the risk perception of participants with high school degree is always less than the average risk perception. The risk perception of some graduate or professional with no advanced degree participants is always greater than the average risk perception of the entire sample population.

Risk Perceptions by Income

The relation between risk perception and family annual income was also studied and is presented in Figure 2. Except exceeding safe speed limit for conditions and DUI, all other traffic rule violations are best fitted by a polynomial curve. As the income increased, there was no change in the risk perception toward DUI. The middle-income participants perceived risk slightly higher than low- and high-income participants for exceeding speed limit by 20 mph. Except for disregarding traffic signals, the trend-line follows a very slight concave shape. The risk perception toward exceeding speed limit by 10 to 20 mph reduced with an increase in income. The risk perception of low-income participants is greater than the risk perception of high-income participants. The slope of linear equations is almost zero, implying that income has a very less influence on risk perception. Even the average risk polynomial curve does not have a change in risk perception with income. The notable thing in the graph is the range of risk perception for low-income participants and high-income participants. The range is wider for high-income participants, implying their risk perceptions depend on the type of traffic rule violation.

Discussion

DUI and disregarding traffic signals are perceived as most risky among the many other traffic rule violations. Over the last two decades, numerous advertisement campaigns or wide range of information were provided on the internet or television about the risks associated with these traffic rule violations, which might be the reason behind the high-risk perception. Exceeding speed limit by 10-20 mph is perceived as least risky by almost all the age groups. These perceptions might be a result of numerous factors (cultural, demographic, socio-economic, geographical, etc.) influencing an individual. For example, a person driving over the speed limit might consider the reward of exceeding the speed limit over the low probability of a negative outcome (as the chances of getting involved in a crash or getting a citation from an enforcement officer are seldom).

In terms of risk perception, exceeding speed limit is followed by operating vehicle aggressively and exceeding safe speed limit for conditions. However, according to Penmetsa and Pulugurtha (2017a, 2017b), these traffic rule violations are ranked among the top in terms of risk associated to drivers when it resulted in a crash. This implies that people perceived the riskiest violations (in terms of injury severity risk) as the least risky. The discrepancy between these two could be avoided by educating people about the risk associated with different risky driving behaviors as well as traffic rule violations.

Risk perceptions could be influenced by several factors beyond the demographic characteristics that are considered in this study. For example, past experiences, level of enforcement activity, the associated penalties, etc. can also influence how a given traffic rule violation is perceived. Factors that can positively influence one’s risk perception should be identified. Eventually, countermeasures to influence such factors can be implemented to change drivers’ risk perceptions.

Conclusions and Future Research

The risk perception of drivers can be influenced through education. Especially, educating drivers about the risk associated with traffic rule violations (that were perceived as low risk by drivers from this research) would help in making drivers adopt safe driving behaviour on roads. As of now, North Carolina Department of Motor Vehicles (DMV) handbook provides the risk associated with driving under the influence of alcohol only. If such information is provided for other traffic rule violations, drivers will be aware of the risk associated with violating these traffic rules and make safe driving decisions.

SHRP 2 NDS data does not provide any details on the representation of the sample data to the actual population. Especially, the data is over-represented by younger drivers. Even with these limitations on the data, this research presents interesting observations on risk perceptions towards traffic rule violations.

Data for only selected traffic rule violations is available and considered in this research. Driving without a valid license, driving under the influence of alcohol, using a handheld device, texting while driving, driving while feeling sleepy, etc. are a few other contributing factors that increase risk to drivers on roads. Additionally, the risk perception could be different from what may be objectively observed in the real-world (Wåhlberg, 2009). These aspects merit further research and investigation. Furthermore, the impact of disseminating information related to the risk associated with traffic rule violations through the internet, television or other mechanisms merits a study. Additional questions directly related to collision causation or those that increase the probability of getting involved in a crash (for example, disregarded stop sign, failed to reduce speed, drove wrong way, overcorrected/oversteered, was not attentive, or operated defective equipment) are recommended for inclusion in future surveys.

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Appendix

		Education Level								Education Level					
		1	2	3	4	5	6			1	2	3	4	5	6
Disregarding Traffic Signals	1							Failing to yield the Right-of-Way	1						
	2	¤							2	¤					
	3	¤	¤						3	*	¤				
	4	*	¤	¤					4	*	¤	¤			
	5	*	*	*	*				5	*	¤	¤	¤		
	6	*	*	*	*	¤			6	*	*	*	*	*	
Exceeding Speed Limit by 20 mph	1							Operating Vehicle Aggressively	1						
	2	¤							2	¤					
	3	¤	¤						3	*	*				
	4	¤	¤	¤					4	*	*	¤			
	5	¤	¤	¤	¤				5	*	*	¤	¤		
	6	*	*	*	*	*			6	*	*	*	*	*	
Following Vehicle Closely	1							Exceeding Safe Speed Limit for Conditions	1						
	2	¤							2	¤					
	3	*	¤						3	¤	¤				
	4	*	¤	¤					4	¤	*	¤			
	5	*	*	*	¤				5	¤	¤	¤	¤		
	6	*	*	*	*	*			6	*	*	*	*	*	
Average Risk Perception	1														
	2	¤													
	3	¤	¤												
	4	*	*	¤											
	5	¤	¤	¤	¤										
	6	*	*	*	*	*									

Note: * implies significant at 95% confidence level and ¤ implies insignificant at 95% confidence level.

The relative efficacy of positively and negatively valenced road safety campaign messages in improving dangerous driving attitudes

Ben W Morrison[1,2], Mark Sasaki[3], and Natalie M V Morrison[4]

[1] *Charles Sturt University, Bathurst, Australia*
[2] *Macquarie University, Sydney, Australia*
[3]*Australian College of Applied Psychology, Sydney, Australia*
[4]*Western Sydney University, Sydney, Australia*

Corresponding Author: Ben Morrison, Department of Psychology, Macquarie University C3A-4 First Walk, Macquarie University, NSW 2109, Australia Email: ben.morrison@mq.edu.au. Phone: +61 2 9850 9012.

Key Findings

- The research investigated the relative efficacy of positively and negatively valenced road-safety campaign messages in improving dangerous driving attitudes.
- Marked differences across sex existed in drivers' motivations to drive dangerously, as well as their planned driving behavioural change after viewing the safety messages.
- There was significantly greater reported message impact from the positive campaign, compared to the negative campaign overall, however, differences in impact existed as a function of drivers' age and sex.
- Among female drivers, a number motivators of dangerous driving were linked to message impact from safe driving campaigns, revealing potential value in the leveraging of psychological individual differences in anticipating message impact.

Abstract

Dangerous driving is a social problem that results in serious injuries, fatalities, and significant economic costs. Extensive research has examined the efficacy of road safety campaigns in curbing dangerous driving, however, these investigations have largely focused on negatively valenced messages. Less attention has been paid to positively valenced examples, and the role of drivers' motivations for dangerous driving in relation to message impact. One hundred sixty licensed drivers (female, n = 120; male, n = 30; other, n = 10) completed a questionnaire that measured their current driving behaviours and their motives for driving dangerously. Drivers then viewed one of two safe driving messages (either positive or negative in valence) and provided a gauge of message impact. Finally, looking to the future, participants completed a measure of planned driving behaviour. Results revealed differences across sex in drivers' motivations to drive dangerously, as well as their planned behavioural change after viewing the safety messages. On average, participants recorded greater response efficacy and message acceptance, and lower message rejection in the positive message group, compared to the negative message group. Further, in a separate analysis of female-only drivers, a number motivators of dangerous driving were linked to message impact from safe driving campaigns. The findings suggest that, despite the traditional dominance of negatively valenced campaigns, there may be benefit in the use of positive campaigns, and further that motivators of dangerous driving can be linked to message impact from safe driving campaigns, supporting the case for a more targeted approach in campaign design.

Keywords

Driving; road safety; motivation; message impact; safety marketing

Introduction

Dangerous driving is a problem that society has faced for decades, resulting in significant social costs such as fatalities, injuries and reduced quality of life, and economic costs such as medical expenses, property damage, and loss of productive capacity (Elvik et al., 2007). Crashes may be defined as "any apparently unpremeditated event reported to the police and resulting in death, injury or property damage attributable to the movement of a road vehicle on a road" (Transport for NSW, 2017, p. 12). The World Health Organisation (WHO) estimates that such traffic collisions may become the third largest cause of death by 2020 (Carey, McDermott, & Sarama, 2013). Although a large number of traffic incidents may be causally attributed to situational factors largely outside of a driver's control, a significant number are attributed to dangerous driver behaviours. For instance, in Australia's most populated state (New South Wales), speeding was deemed a factor in 23.5% of crashes resulting in serious injury.

Some well-researched factors associated with dangerous driving include driver anger (Lawton, Parker, Stradling, & Manstead, 1997; Parker, Lajunen, & Stradling, 1998; Van Rooy, Rotton, & Burns, 2006), age and sex (Arnett, Offer, & Fine, 1997; Ben-Ari, Florian, & Mikulincer, 1999; Fleiter, Watson, Lennon, & Lewis, 2006; Harré, Field, & Kirkwood, 1996; Jonah, 1997; Kohler, 1996), and other situational characteristics (e.g., the presence of certain passengers, forms of music, ambient temperature, and even the colour of other cars; Arnett, et al., 1997; Guéguen, Jacob, Lourel, & Pascual, 2012; Kenrick & MacFarlane, 1986; Pêcher, Lemercier, & Cellier 2009).

Some contributing factors to dangerous driving are not easily (if at all) changeable by road authorities aiming to improve road safety (e.g., drivers' personality, age, sex, etc.). However, key features that can potentially be targeted for change are a person's motivators to engage in various driving behaviours. By identifying specific motivators, and designing messages targeted to either change or raise awareness of them, authorities may influence drivers' behavioural choices to effect safer driving outcomes. Research identifying underlying motivators and methods to influence them is an area that has received comparatively less research than others.

Ho and Gee (2008) investigated motivators of young males (200 aged 18-24 years) to drive dangerously and found three factors when developing the Motives for Dangerous Driving Scale (MDDS): "driving fast/ risk taking", "confidence in one's driving skills", and "disrespect for traffic laws". The motivators of driving fast/ risk taking is a useful one to target, as chosen speed and undertaking risky driving manoeuvrers are explicit choices addressable by road safety campaigns by, for instance, clearly articulating the demonstrable consequences to both themselves and others (e.g., imprisonment, death, etc.) of this behaviour. Confidence in one's driving skills is another that can be addressed by, for instance, providing illustrative examples of even skilful drivers being involved in serious at-fault crashes. And finally, disrespect for traffic laws is fundamental, as traffic laws represent enforceable guidelines as to what does and does not constitute safe driving practices. Disrespect for these laws may indicate, for example, a digression of one's perception of danger from that espoused by authorities, a disregard of the potential consequences and risks, or both. This motivator could be addressed by communicating the bases of traffic rules and their evidence-based role in preventing injury, in a persuasive manner suitable for the particular target audience. Overall, the MDDS provides a platform for gauging drivers' motivators that may be associated with drivers' engagement with road safety campaigns.

Road safety campaigns involve communicating persuasive messages to motivate a target population to change attitudes and behaviours, with a view to improving road safety (Delhomme, Dobbeleer, Forward, & Simões, 2009). Whilst they can be conveyed in a rational manner by using the presentation of basic information (e.g., penalties for speeding), the generation of an emotional response on the part of the viewer can increase the effect (Elliott, 1993; Ulleberg et al., 2009), including both positive (Weinberger & Gulas, 1992) and negative (Lewis, Watson, & White, 2008) valence.

There is definitional inconsistency for "positive" and "negative" road safety messages (Donovan, Henley, Jalleh, & Slater, 1995; Henley, Donovan, & Moorhead, 1998), making generalisation of research findings difficult. An appealing differentiation to make is that positive messages communicate the positive (favourable) consequences of driving safely, compared to negative messages which emphasise negative (unfavourable) consequences of driving dangerously (Sibley & Harré, 2009). Multiple elements of a message can vary in valence, including message framing effects, offer of rewards or punishment, and motivations referred to (Lewis, Watson, & White, 2009). For example, a message could be framed to encourage the viewer to drive to the speed limit by presenting the negative consequences of not doing so, such as the loss of licence. This message may also engage a particular motivation (e.g., the viewer desires to keep their licence), which could lead to the arousal of emotion (e.g., fear of losing their licence).

Inconsistent findings have led to difficulty in concluding which emotions work best in road safety campaigns (Institute for Road Safety Research, 2008; Lewis, Watson, Tay, & White, 2007; Ulleberg et al., 2009), whether to refer specifically to risks in messages (Elliott, 1993; Lewis et al., 2007; Snyder, 2001; Weber, Martin, & Corrigan, 2006; Williams, Reinfurt, & Wells, 1996), and whether an alternative should be communicated. For example, Tay and Watson (2002) found that effectiveness for anti-fatigue messages was higher if an alternative behaviour was offered (e.g., having a nap); a similar effect has been shown for drink-driving (Tay, 2005). Unfortunately, unless the primary reason a person chooses to speed is due to poor time management (addressable by, for example, leaving for one's destination earlier), there are few clear alternatives to speeding other than to simply not speed.

A range of person-related characteristics including socio-demographic features and pre-existing beliefs will influence a message's effectiveness when received by the target (Lewis, Watson, & White, 2009), which is a compelling argument for thorough pretesting of a message to ensure that these are factored into the design, and that the message is a good fit for the target audience (Ben-Ari, Florian, & Mikulincer, 1999; Donovan, Henley, Jalleh, & Slater, 1995). A perception of personal involvement with and relevance of message content influences its persuasive ability (Petty, Haugtvedt, & Smith, 1995; Petty & Wegener, 1999). Generating an optimum level of perceived relevance is crucial to mitigate the 'Third Person Effect' (TPE), in which the viewer believes that the adverse consequences demonstrated are more likely to impact another person (Davison, 1983). However, a message can also be seen as "too relevant" (Higbee, 1969; Phau, 2000; Quinn, Meenagha, & Brannick, 1992), and then be ignored or rejected due to, for example, it being perceived as an overt attempt by an authority to change their behaviour. Demographic differences in the experience of the TPE (and other biases) are worthwhile considering when designing messages targeted at, for example, a particular sex. Indeed, males tend to demonstrate the TPE when viewing messages containing fear but less so for humorous messages (Lewis, Watson, & Tay, 2007; Lewis, Watson, & White, 2008). The arousal of fear by way of the "threat appeal" has been a prominent feature of road safety campaigns.

Threat appeals are frequently used in road safety campaigns, based on the premise that fear arousal increases the likelihood that viewers pay attention to and accept recommendations (Witte & Allen, 2000). They attempt to scare people into performing (or not performing) particular behaviours by depicting terrible consequences (Witte, 1992). Whilst many safe driving messages include physical threat such as death (Tay & Watson, 2002), some audiences do not perceive these as relevant, including high-risk drivers (Lewis, Watson, & Tay, 2007; Tay, 2002). By contrast, social threat (e.g., stigma associated with loss of licence) can be more effective (Kohn et al., 1982; Lewis, Watson, White, & Tay, 2007; Pechmann & Knight, 2002; Rotfield, 1999; Schoenbachler & Whittler, 1996).

The "Extended Parallel Processing Model" (EPPM; Witte, 1992) suggests that two cognitive appraisals occur upon fear inducement: "threat appraisal" and "coping appraisal". Threat appraisal is the degree to which a threat is felt personally, its perceived relevance, and perceived likelihood of occurring. If the threat is sufficiently strong, the fear invoked may motivate more in-depth processing and engagement with the recommendations, referred to as "danger control". If the threat is too severe, defensive mechanisms may be engaged (such as avoidance) such that in-depth processing would not occur; this process is referred to as "fear control". Coping appraisal involves assessing the viability of the alternative behaviour suggested (if any) to avoid the threat ("response efficacy"), and whether the viewer perceives that they can execute it ("self efficacy"). Successful communication of response efficacy and self efficacy can lead to the desired outcome of danger control; failure to communicate response efficacy may invoke feelings of helplessness towards the threat and lead to fear control. Witte (1992) found that fear led to failure in the threat appeal (via fear control), but cognitions lead to success (via danger control). Coping appraisal is followed by selection of either adaptive or maladaptive behaviours, which may be represented by the factors of "message acceptance" and "message rejection" (Witte, 1992) that can be used to gauge message efficacy.

One of the ways that efficacy of threat appeals has been measured is by the degree of message acceptance, which is the intention to change behaviour as advocated by the message (Witte, 1992). Message rejection is another, less used measure (Lewis, Watson, & White, 2009), and refers to defensively avoiding, ignoring, denying or minimising the essence of the message (Tay & Watson, 2002; Witte, 1992). Message rejection adds to the explanation of actual behaviour, incremental to message acceptance (Lewis, Watson, & White, 2008). Response efficacy is positively associated with message acceptance and negatively associated with message rejection (Tay & Watson, 2002; Witte, 1992), and has more influence on adaptive outcomes than the amount of fear induced (Floyd, Prentice-Dunn, & Rogers, 2000; Tay & Watson, 2002; Witte & Allen, 2000). Response efficacy improves persuasive ability (Floyd, Prentice-Dunn, & Rogers, 2000), and whilst its inclusion may depend on targeted behaviour (e.g., drink driving as distinct from speeding), empirical evidence suggests that all safe driving messages ought to incorporate it to some degree (Lewis, Watson, & White, 2009).

The efficacy of threat appeals has been questioned, in addition to ethical and practical concerns (de Hoog, Stroebe, & de Wit, 2008). For example, whilst threat appeals work under certain conditions (e.g., Witte & Allen, 2000), they can also be ineffective and actually lead to an increase in the undesirable behaviour (e.g., Caren & Sarma, 2011; Jessop, Albery, Rutter, & Garrod 2008). Message efficacy is also influenced by sex; females generally show a more effective response than males (Goldenbeld, Twisk, & Houwing, 2008; Lewis, Watson, & Tay, 2007; Tay & Ozanne, 2002). Uncertainty in the causal relationship between fear and behaviour, including inconsistencies in definitions and confounding emotions (Baumeister, Vohs, DeWall, & Zhang, 2007; Carey, Mcdermitt, & Saram, 2013), has contributed to interest in positive safe driving messages from researchers (Elliott, 2005) and the general public (Lewis, Watson, White, & Tay, 2007).

Positive road safety messages are likely to invoke positive reactions such as laughter, and may be considered as positive emotion based appeals (Lewis, Watson, White, & Tay, 2007). These are more likely to appeal to some target groups, such as males (Goldenbeld, Twisk, & Houwing, 2008; Lewis, Watson, & White, 2008), which is opposite to the relationship with threat appeals (Conway & Dubé, 2002; Goldenbeld, Twisk, & Houwing, 2008; Lewis, Watson, & White, 2008). They are also effective for young drivers (Sibley & Harré, 2009) who, along with males, are chief among those who violate traffic laws, so a more widespread utilisation of targeted positive safe driving messages seems logical. While the value of positively valenced media has been found to promote stronger engagement and even greater ‘viral’ sharing compared to negative approaches in other media (e.g., Berger, & Milkman, 2013), there are far fewer studies exploring the efficacy of positive safe driving messages compared to negative ones, which is an area worthy of further research (Goldenbeld, Twisk, & Houwing, 2008; Lewis, Watson, & White, 2008; Nabi, 2002).

Whilst some published evaluations of road safety campaigns analyse efficacy for particular groups or behaviours, there appears to be a lack of similar attempts to correlate efficacy with particular motivators of dangerous driving. As reviewed earlier, people drive dangerously for many reasons, including the influence of underlying motivators and pre-existing beliefs, which may offer some specific target areas for road safety campaigns. As mentioned previously, targeted and personalised messages can be more effective than campaigns en masse. Therefore, applying a targeted approach to address specific motivators and beliefs may provide a useful method to direct the most relevant messages to where they would be most effective. Evaluations of this approach would yield valuable data for the design of future road safety campaigns, and mandatory safe driving programs for repeat offenders.

The current study aimed to test the relative efficacy of positively and negatively valenced road safety campaigns in relation to drivers’ reported message acceptance, message rejection, and response efficacy. Self-efficacy was intentionally excluded from the investigation, as the authors believe that response efficacy has the greatest potential for practical implications for a persuasive message (i.e., campaign designers can more readily identify strategies that may be useful for a particular audience), compared to self-efficacy, which is presumed to be less amenable to change following brief exposure to a campaign message (Lewis, Watson, & White, 2010). Participants’ pre-message dangerous behaviour was also compared to post-message planned behaviour, to examine whether the messages were effective in changing drivers’ intentions regarding future driving. Further, the study explored whether three dimensions of motivation for dangerous driving previously highlighted by Ho and Gee (2008) (i.e., driving fast/risk taking, confidence in one’s driving skills, and disrespect for traffic laws) could predict message impact for the positive and negative campaigns. Finally, as drivers’ age and sex has consistently been shown to be a salient factor in drivers’ attitudes and behaviours (Allison, Jordon, & Yeattes, 1992; Arnett et al., 1997; Deffenbacher, Oetting, & Lynch, 1994; Fleiter, Watson, Lennon, & Lewis, 2006; Harré, Field, & Kirkwood, 1996; Harré, Foster, & O’Neill, 2005; Iram & Taubman, 1994; Jonah, 1997; Kohler, 1996; Zuckerman et al., 1966) as well as message efficacy (Goldenbeld, Twisk, & Houwing, 2008; Lewis, Watson, & Tay, 2007; Tay & Ozanne, 2002), the study aimed to investigate potential age and sex-based differences in motivations for driving dangerously, message impact relating to the driving campaigns, and potential attitude change following the safe driving message.

Methods

Participants

One hundred sixty students enrolled in first and second year psychology units at the Australian College of Applied Psychology (ACAP) participated in the study via the College research portal. Participation was entirely voluntary, and participants were reimbursed for their time with a small percentage of course credit. Of these, 120 were female (M_{age} = 28.71, SD_{age} = 8.86, *Range* = 18 - 54), 30 were male (M_{age} = 29.32, SD_{age} = 8.24, *Range* = 19 - 57), and 10 did not specify sex (M_{age} = 31.48, SD_{age} = 9.98, *Range* = 20 - 53). All were licensed drivers.

Measures

Participants completed an online survey comprising questions assessing: demographics(age, sex, driving experience); current dangerous driving behaviours; motivators of dangerous driving (measured using driving fast/risk taking, confidence in one’s driving skills and disrespect for traffic laws); and message efficacy (measured using message acceptance, message rejection, and response efficacy). Participants then viewed one of two (positively or negatively valenced) video-based road safety messages, and after viewing completed a measure of planned dangerous driving behaviours. The between-subjects design was adopted to eliminate potential contrast effects that could arise from participants viewing both messages.

Materials

Manchester Driving Behaviour Questionnaire (DBQ)

A version of DBQ (Reason et al., 1990) modified by Davey, Wishart, Freeman, and Watson (2007) for an Australian driving population was chosen to measure actual driving behaviour. Respondents were required to indicate on a six point Likert-type scale (0 = *Never* to 5 = *Nearly all the time*) how often they engage in various driving behaviours, such as “race away from traffic lights to beat the car besides you”. The measure consisted of 20 items, with greater total scores indicating greater endorsement of dangerous driving behaviours.The modified DBQ has shown acceptable reliability (Cronbach α of .60 to .80; Davey, Wishart, Freeman, & Watson, 2007). The measure was also used to assess planned driving behaviour, with slight adjustments to wording to relate questions to future tense.

The Motives for Dangerous Driving Scale (MDDS)

The MDDS (Ho & Gee, 2008) was used to measure motivators of dangerous driving. The MDDS was originally developed using a population of young male drivers, showing acceptable reliability (Cronbach α of .82 to .94). Respondents were required to indicate on a six point Likert-type scale (1 = *Strongly agree* to 6 = *Strongly disagree*) how often they engage in various driving behaviours such as "I take out my frustrations by driving fast" and opinions such as "I am a more skilful driver than most other drivers on the road"; it is these behaviours and opinions from which underlying motivations are implied. Its 29-items yield three factors: driving fast/risk taking (15 items), confidence in one's driving skills (eight items), and disrespect for traffic laws (six items). Scale scores were converted where necessary so that greater total scores indicated greater endorsement for each factor (i.e., higher scores equated to greater instances of driving fast/risk taking, confidence in one's driving skills, and disrespect for traffic laws).

Message Impact

Measures of message impact were drawn from Lewis, Watson, and White (2010), and comprised items relating to three factors: message acceptance (four items), message rejection (five items), and response efficacy (three items). These measures yielded acceptable internal reliability in the original study (Cronbach α of .73 to .86). For all items, respondents were required to indicate on a seven point Likert-type scale (1 = *Strongly agree* to 7 = *Strongly disagree*) the extent to which they agreed with various statements about the safe driving message they watched, such as: "adopting the advertisement's recommendations would be effective in reducing speeding", and "as a result from watching the video, do you intend to obey the speed limit". Scale scores were converted where necessary so that greater total scores indicated greater endorsement for each factor (i.e., higher scores equated to greater instances of message acceptance, message rejection, and response efficacy).

Safe Driving Messages

The negative safe driving message was a television advertisement released as part of the "10 km less" campaign by the Transport and Accident Commission (TAC) in the Australian State of Victoria in 1997 (TAC, 1997). It depicted a computer generated slow-motion video of a man being hit by a car, with a narrative spoken by a trauma surgeon describing the effect on the human body during each stage of the incident (e.g., "bumper hits the knee joint, tearing flesh and ligaments"). A second video then shows what would have happened had the driver been travelling at a speed 10 km/h less than what was portrayed in the first video. This was chosen as the negative safe driving message as its main focus was the depiction of the potential adverse consequences of speeding. The advertisement was 60 seconds in length.

The positive safe driving message used was a television advertisement released as part of the "Enjoy The Ride" campaign by the Office of Road Safety (OSR) in the Australian State of Western Australia in 2011 (OSR, 2011). It depicts various scenarios in which people are moving at a rushed pace (e.g., running down a busy city street), with a narrator posing rhetorical questions about the virtues of such an approach to life. It then depicts other scenarios in which people are behaving at a more relaxed pace (e.g., a woman relaxing in a bath), with the narrator espousing the virtues of slowing down in life. Various driving scenarios then show actors behaving in a relaxed state whilst in their vehicle, including a comparison between a driver that is explicitly depicted as speeding, and another driver who follows the speed limit, with the latter exhibiting a decisively happier expression than the former, who appears tense and stressed. This was chosen as the positive safe driving message as its main focus was the depiction of the favourable consequences of driving at the speed limit. The advertisement was 64 seconds in length.

Procedure

Survey platform Qualtrics® (Qualtrics LLC, Provo, UT, USA) was used to host the driving messages and measures. Upon completing the demographics, DBQ, and MDD measures, the platform randomly assigned participants into one of two groups: one group was to be shown the positive safe driving message, and the other group to be shown the negative safe driving message. The format for both videos was identical, and was displayed via an embedded YouTube link. After viewing, participants answered the questions relating to message impact. Finally, the DBQ (adjusted to refer to planned driving behaviour) was administered.

Results

Message impact

Using a one-way multivariate analysis of variance (MANOVA), three dependent variables (DVs) related to message impact (message acceptance, message rejection, and response efficacy) were analysed for differences across the two road safety campaign conditions. The DVs were found to be moderately intercorrelated, and all parametric assumptions were met. Wilks's Lambda test revealed a significant multivariate effect for valence, λ (3, 144), $p = .041$, $\eta p^2 = .06$. Tests of between-subjects effects revealed significantly greater response efficacy ($p = .050$) and message acceptance ($p = .008$), and lower message rejection ($p = .040$) in the positive message group, compared to the negative message group. Descriptive statistics are shown in Table 1.

To determine whether message impact varied as a function of drivers' age and/or sex , Pearson's correlational analyses were performed on the three variables relating to message impact (message acceptance, message rejection, and response efficacy), stratified by drivers' sex and the

Table 1. Descriptive Statistics for Message Impact

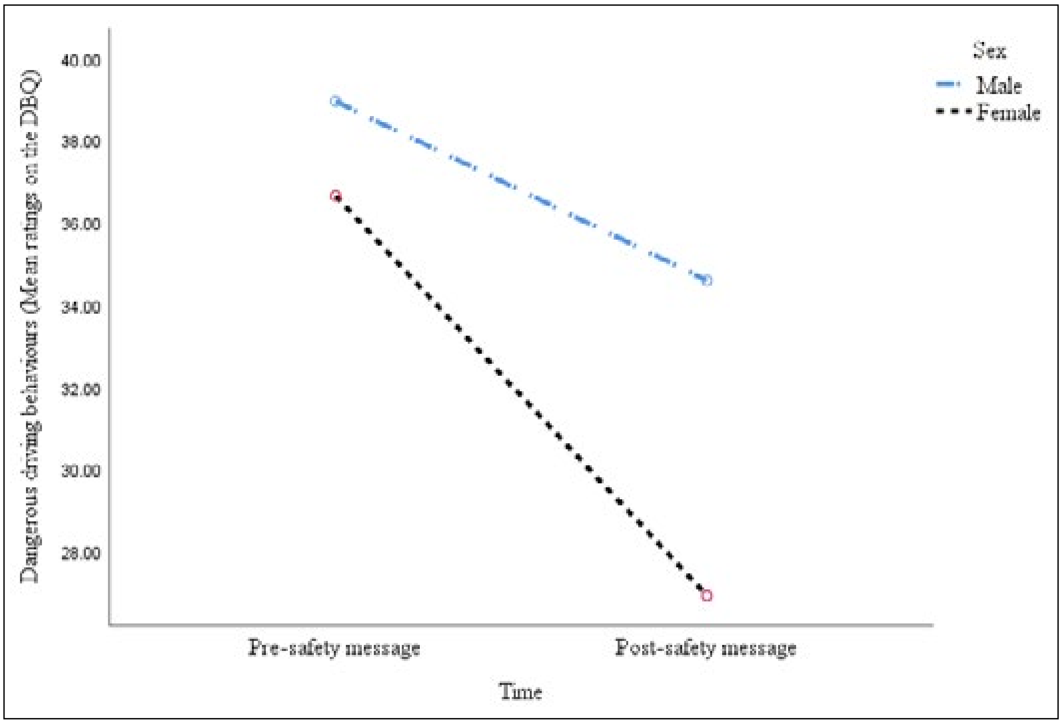
Group	*M (SD)*	95% CI
Positive		
Message Acceptance	10.76	[9.60, 11.92]
Message Rejection	23.91	[22.38, 25.44]
Response Efficacy	8.57	[7.63, 9.52]
Negative		
Message Acceptance	8.51	[7.33, 9.68]
Message Rejection	26.19	[24.64, 27.74]
Response Efficacy	7.26	[6.30, 8.22]

Note: M = Mean; *SD* = Standard Deviation; CI = Confidence interval. Scores for each factor of message impact had a possible range of 4-28 (Message Acceptance), 5-35 (Message Rejection), and 3-21 (Response Efficacy); with greater scores indicating greater endorsement of the factor.

message valence (positive and negative). Participants who did not report a sex were excluded from the analysis. The results revealed several statistically significant associations. For male drivers, age was negatively associated with message acceptance in the positive condition (r = -.503, p = .047), suggesting that younger male drivers showed greater levels of acceptance of the positive message. In contrast, older female drivers were typically more accepting of the positive message (r = .248, p = .050), also rating less message rejection (r = -.302, p = .017), and greater response efficacy (r = .357, p = .005). In relation to the negative message, neither females' nor males' age shared a relationship with message impact (all p > .05).

Intention to change driving behaviour

Participants' reported pre-message dangerous driving behaviour was compared to their post-message planned behaviour to test the effectiveness of the campaigns in changing participants' intentions. Participants ratings were



Note: Scores on the DBQ had a possible range of 0-100; with greater scores indicating greater endorsement of dangerous driving behaviours.

Figure 1. The interaction between time and sex for participants' reported dangerous driving behaviours

Table 2. Individual parameter estimates (motivators) by outcome (message impact) for both positive and negative valence conditions for the female driver subgroup

Valence	Outcome (Message Impact)	Parameter (Motivator)	B	Std. Error	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Positive	ResponseEfficacy							
		Driving Fast/Risk Taking	-.055	.075	-.728	.470	-.205	.096
		Confidence In Driving Skills	.306	.115	2.657	.010	.075	.538
		Disrespect For Traffic Laws	-.047	.205	-.231	.818	-.458	.364
	MessageAcceptance							
		Driving Fast/Risk Taking	-.142	.106	-1.345	.185	-.355	.070
		Confidence In Driving Skills	.246	.156	1.579	.121	-.067	.560
		Disrespect For Traffic Laws	-.060	.295	-.203	.840	-.653	.533
	MessageRejection							
		Driving Fast/Risk Taking	.170	.138	1.237	.222	-.106	.447
		Confidence In Driving Skills	-.298	.211	-1.415	.163	-.721	.125
		Disrespect For Traffic Laws	.548	.372	1.475	.146	-.198	1.294
Negative	ResponseEfficacy							
		Driving Fast/Risk Taking	-.006	.112	-.057	.955	-.231	.219
		Confidence In Driving Skills	-.202	.160	-1.261	.214	-.524	.121
		Disrespect For Traffic Laws	-.216	.239	-.902	.372	-.697	.266
	MessageAcceptance							
		Driving Fast/Risk Taking	-.018	.109	-.165	.869	-.237	.201
		Confidence In Driving Skills	-.166	.158	-1.052	.298	-.484	.152
		Disrespect For Traffic Laws	-.500	.234	-2.136	.038	-.970	-.029
	MessageRejection							
		Driving Fast/Risk Taking	-.150	.130	-1.150	.256	-.412	.113
		Confidence In Driving Skills	-.040	.189	-.209	.835	-.419	.340
		Disrespect For Traffic Laws	.408	.280	1.458	.152	-.155	.972

Note: Scores for each factor of message impact had a possible range of 4-28 (Message Acceptance), 5-35 (Message Rejection), and 3-21 (Response Efficacy); with greater scores indicating greater endorsement of the factor. Scores for each factor of motivation had a possible range of 15-90 (Driving Fast/Risk Taking), 8-48 (Confidence In Driving Skills), and 6-36 (Disrespect For Traffic Laws); with greater scores indicating greater endorsement of the factor.

analysed using a 2 (time) x 2 (sex) x 2 (valence) mixed repeated measures analysis of variance (ANOVA) (α = .05). Age was initially considered as a covariate, however as correlational analysis failed to reveal a significant relationship with drivers' actual or planned behavior, it was excluded from the analysis. A significant main effect was identified for the differences in reported driving behaviours means across time, $F(1, 1974) = 71.60$, $p < .001$, $\eta p^2 = .06$; with participants intending to drive less dangerously after watching the safety message. This effect was irrespective of the message valence. Further, a main effect for sex existed, $F(1, 1974) = 71.60$, $p < .001$, $\eta p^2 = .40$; whereby males' possessed significantly higher ratings for driving dangerously compared to females overall, regardless of when the ratings were taken. Most importantly, the results revealed a significant interaction between Time and Sex, $F(1, 275) = 9.98$, $p = .002$, $\eta p^2 = .09$, demonstrating that only the female drivers reported that they intended to significantly change their future driving behaviour at the conclusion of the study. The interaction is shown in Figure 1.

Motivators for dangerous driving and message impact

Several analyses were performed to test whether significant differences existed in participants' reported motivators for dangerous driving based on drivers' sex and age. Independent *t* tests revealed significant differences between female and male participants across drivers' motivators: Driving Fast Risk Taking ($p = .033$, $r = .17$); Confidence in Driving Skills ($p = .025$, $r = .17$); and, Disrespect for Traffic Laws ($p = .001$, $r = .24$). Males were found to have significantly higher ratings for all three variables. Pearson's correlational analyses revealed no significant association between the motivators and drivers' age.

In light of the significant differences in motivators found between males and females, it was decided that participants' data could not be collapsed into a common group for the final analysis examining drivers' motivators. Further, as the male sample size was modest (30), a lack of projected statistical power using regression techniques precluded the group's inclusion in a separate analysis. Regression analyses were performed on the female driver sample to attempt to predict message impact from motivations for driving dangerously. Analyses included the three motivators regressed on the three outcome dimensions of message impact (i.e., response efficacy, message acceptance, and message rejection), for responses in the positive and negative safety campaign conditions. The results revealed that confidence in driving skills positively predicted response efficacy in the positive driving condition. Further, disrespect for traffic laws negatively predicted message acceptance in the negative condition. Individual parameter estimates for both conditions are shown in Table 2.

Discussion

The current study aimed to test the relative efficacy of positively and negatively valenced road safety campaigns in relation to drivers' reported message acceptance, message rejection, and response efficacy. Participants' pre-message dangerous behaviour was also compared to post-message planned behaviour, to examine whether the messages were effective in changing drivers' intentions for future driving. Further, the study explored whether three dimensions of motivation for dangerous driving (i.e., driving fast/risk taking, confidence in one's driving skills, and disrespect for traffic laws) could predict message impact for the positive and negative campaigns. Finally, the study explored potential age and sex-based differences in motivations for driving dangerously, message impact relating to the driving campaigns, and potential attitude change following the safe driving message.

Message impact

The results revealed significantly greater response efficacy and message acceptance, and lower message rejection in the positive message group, compared to the negative message group. The findings suggest that there may be benefit in the use of positively valenced safety campaigns, despite the traditional dominance of negative campaigns. Although the initial analyses revealed an overall greater benefit from the positive message, examination of the relationship between message impact and drivers' age and sex revealed a far more complex picture.

For male drivers, age was negatively associated with message acceptance in the positive condition, suggesting that younger male drivers showed greater levels of acceptance of the positive message. This result is largely consistent with the extant literature, which would suggest that positive emotion-based messages would appeal most to young males (Goldenbeld et al., 2008; Lewis et al., 2008; Sibley & Harré, 2009). In contrast, older female drivers were typically more accepting of the positive message also rating less message rejection, and greater response efficacy. These relationship were not present for the negative message. While the reasons for these differences across age and sex are largely a matter of speculation, most importantly, the finding provides evidence that the efficacy of safety messages in engaging viewers does vary significantly as a function of individual features, such as drivers' age and sex; simply, one size does not fit all, and there is a clear case to continue this line of investigation into the role of individual differences in drivers' engagement with safety messages.

Intention to change driving behaviour

While the safe driving messages were found to have a positive influence on drivers' planned behaviours, this effect occurred irrespective of message valence, and critically, was only observed in the female driving group. In relation to the female drivers, this promising result suggests that video-based safety driving campaigns, whether negative or positive in valence, may be effective in inspiring positive attitudinal change. In contrast, for the male drivers, these results while equally disheartening, are unfortunately unsurprising. Males have been frequently found to demonstrate the 'Third Person Effect', in which the viewer believes that the adverse consequences demonstrated are more likely to impact another person (Davison, 1983), when viewing messages containing fear (Lewis, et al., 2007; Lewis, et al., 2008); presumably the predominant emotion intended to be evoked by the negative message used in the study. While males experience the 'Third Person Effect' to a lesser extent for humorous messages, humour was notably absent from both the positive and negative messages used. Future research should look to expand on the safety messages used to investigate a broader array of emotions, which may impact male drivers' attitudes to dangerous driving behaviour.

Message impact and motivators for dangerous driving

Significant differences between female and male drivers were revealed in relation to the motivators of dangerous driving. These results are consistent with the extant literature, which consistently finds males to be more likely to engage in risky driving behaviours (Fleiter, Watson, Lennon, & Lewis, 2006; Harré, Field, & Kirkwood, 1996), are more prone to overconfidence in their skills (Harré, Foster, & O'Neill, 2005), and are disproportionately represented in experiencing road trauma (Australian Transport Safety Bureau, 2007). These findings provide further support for the consideration of target drivers' sex when designing road safety campaigns.

When isolating the female driving sample, confidence in driving skills predicted response efficacy (positively), but showed no such relationship with the negative safe driving message. This suggests that those who were more confident in their driving skills were more likely to perceive that the suggestions contained in the positive safe driving message (e.g., slowing down) could lead to safer driving outcomes. How this perception could relate to one's confidence in their own driving is unclear; perhaps those with lower confidence may grapple with challenges on the road not easily mitigable by slowing down, which is something that they may already do. Notably, confidence was did not predict perceptions of response efficacy for negative campaigns, suggesting that participants may have felt helpless towards the threats depicted in the campaign. This is quite possibly due to the fact that the campaign focussed largely on the consequences to the pedestrian being hit by the car, not those experienced by the driver directly. This finding is noteworthy, as although the consequences in the negative video are presumably somewhat relatable, there may exist an important barrier to attitude change. Here, we may again see evidence of a 'Third Person Effect' in relation to threat appraisal. Threat appraisal, the degree to which a threat is felt personally, its perceived relevance, and perceived likelihood of occurring, is thought to be critical in relation to engagement and processing of negative campaigns. More research is needed to investigate drivers' specific perceptions of threat appraisal in safety messages and the relationship it may hold with message impact.

Importantly, driving fast/risk taking failed to predict message impact in both conditions. This is particularly interesting, as both campaigns incorporated an emphasis on the consequence of drivers' speed. This demonstrates that neither the positive or negative safe driving message was effective in their persuasive ability for drivers who seek to drive fast and take risks. This population continues to be a research priority in the design of safety interventions.

Disrespect for traffic laws negatively predicted message acceptance for the negative safe driving message, meaning that drivers who were higher in this motivator were less likely to accept the safe driving message. These findings are not surprising given the obvious conflict between this motivator and the notion contained within most safe driving messages, either implicitly or explicitly, that traffic laws ought to be followed. This confirms an intuitive notion: the more a person disrespects traffic laws, the more likely they are to reject messages that seek to promote them. This study also suggests that communicating this message in a negative manner is even less effective than using a positive one; in fact, the negative campaign may even strengthen their resolve to maintain current behaviour (Lennon, Rentfro, & O'Leary, 2010). Here, it could be speculated that the prominent use of negative campaigns targeting particular populations may be perceived as threatening to those individuals from the population, potentially instilling a broader perception of prejudice, and a high level of resistance to accepting the message. This is a noteworthy finding, as it may be presumed that those drivers with a heightened disrespect for the law are potentially among the most at-risk and in need of behavioural change.

This study has demonstrated linkages between the efficacy of safe driving messages and motivators of dangerous driving which could be further used to, for example, pre-test particular elements of safe driving messages with participants who have elevated levels of the motivators which authorities are seeking to change. These motivators represent variables that authorities can seek to change, as distinct from characteristics that are fixed such as drivers' age and sex.

Limited budgets and time allocation for road safety campaigns underscore the importance of effecting the most behavioural change for the most at-risk drivers, in the most economical way. Whilst creating specific messages for each individual motivator may not be economically feasible (nor practical), identifying broad groupings of motivators and their relationship with particular demographic features would provide useful input for campaign strategies. The comprehensive statistics available on traffic incidents can be used to guide this evidence-based approach and determine which particular regions need the most effort and the best type of methods to use. Alternatively, research may reveal no easily identifiable motivational patterns in a particular area, with the cause of road traffic incidents being more related to, for example, a lack of traffic law awareness, poor road safety, or traffic "black spots".

Limitations and future directions

There were limitations in the design of this study. Firstly, it relied on self-report for the motivators of dangerous driving as well as current and planned driving behaviours. Previous studies have demonstrated that response acquiescence and a lack of willingness to accurately disclose driving behaviour is often present in self-report measures (af Wåhlberg, 2010), implying that how people respond in questionnaires about how they drive may be quite different to their actual driving habits. However, this study did confirm some intuitive relationships (e.g., the male drivers' relatively worse, and more pervasive attitudes to dangerous driving), which should add some degree of comfort regarding the accuracy of the responses. Further, previous studies have confirmed the veracity of self-report measures for driving behaviour (e.g., Lajunen & Summala, 2003). Regardless, future research should look to further validate the current findings using triangulation methods, which incorporate more objective accounts of driver behaviour (e.g., simulation studies similar to Plant, Irwin, & Chekaluk, 2017), more 'online' measures of emotional response (e.g., neuroimaging and facial coding), as well as qualitative accounts of drivers' motivations to drive dangerously and their perceptions of safe driving messages.

Another limitation was the presence of confounds within each of the safe driving messages. Whilst the messages were distinctly contrasting in their depiction of the consequences of driving behaviours (i.e., favourable or unfavourable outcomes), both messages contained elements of positive and negative valence. For example, the negative safe driving message depicted both the adverse consequences of driving dangerously (i.e., the collision with a pedestrian, which was the main focus), but also demonstrated an avoidance of these consequences by reducing speed (i.e., a positive outcome). Similarly, whilst the main focus of the positive safe driving message was to demonstrate the benefits of driving safely (e.g., a more relaxed state of mind), it also contained negative imagery associated with not doing so (e.g., being stressed out), reflecting a negative outcome. Differences in other features such as the age and sex of the protagonist and narrator, sound effects, music, and pace, mean that the valence was not the sole difference between the two messages, albeit a major one. Also, as found in previous studies and summarised by Lewis, Watson, and White (2009), there is a difference between how safe driving messages are viewed during experiments compared with that in everyday life (e.g., during a television advertisement break or on a billboard, observed repeatedly over the length of the campaign). In this experiment, the message was displayed once with a very small delay between viewing and appraisal; previous studies have demonstrated a delay between viewing safe driving messages and their benefits being realised (Lammers, 1990).

Finally, the sample in this study was heavily skewed towards female participants (approximately 72% were female). As sex is consistently found to be a factor in driving behaviour (e.g., Lewis, Watson, & White, 2008) as well as responses to safe driving messages (Lammers, 1990), the ability to generalise findings to the overall population of drivers was limited. Indeed, the current study revealed significant differences between females and males in both their actual and planned driving behaviours, as well as their motivations for dangerous driving. As a modest male sample size precluded their inclusion in the study's analyses relating to individual motivators, future researchers should look to better incorporate this group to improve our understanding of the role of sex in message impact. Further research should also attempt to add greater granularity in personal data collection, so as to better capture other pertinent social factors that may influence message impact (e.g., lifestyle factors).

Conclusions

Dangerous driving is a social problem that can result in serious injuries, fatalities, and significant economic costs. An extensive amount of research has examined the causes of dangerous driving, and road safety campaigns designed to address them, which mostly utilise negatively valenced safe driving messages. However, less research has investigated the relative efficacy of positively valenced safe driving messages, and the role of drivers' motivations for dangerous driving in relation to message impact. The current study revealed marked differences across sex in drivers' motivations to drive dangerously, as well as their planned driving behaviours after viewing safety messages; underlining the critical role of driver sex in influencing drivers' attitudes and behaviours. Results relating to message impact revealed significantly greater response efficacy and message acceptance, and lower message rejection in the positive message group, compared to the negative message group overall. This finding suggests that there may be benefit in the use of positively valenced safety campaigns, despite the traditional dominance of negative campaigns. However, this impact was found to vary significantly as a function of drivers' age and sex, further underlining the case for consideration of individual differences in drivers' engagement with safety messages. Finally, among the female drivers, a number of motivators were observed to predict message impact in the positive and negative conditions, , suggesting potential value in the leveraging of psychological individual differences in anticipating message impact, supporting the case for a more targeted approach in campaign design.

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Review of Post-Licence Motorcycle Rider Training in New South Wales

Ross Blackman[1], Narelle Haworth[1], Herbert Biggs[1], Darren Wishart[2]

[1] *Centre for Accident Research and Road Safety – Queensland (CARRS-Q), Queensland University of Technology, Brisbane, Australia*
[2] *Griffith University, Brisbane, Australia*

Corresponding Author: Ross Blackman, L2 K Block, 130 Victoria Park Rd, Kelvin Grove, Queensland 4059.
Email ross.blackman@qut.edu.au Phone +61 7 3138 4638.

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Key Findings

- Forty post-licence rider training (PLRT) options were offered in New South Wales
- Most PLRT courses (55%) appeared likely to support riders' risk management
- Basic skills are sometimes lacking in prospective PLRT participants
- Strategies to increase PLRT participation are worth considering

Abstract

Fully licensed motorcyclists represented over two thirds of riders killed on New South Wales (NSW) roads from 2010 – 2014. An ongoing need to address crash risks among this cohort is recognised and there is strong support for post-licence rider training (PLRT) among rider advocates and stakeholders. This research, commissioned by Transport for NSW, examined the PLRT environment in NSW to assess the extent to which courses targeted specific rider skills and competencies. Before commencement of this research, key riding competencies were identified by Transport for NSW in consultation with motorcycle stakeholder groups, and included scanning, buffering, setting up brakes, basic motorcycle handling, cornering, and lane positioning. A desktop review of 40 available courses provided an overview of relevant course content, locations and costs. The review was supplemented by interviews with eight training providers to gather information on course structure, components, delivery, promotion and trainee characteristics. The collective information was used to identify which training options support riders' risk management and promote improved safety outcomes. A wide range of courses was identified, and in most cases there was no standardised curriculum. Most courses appeared to support rider risk management and most also appeared to address roadcraft and defensive riding principles, albeit to varying degrees. Providers noted participant diversity in characteristics, needs and motivations for undertaking rider training, reflecting a need for a diverse range of course offerings including individualised training. Key groups were catered for including returning riders, female riders, inexperienced riders, commercial riders and aspirational racers.

Keywords

Motorcycle, Rider Training, Post-licence, Returning Rider, Skills, Competency

Introduction

Motorcyclists comprised 15 to 20 percent of all Australian road user fatalities over the 10 years commencing 2009 (BITRE, 2019). This situation is reflected in New South Wales (NSW) where a continuing need to address rider crash and injury risks was identified in the *Motorcycle Safety Strategy 2012-2021* (TfNSW, 2012). NSW rider fatalities fluctuated between 51 and 71 annually from 2009 to 2018 (BITRE, 2019). A similar pattern is observed for serious injuries, with a yearly average of 2,600 NSW riders hospitalised from 2008 to 2015 (TfNSW, 2017). This lack of progress in terms of raw numbers should be viewed in the context of the consistent upward trend in NSW motorcycle licences and registrations (TfNSW, 2019); reducing the number of crashes is especially challenging in an environment of apparent increased usage (Figure 1).

Much attention has been directed in recent decades to improving the safety of novice motorcycle riders in NSW, with the introduction of a Graduated Licensing Scheme

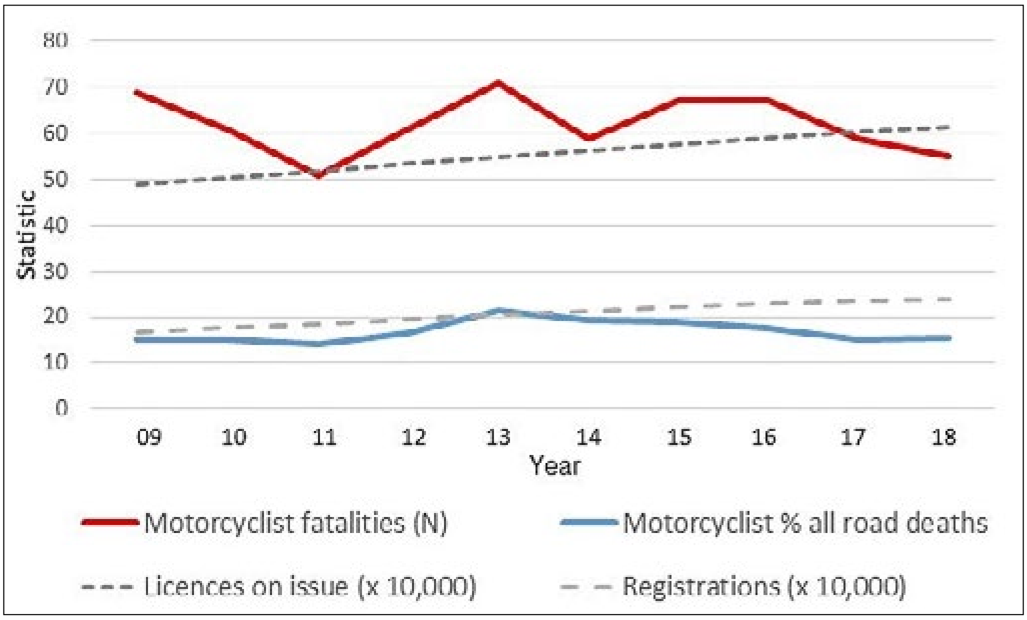

Figure 1. Ten-year NSW motorcycle fatality, registration & licensing trends 2009-2018 (BITRE/Transport for NSW)

(GLS) in 2009 and the Learner Approved Motorcycle Scheme (LAMS) in 2002. Research in Australia and elsewhere has generally focused on novice and pre-licence rider training programs and their effects (Langford, 2003; Kardamanidis, Martiniuk, Ivers, Stevenson & Thistlewait, 2010; Ivers et al., 2016). However, fully licensed riders comprised around 90 percent of all licensed riders and more than two thirds of rider fatalities in NSW from 2010 to 2014 (TfNSW, 2015). Moreover, analyses of motorcyclist fatalities and injuries by age group show an increasing involvement of riders aged 40 years or older (TfNSW, 2017). Factors underlying this trend likely include the ageing of the rider population, the greater susceptibility of older riders to serious injury (relative to younger riders), and potentially motorcyclists returning to riding after an extended break (often termed ‘returning riders’). These trends support previous recommendations for the development of programs to address the issue of returning riders (Haworth, Blackman, Fernandes, & Ma, 2013) and, by extension, increases in recreational riding in general.

Research on returning riders and their crash involvement is complicated by inconsistencies in returning rider definitions, and difficulties identifying them in official crash datasets. Conceptually, Haworth et al. (2013, p. 2) describes a returning rider as ‘someone who was an active rider in the past, who then became a dormant rider for a period and recently became an active rider again’. An operational definition is more challenging, where difficulties arise particularly in determining (a) the length of break from riding and (b) the exposure or amount of riding undertaken since resuming the activity. These parameters are key to examining the relative safety of returning riders, but there is wide variation in the setting of these in research to date, with the minimum length of break ranging from one to ten years and the exposure since returning similarly inconsistent (Haworth et al., 2013). Absence of a validated definition notwithstanding, a 2018 survey of 1,290 active Queensland riders by the current authors (unpublished) found that 19.1 percent had taken a break of two or more years from riding at some point in their motorcycling history. When returning to riding after an extended break, these riders face potential challenges including loss of vehicle handling skills due to lack of practice, unfamiliarity with a motorcycle or motorcycle type (including changes in design and performance), riding on unfamiliar routes (Brown et al., 2015; Haworth et al., 2013) and loss of physical fitness. While the concern for returning riders’ safety is warranted, they are but a subset of fully licensed riders whose crash risk needs to be reduced to meet the goals of current and future road safety strategies.

Fully licensed riders, including returning riders, are not currently required to undertake any post-licence rider training (PLRT) in NSW or other Australian jurisdictions and there is no requirement to demonstrate continuity of riding to maintain a motorcycle licence. Some insurers in Australia offer small policy discounts for PLRT participation, but the effects of these or other incentives on participation rates are unknown. Voluntary PLRT has general support from key motorcyclist stakeholder groups and organisations, including the Australian Motorcycle Council. The Motorcycle Council of NSW goes somewhat further, having advocated mandatory refresher courses for riders whose records show a gap in motorcycle ownership. Beyond Australia, voluntary PLRT is supported by organisations such as the Federation of European Motorcyclists’ Associations (FEMA) and the American Motorcyclist Association (AMA), but these stakeholders are largely opposed to mandatory training programs for fully licensed riders.

A recent online survey of crash-involved riders distributed by motorcycling-focused organisations, clubs, social media and websites across 30 countries provides a global perspective on the prevalence of PLRT. The sample included riders who were members of motorcycle clubs or organisations as well as other participants recruited through social media (Hardy, Margaritis, Ouellet, & Winkelbauer, 2020). Among 1,578 respondents (85 percent held full licences), 43 percent reported having undertaken voluntary PLRT. Of the Australia respondents (n=127), 46 percent had undertaken PLRT. Research in Australia also indicates that most riders do not undertake PLRT (Haworth, Rowden, Wishart, Buckley, & Watson, 2012), but the perceived value of rider training in general has been shown to increase with age, with riders in their fifties tending to value it most highly (Sakashita, Stephen, Senserrick, Lo, & Ivers, 2014). Interestingly, Sakashita et al. (2014) also found that perceived value of training declined with participation, but these results may be related to the type of training and participant recruitment and selection in their study. While there is likely some self-selection for PLRT for safety reasons, perceived value may not always relate to safety; participants seeking to primarily to increase skills may suffer from overconfidence and increased crash risk as a result of PLRT (Kardamanidis et al., 2010).

PLRT courses for road riders include on-road advanced rider courses, refresher courses and track-based courses. With notable variations within and between these categories of rider training, different objectives and motivations can be expected to influence rider participation. As well as general advanced rider training courses and refresher courses there are also PLRT courses focusing on specific environments, such as urban riding, group riding and adventure riding courses, for example. With a wide range of PLRT options, course participation outcomes may differ in terms of rider safety. Research to date has examined numerous pre- and post-licence rider training programs including their observed effects in various locations, with generally inconclusive results (Langford, 2003; Kardamanidis et al., 2010; Haworth et al., 2012; Ivers et al., 2016; Sakashita et al., 2014). However, research has not considered in detail the broader PLRT environment in a specific geographic region or jurisdiction. Therefore, the current research was commissioned by Transport for NSW to explore the characteristics of PLRT courses in NSW and the extent to which they targeted identified rider skills and competencies to address motorcycle crash and trauma risk.

Aims and Scope

As noted above, statistics show a lack of progress in reducing crash involvement of fully licensed and older riders in NSW. PLRT is often raised as one potential avenue to address this problem, but the nature and characteristics of the overall PLRT environment are poorly understood. The aim of this study was to investigate the extent to which existing PLRT courses target identified key rider skills and competencies to address motorcycle crashes in NSW, and to identify courses that appear likely to provide a safety benefit for participating riders. The findings were intended to inform recommendations on which courses, if any, appear appropriate for supporting riders to manage crash risk. The study did not attempt to objectively evaluate PLRT courses in terms of effectiveness in reducing crash and injury risk.

The study scope encompassed PLRT courses offered to licensed motorcyclists in NSW, including courses conducted on public roads as well as closed circuits. Whilst ‘public roads’ may include unsealed roads, courses tailored specifically for off-road motorcycle riders (including ATV riders) were not within the scope of the research. Track day courses aimed exclusively at training riders to participate in race days were also out of scope.

Methods

The research involved two key tasks, including: (1) a desktop review of PLRT courses available in NSW, including an overview of available courses describing their stated objectives, content, cost and locations; and (2) interviews with training providers to facilitate in-depth review of theoretical and practical course components and to obtain information on PLRT participant characteristics.

Task 1: Desktop Review

Electronic and printed media were searched in December 2015 to identify PLRT courses on public roads and/or closed circuits. The promotional and marketing material were examined to assess the extent to which each course *claimed* to address six key rider competencies which had been identified by Transport for NSW through feedback from motorcycle stakeholder groups and analysis of crash types:

- Scanning (hazard observation)
- Buffering (maintaining crash avoidance space)
- Setting up brakes (hazard response). Note, this entails light initial brake application to ensure controlled and progressive deceleration.
- Basic motorcycle handling (balance, steering and braking technique)
- Cornering
- Lane positioning

The desktop review also examined the extent to which the courses stated that they addressed ‘roadcraft’ and/or ‘defensive riding’. ‘Roadcraft’ is a popular term among practitioners (e.g. the UK Police Foundation ‘Motorcycle Roadcraft’ handbook (Mares, Coyne, & MacDonald, 2013; Allardice, 2002), but not academics. Broadly speaking, roadcraft constitutes an optimal combination of practical skills, situational awareness, hazard perception and response, and attitudes and behaviours. While a comprehensive range of skills and factors can be the focus of training programs, roadcraft essentially is an overarching strategy that riders may adopt to transfer these skills and concepts to the road environment. These components have been demonstrated to have a significant influence on rider safety (Haworth et al., 2012; Transport for NSW, 2015).

Task 2: Interviews

Interview methods and recruitment

The audio-recorded interviews consisted of a series of semi-structured and open-ended questions for discussion over a scheduled period of one hour (according with QUT Human Research Ethics Committee Approval 1500001138). All training providers identified in Task 1 were invited to participate in a telephone or Skype interview to discuss their full range of PLRT options. The NSW Motorcycle Alliance assisted in establishing contact with relevant training providers. Initial contact with training providers occurred by telephone or email, through which agreement to participate in the research was sought and the processes for participation established. Active rider trainers and PLRT program managers (with practical training experience) from eight of the 10 training providers were interviewed in January to February 2016. Two providers declined to participate: one because a suitable time for interview could not be established and the other being a single instructor who was then contracting to another provider and not providing training independently. Note that training was advertised by Provider E (see Results) as described above but was not being delivered as such at the time of writing. Interview length ranged from 49 to 71 minutes, with average duration of 61 minutes.

Interview topics

The interviews explored the theoretical and practical components of the relevant courses offered, and how course delivery in practice addressed the six key rider competencies listed above, as well as roadcraft, defensive riding and related attitudinal and behavioural issues. Relevant course materials that were not publicly available were also discussed.

Interviewees were queried regarding yearly participant numbers (last 12 months), age, gender, motivations, previous experience, and motorcycle types ridden, but the level of detail provided by interviewees varied. Indications of participants' apparent overall skill level and the proportion of participants that might be loosely defined as 'returning riders' were also sought. These questions were raised in the final section of the interview and in some cases were emailed to providers after termination of the interview because of time constraints.

Results

Task 1: Identification of Providers and Relevant Courses

Ten organisations were identified as PLRT providers in New South Wales (referred to as organisations A to J), who varied in terms of origins, functions and commercial activities. Six organisations were primarily providers of motorcycle rider training, but also offered 'track day' events, guided motorcycle tours, pre-purchase motorcycle inspections and motorcycle transport. Three organisations were associated with motorcycle sales. Two organisations also provided driver training for other vehicles at the post-licence level. Seven organisations provided pre-learner

Table 1. NSW PLRT course information obtained through online search

Provider	Number of PLRT course levels/types	Course duration	Course costs AUD	Location (region)	Training environment*
A	4	1 day	575	Sydney	Track
B	1 (customised)	Not specified	Not specified	Mid North Coast	Road, Other
C	4	3hrs – 1 day	145 - 300	Sydney	Road, Track, Other
D	5	1 day	395	Sydney	Track
E	2	1 – 3.5hrs	80 - 170	Sydney	Road, Other
F	7	3hrs – 3 days	85 - 2200	Sydney, Sth Tablelands, Central Coast	Track, Road, Other
G	5	3hrs – 1 day	0 - 550	Sydney	Track
H	3	3 – 11hrs	Not specified	Not specified (variable)	Not specified
I	6	1 day	450 - 690	Sydney	Track
J	3	3 – 4hrs	Not specified	Central & Nth Coast, Nth Tablelands, Wollongong	Not specified

*Track = Closed circuit race/training track; Road = Public road; Other = Isolated area (e.g. carpark) and licence training as well as PLRT, advertising qualified and formally accredited instructors. Three organisations providing only track-based PLRT courses emphasised the competitive riding and racing experience of instructors, for whom formal accreditation as qualified on-road instructors was not confirmed in online material.

Forty different PLRT options were identified, including two courses with no practical riding component (a seminar addressing ‘roadcraft and mental skills’ and a workshop on basic motorcycle care, maintenance and repair). Two options were for female-only groups that were similar in content to equivalent-level courses open to all genders. Four options were described as personalised, specialised, private lesson or private tuition, indicating one-on-one training or very low student-instructor ratios closely tailored to individual needs. For three providers offering multiple levels of training, the highest or most advanced levels appeared to involve a substantial amount of one-on-one coaching and tailoring to individual requirements. One-on-one training may also occur in other courses, but most options seemed to involve student-instructor ratios of three to ten students per instructor.

Course costs and locations (regions), where available, are summarised in Table 1. The costs vary according to factors such as course duration, location, facilities and student-instructor ratio. The least expensive courses were those of short duration, with courses of half a day or less generally priced below $200. One provider (G) offered short classroom-only workshops free of charge, which may have been designed to attract participants to the provider’s practical courses. Courses of one-day duration were the most numerous with all levels of training considered, however entry to some higher-level courses required prior completion of a lower-level course. The advertised costs for a single one-day course ranged from about $300 to $700, although most were in the $400 to $600 range.

Training locations were generally concentrated close to larger population centres, including Sydney and surrounds, Wollongong, Newcastle and the Central Coast region. The training locations identified in the North Coast region were largely limited to one provider. NSW riders may also have attended some training courses in South East Queensland and Victoria; these are not identified in the current research. No PLRT courses were identified in central, western or far southern NSW.

Website Content and PLRT Course Descriptions

This section provides a description of the content on training providers’ websites and, specifically, references to the six identified key riding competencies (scanning, buffering, setting up brakes, basic motorcycle handling, cornering, and lane positioning), as well as roadcraft and defensive riding. All course descriptions were sourced from the online material.

Key competencies

Table 2 summarises the key competencies that were identified in the providers’ online material, either as general references or specific references for any of the PLRT options promoted. One website did not provide any detail (Provider B). Cornering and vision or scanning (hazard observation) were the two key competencies identified by all other providers.

Seven providers referred to braking and related skills. While this key competency refers specifically to ‘setting up brakes’, the online content suggests varying levels of attention to different braking issues (e.g., straight line, front brake, rear brake, cornering and trail braking), and perhaps different approaches to teaching. However, it could arguably be expected that coverage of brake application would generally include ‘setting up’ (which refers to initial

Table 2. Website reference to key competencies and roadcraft/defensive riding

Provider	Key Competencies identified on website						Roadcraft Defensive
	Scanning	Buffering	Braking	Handling	Cornering	Lane Pos.	
A	✔				✔		
B							
C	✔		✔	✔	✔		✔
D	✔		✔		✔	✔	
E	✔			✔	✔	✔	✔
F	✔	✔	✔	✔	✔	✔	✔
G	✔		✔		✔		✔
H	✔		✔		✔		✔
I	✔		✔		✔		
J	✔		✔	✔	✔		✔

light application of both brakes to ensure controlled and progressive deceleration thereafter).

The concepts of buffering and lane positioning were identified as separate key competencies. However, as overlapping concepts, they seem likely to be addressed together in most instances. Either or both of these concepts were explicitly referred to in three providers' website content. As skills and competencies, these concepts may be less relevant for courses primarily aiming to support track-day participation and racing.

'Basic motorcycle handling (balance, steering and braking technique)' is expressed as a key competency comprising at least several separate skills and tended not to be readily identifiable in providers' online content. Moreover, it refers to a general level of competency that might be assumed to have already been attained by prospective PLRT participants through mandatory licensing and training processes (or through experience for riders whose licensure predates such requirements). It is likely that all PLRT options (excepting classroom- and workshop-only courses) address 'basic motorcycle handling' as a matter of course, although it may not be mentioned as such in the online material.

Safety, roadcraft and defensive riding

Most providers made few specific references to 'safety' in their course descriptions, particularly in relation to public roads. In one Level 1 (track-based) course, the provider stated that 'within the boundaries of good sense and safety, the speed you ride is up to you'. Similarly, another provider referred specifically to ensuring 'safety' at the training venue only. Another provider included a small section on each page stating that 'safety is a key objective for (the provider) and has a large focus in the training courses on offer' and in other information indicated that courses at all levels aim to enhance safety on public roads. One provider also referred specifically to an objective to 'improve your on-road safety'. The absence of any literal reference to 'safety' of course does not necessarily mean that it was overlooked. For example, one provider's homepage stated that 'the primary objective of all courses is to minimise the chance of being involved in a road crash', although the term 'safety' was not used.

All provider websites and online course descriptions were searched for references to 'roadcraft' and/or 'road craft'. There were specific references to 'roadcraft' or 'defensive riding' in six of the providers' websites (Table 2), and three providers also used the term in their course descriptions. Only one reference to 'roadcraft' in the online content approached any explanation of the term, describing it as including 'group riding, overtaking, line sacrifice, creating a buffer at any time, braking in a corner, manoeuvring in tight areas, and road positioning'.

Task 2: Interviews with PLRT Providers

Table 3 summarises the information collected regarding the 29 course options offered by the eight interviewed providers.

Providers were asked if they could rate the average skill level of PLRT attendees. The overall response was that participants' motorcycle control skills were often poor, with braking skills a particular concern. When asked what aspect of training participants were most enthusiastic about, one provider responded that they 'should be most enthusiastic about the front brake, but they're not'. The stated objective of providers overall was to see 'improvement' at the end of training.

End of course testing was not conducted as such for any of the PLRT options identified. Providers of track-based courses appeared to conduct some form of assessment for entry to higher level courses, but details of the assessment/s were not sought by the researchers. Providers were not asked whether they conducted formal PLRT course evaluations, but note that these courses were not subject to auditing as applied to the mandatory pre-licence courses. One provider noted that they invited post-course feedback from participants, which most were said to have provided with variable detail.

Table 3. Post-licence training participation among interviewed NSW providers*

Provider	Trainee Age range	Male %	Motorcycle types	Returning %	Average skill level	Trainees per year
A	Up to 87	95	Sport	NA	Variable	Up to 900
B	18-60	NA	Touring, Cruiser	20	NA	Up to 40
C	Up to 80	80	NA	20	NA	NA
D	NA	85	Mixed	10-15	Poor	NA
F	20-75	80	NA	NA	Poor	NA
G	NA	84	Sport, Touring, Adventure, Cruiser	25-30	Avge-poor	~320
J	17-60	50	Cruiser, Adventure, Touring	40	Avge-poor	>200

*Relevant information was not obtained from one interviewed provider. NA = Not available.

Returning riders

Providers indicated that 10 to 40 percent could be categorised as 'returning riders'. The estimate was highest for the only provider offering a 'Refresher Rider' course explicitly targeting this group. Many other providers indicated the suitability of some courses for returning riders, but their course titles did not explicitly target this group.

Courses with the lowest representation of returning riders appeared to be those that are exclusively track-based with high-level skills development focus. One provider also reported efforts to increase returning rider representation, noting that these riders can tend to exhibit concerning levels of over-confidence.

Motorcycle types

The mix of motorcycle types reported differed according to the particular courses and course providers, with track-based courses predominantly attended by riders of sport motorcycle. One provider indicated that there was no particular 'stand out' motorcycle type in his experience and, further, that a mixture of different types was not difficult to manage due to riders generally being graded on 'pace' rather than motorcycle type. However, this provider reported that cruiser riders had relatively greater challenges to overcome in cornering and braking due to lower ground clearance and heavier machine weight compared with other motorcycle types.

Another provider talked of some of the challenges faced as an instructor when confronted with an apparent student-motorcycle mismatch. To summarise, a physically small rider had acquired a relatively large and tall 'Adventure' type motorcycle. This motorcycle choice was reportedly influenced by an adventure riding story that the student had seen on television. Clearly reluctant to tell his client that she had erred in her choice of motorcycle, he went on to discuss a strategy to support the rider in successfully managing the associated physical challenges.

Addressing individual needs and specified competencies

The specified competencies were often framed as skills or abilities by providers. The interviews showed that the courses often address a wider range and greater number of competencies than suggested by the online material. When asked about how they address the specified competencies, the response was typically that the training was individually tailored. In the case of lower level courses, a modified version of the pre-provisional curriculum was sometimes followed but otherwise set curricula were either highly flexible or avoided altogether. Although each provider appeared to have a somewhat different approach, potentially influenced by student characteristics as well as course design, similar outcomes were generally sought for equivalent-level courses across the providers.

For example, the discussion with the provider of the 'Refresher Rider' course outlined the course background, content and process. This three-hour course was said to be popular with returning riders and was usually conducted one-on-one. Participants often took the course before returning to riding and an element of the training was said to address participants' unfamiliarity with a new motorcycle where appropriate. When asked about specific competencies, the provider stated that they first conduct an assessment to gauge students' apparent skill level, including demonstration of how to start and stop in the 'ready position' and basic low speed cornering. This occurred before going on-road, as did a component on roadcraft covering buffering, lane positioning and general hazard avoidance. The on-road component began initially on quiet roads, where the student led the instructor with regular stops and debriefings.

Another course was primarily aimed at pre-provisional riders but was well attended by returning riders who were said to comprise 20 percent of participants on average and on occasions, an entire group. The components of this half-day closed-circuit course progressed through: posture, mount/dismount, the 'ready position' and starting; left turns (said to be the direction that most did well); gear changing; hill starts; slow rides (gears 1-3, maximum 60 km/h); right turns; harder braking; and cornering preparation (including posture, scanning, path choice). A lead-follow method was employed, with the lead alternating in this case between student and instructor in contrast to the course previously described.

Another provider suggested all their post-licence courses included the same basic components, commencing with posture which was said to 'feed into all else'. Next addressed were braking and downward gear changes including revving on the change to enhance compatibility of engine and wheel speeds (sometimes referred to as 'blipping'). Simulated hazard avoidance using traffic cones was then reportedly addressed, followed by cornering, lane positioning and buffering. The provider also noted attention to 'mental skills', interpreted broadly to include situational awareness, behaviour and attitudes appropriate to the riding context, as well as physical skills.

Unlike most others, one provider followed a set curriculum for the first three of its four training levels. Attracting mostly 'sport' riders, the curriculum was described as set, but tailored, involving a mixture of classroom and track sessions, with drill sheets to be completed. The course reportedly focused primarily on cornering, vision and improvement of related skills, while roadcraft did 'get a mention' during lower level courses.

Roadcraft and defensive riding

As proposed earlier by the authors, roadcraft can be viewed broadly as an optimal combination of practical skills, situational awareness, hazard perception and response, and attitudes and behaviours. With some exceptions, most courses appeared to address the principles of roadcraft and defensive riding, but varied in the extent to which and the ways in which they did this. The terms and concepts used by providers in reference to roadcraft included the following, in no particular order:

- Buffering
- Lane positioning
- Following distance (gap to vehicle in front)
- Sideswipe risks
- Hazard perception
- Scanning
- Planning in advance (choosing the time to ride)
- Decision-making (choosing between high risk and low risk)
- Group riding
- Mental skills (self-control)
- Overtaking
- Line sacrifice
- Braking in a corner
- Manoeuvring in tight areas

These terms and concepts are neither mutually exclusive, nor independent where cognition is involved from basic practical skills and their execution. For example, choosing an appropriate following distance or whether to overtake are aspects of decision-making and self-control. Additionally, they were apparently addressed selectively not only among the providers but also among the courses offered, usually based on perceived need or value. Indeed, in a small number of cases attitudinal concerns were reportedly addressed outside the concept of 'roadcraft' as such, with one provider noting for example that some participants would appear to 'pay to argue'. In other words, some riders were not very open to learning or absorbing what was taught.

The extent to which roadcraft was included as an explicit course component varied. One provider indicated that roadcraft was a program element that was currently under development. In contrast, another relatively new provider appeared to have already fully incorporated roadcraft into their overall training program. Yet another provider indicated that roadcraft sessions were an optional course component.

Discussion

The current research sought to examine the PLRT environment in NSW and to identify course options showing potential to improve safety outcomes for licensed motorcycle riders, in particular through attention to identified skills and competencies. A wide range of options were identified and the PLRT environment continues to evolve in terms of course content and availability. Some of the available options had road and traffic safety improvement as explicit core objectives, while others did not. Generally, courses of the latter type (track-based) may attract participants with higher sensation-seeking tendencies, while those of the former type may appeal to riders who are relatively risk averse. Although this proposition invites speculation as to potential safety outcomes, it is unfortunately not possible in the current research to estimate the effects of either type of course in terms of on-road crash and injury risk. Evaluations of specific PLRT programs to date are extremely limited, have been methodologically compromised and have shown mixed results (Kardamanidis et al., 2010). However, regardless of the type of course, the stated key goal of PLRT providers generally is to improve participant skills, knowledge and abilities. Providers reported achieving this to varying degrees with most participants across all levels. As noted, however, PLRT is not subject to external auditing and formal post-course testing of participants was not conducted by providers for the purpose of internal evaluation.

As both a fundamental attraction and an inherent challenge of motorcycle riding, it is unsurprising that much attention and emphasis in PLRT concerns cornering and related skills. Vision, scanning and observation skills are important for more than just hazard perception in the context of motorcycle riding and can be considered integral to cornering manoeuvres in general. In this sense, where providers pay specific attention to cornering, they can also be expected to address in some way vision and observation as part of those activities. However, it is important to distinguish between traffic and non-traffic contexts in relation to these skills and competencies, feeding into the concept of roadcraft. To the extent that roadcraft and defensive riding are attitudinal and behavioural issues, it is interesting that relevant course components can be optional; negative attitudes toward (and avoidance of) a roadcraft component may reflect a belief among some PLRT participants that they have little or nothing to learn in that area.

The deficient skill levels frequently observed by some providers seemed in part to reflect a perceived failure of pre-licence training and assessment. Several providers expressed frustration with the then-current motorcycle rider licensing and training system. These issues were beyond the scope of the current research and providers were therefore not asked to expand on such comments. However, there is potential for research to further examine why some fully licensed riders present to PLRT courses lacking basic skills and competencies. While pre-licence training and assessment may be a factor in these observations among providers, other factors including lack of recent riding experience (practice) and/or general complacency toward maintaining skills may also contribute. Responses on returning rider representation were estimates only and given the lack of a clear 'returning rider' definition, reluctance or inability among providers to offer an estimate is understandable. Nonetheless, returning riders appear to comprise a substantial proportion (10 – 40%) of all PLRT participants and are included in those observed by some providers as lacking basic skills.

The current research suggests that PLRT frequently aims to correct unsafe behaviours and improve basic skills as well as strengthening the competencies of riders who are relatively accomplished. The absence of direct evidence of safety effects is acknowledged in the current research, while any positive effects of PLRT on motorcycle safety overall may be minimal due to low participation rates. Unfortunately, with relevant data not obtained from several providers, it has not been possible in the current study to reliably estimate PLRT participation rates (see Table 3). However, with just over 241,000 registered motorcycles and scooters in NSW in 2018, it seems likely that only a small fraction of licenced riders undertakes PLRT in any given year (acknowledging that some individuals hold multiple registrations).

As noted in the introduction to this paper, clear support for PLRT has been shown among local and international stakeholders. The current research supports their promotion of ongoing, repeated and progressive training experiences. However, there are relatively few riders self-selecting for PLRT. On the prospect of mandating PLRT participation either periodically for continuing riders or as a 'refresher' for returning riders (however they be defined), there is currently no evidence base for program effectiveness to support such a recommendation. The challenge of objectively evaluating PLRT effectiveness in reducing crash risk thus remains a topic for further research. Whether voluntary or mandatory, efforts to increase participation must consider the diversity of PLRT programs available, as identified in the current research, and that course costs are a likely barrier for many riders. Further, it is not clear which strategies, such as increased advertising and promotion or added incentives, would significantly increase participation.

Conclusions

The research identified 36 practical PLRT courses and four theoretical, classroom or workshop options that may assist riders to manage potential crash risks. Trainees were reported to have vastly different characteristics, needs and objectives for undertaking training; some reportedly required skills development from a low level while some were highly competent. This reflects a need for a diverse range of course offerings, which appears to be largely met across NSW overall, although courses were geographically limited and some course costs a potential if not likely barrier to participation.

Many of the PLRT programs contained, and were often structured around, the key competencies identified above. There was generally no standardised curriculum and, arguably, such an approach would not provide the flexibility needed for providers to realise the goal of 'improvement' across a diverse PLRT participant population. Providers indicated that prospective PLRT participants sometimes lacked basic skills that could be expected to be acquired through pre-licence training. Prerequisites were usually set for higher level course participation, and training was often tailored to participants' individual requirements.

The extent to which each training course would likely support riders to manage on-road risks was examined, based on the inclusion of key competencies in program components, as well as the broadly defined concepts of 'roadcraft' and 'defensive riding'. Around half of available courses appeared likely to support riders' risk management, clearly addressing both skills and roadcraft, while 20 percent appeared to include only limited skills and roadcraft content. The remaining options were track-based courses, with a higher degree of uncertainty regarding potential road safety benefits.

Advocacy for motorcycle rider training, including voluntary PLRT, continues among stakeholders as a key strategy for improving rider safety and reducing motorcycle crash risk. With existing evaluations of rider training showing mixed results and notable limitations, and with a wide range of PLRT options available, the need seems clear for further research examining the potential contribution of specific forms of PLRT toward achievement of road safety strategy goals.

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Use of Spatial Analysis Techniques to Identify Statistically Significant Crash Hot Spots in Metropolitan Melbourne

Elizabeth Hovenden[1] and Gang-Jun Liu[2]

[1]*Department of Transport, Melbourne, Australia*
[2]*Royal Melbourne Institute of Technology, Melbourne, Australia*

Corresponding Author: Elizabeth Hovenden, Department of Transport, 60 Denmark Street, Kew Vic 3101, Elizabeth.Hovenden@roads.vic.gov.au, +61 423 597 433.

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Key Findings

- In metropolitan Melbourne 15.7 per cent of casualty crash locations were hot spots;
- The degree, location and extent of clustering varied for different crash categories;
- Fatal crashes had the lowest clustering level whilst bicycle crashes had the highest;
- There are temporal variations in clustering;
- Hot spot clusters were in locations with a high proportion of commercial land use.

Abstract

Understanding where, when, what type and why crashes are occurring can help determine the most appropriate initiatives to reduce road trauma. Spatial statistical analysis techniques are better suited to analysing crashes than traditional statistical techniques as they allow for spatial dependency and non-stationarity. For example, crashes tend to cluster at specific locations (spatial dependency) and vary from one location to another (non-stationarity).

Several spatial statistical methods were used to examine crash clustering in metropolitan Melbourne, including Global Moran's I statistic, Kernel Density Estimation and Getis-Ord Gi* statistic. The Global Moran's I statistic identified statistically significant clustering on a global level. The Kernel Density Estimation method showed clustering but could not identify the statistical significance. The Getis-Ord Gi* method identified local crash clustering and found that 15.7 per cent of casualty crash locations in metropolitan Melbourne were statistically significant hot spots at the 95 per cent confidence level. The degree, location and extent of clustering was found to vary for different crash categories, with fatal crashes exhibiting the lowest level of clustering and bicycle crashes exhibiting the highest level of clustering. Temporal variations in clustering were also observed.

Overlaying the results with land use and road classification data found that hot spot clusters were in areas with a higher proportion of commercial land use and with a higher proportion of arterial and sub-arterial roads. Further work should investigate network-based hot spot analysis and explore the relationship between crash clusters and influencing factors using spatial techniques such as Geographically Weighted Regression.

Keywords

Crash Hot Spots, Spatial Statistics, Spatial Analysis, Getis-Ord Gi*

Glossary

Cold spot. Low values surrounded by other low values. Has a low negative z-score (standard deviation) and a low p-value, indicating that the pattern observed was unlikely to be caused by a random process. The lower the z-score, the more intense the clustering (a z-score near zero means no spatial clustering).

Crash cluster. A concentration of crashes.

Euclidean distance. Straight line distance between two points.

Feature Class. A homogeneous collection of common features (for example, roads), each having the same spatial representation such as points, lines, or polygons, and a common set of attribute columns (Esri, n.d.-a).

High off-peak period. The period during the weekday between the AM and PM peak periods. For this research the period was from 10:00 AM to 2:59 PM.

Hot spot. High values surrounded by other high values. Has a high positive z-score (standard deviation) and a low p-value, indicating that the pattern observed was unlikely to be caused by a random process. The higher the z-score, the more intense the clustering (a z-score near zero means no spatial clustering).

Low off-peak period. The period during the weekday between the PM and AM peak periods. For this research the period was from 7:00 PM to 5:59 AM.

Modifiable Area Unit Problem (MAUP). A source of statistical bias and results from the aggregation of data. For example, aggregating crashes to grids of fixed size (such as 100m by 100m) will give a different crash density for a location than if the crashes were aggregated to local government areas.

Non-stationarity. Variation from one location to another (spatial non-stationarity), or from one time-period to another (temporal non-stationarity).

Spatial autocorrelation (spatial dependence). A measure of the similarity between nearby observations. If spatial autocorrelation exists, then the observations are spatially dependent. This can affect the results from statistical analyses that assume data independence.

Introduction

Worldwide, more than 1.25 million people die due to road traffic crashes each year and a further 20 to 50 million people suffer injuries, some of which result in disabilities (World Health Organisation, 2018). Road crashes are the ninth leading cause of death globally, are the leading cause of death in people aged between 15 and 29 and are estimated to cost most countries around three percent of their gross domestic product (World Health Organisation, 2018).

Victoria's Towards Zero Road Safety Strategy and Action Plan 2016-2020 (Victoria State Government, 2016, p. 6) states that 'preventable road crashes conservatively cost the Victorian community more than $3 billion a year'. Between 2012 and 2016, 70,539 casualty crashes occurred on Victorian roads (VicRoads, 2018). Seventy-one per cent of these occurred on metropolitan Melbourne roads, equating to around 10,000 casualty crashes per annum. The resulting cost to the community is massive, both financially and emotionally. Understanding where, when, what type and why the crashes are occurring can help in determining the most appropriate initiatives to reduce this level of road trauma.

Crashes exhibit a spatial and temporal non-random distribution therefore spatial analysis techniques are well suited to provide this understanding. Only a limited amount of studies has been done in Australia on crashes using spatial analysis techniques. This research project addresses this gap by using spatial analysis and spatial statistics tools to investigate the occurrence of casualty crashes in metropolitan Melbourne.

The purpose of this research was to:

- Investigate where, when and what types of casualty crashes are occurring;
- Determine whether clusters differ temporally and by type of crash and vehicle type;
- Identify some of the factors influencing the location of the clusters.

To address the first two items, all casualty crashes in metropolitan Melbourne between 2012 and 2016 were investigated and clustering was examined by year, by time-period, by severity, by crash type and by vehicle type. To address the third item, the output from the hot spot analysis was used to investigate the relationship between hot spot location and explanatory factors including road classification and land use.

It was hypothesised that there would be locations where crashes are clustered and that there would be both temporal differences and differences related to crash type and vehicle type. There was also an expectation that there would be a statistically significant relationship between hot spot location and road classification, and between hot spot location and land use.

Literature Review

As crashes are influenced by spatial factors (Loo & Yao, 2012), spatial analysis techniques are well suited to identify crash patterns and the characteristics of those patterns (Nie, Wang, Du, Ren & Tian, 2015; Prasannakumar, Vijith, Charutha & Geetha, 2011). Statistical analysis by itself, without the spatial component, is limited as it does not allow association of crash characteristics with spatial distribution (Gudes, Varhol, Sun & Meuleners, 2017). Traditional statistical techniques assume spatial independence and stationarity, however crashes exhibit spatial autocorrelation (spatial dependence) clustering at specific locations such as on vertical and horizontal curves (Mohaymany, Shahri & Mirbagheri, 2013) and they exhibit non- stationarity, varying from one location to another. Failure to account for spatial autocorrelation can lead to errors when interpreting models (Getis & Ord, 1992).

Spatial Analysis Techniques

Statistical spatial analysis of crashes can be event-based, where crashes are represented as points, or link- and area-based, where crashes are aggregated to a road segment or area (Loo & Yao, 2012). Clustering can be measured using global or local methods. A global method looks at the whole study area and produces a global statistic indicating the degree of clustering. A local method looks at individual locations to determine spatial association in the vicinity of the location and produces local statistics for each location indicating the degree of clustering.

Moran's I Statistic

Whilst there are several techniques to test for spatial autocorrelation, one of the most common ones is the Moran's I statistic (Getis & Ord, 1992; Mohaymany et al., 2013). This method is suitable for area-based analysis and describes how crashes are distributed across the whole study area (Loo & Yao, 2012; Nie et al., 2015). It evaluates whether a pattern is clustered, dispersed or random for a given set of features and associated attributes by comparing the values of the variable at one location with the value at all other locations (Esri, n.d.-b; Prasannakumar et al., 2011).

Being a global index, Moran's I provides statistics based on the entire study area. Although there is a local version of the Moran's I index that can be used to identify clusters, it cannot identify statistically significant clusters of hot spots (high values surrounded by high values) or cold spots (low values surrounded by low values). To do this, the Getis-Ord Gi* statistic can be used (Nie et al., 2015).

Kernel Density Estimation

Kernel Density Estimation (KDE) is a common method used to identify spatial patterns for event-based data. It can be used to explore crash clustering and analyse patterns. It creates a density surface, and the darker the colour of the surface, the higher the crash intensity (Mohaymany et al., 2013; Plug, Xia & Caulfield, 2011). Considerations when using KDE is what kernel function should be used and choice of bandwidth. Too large a bandwidth will result in the same density for the area (that is, it will show significant smoothing), too small a bandwidth will just highlight individual points (Plug et al., 2011; Pour, Moridpour, Rajabifard & Tay, 2017). To determine the optimum bandwidth a global Moran's I spatial autocorrelation analysis can be applied, and a visual sensitivity analysis can be undertaken of the results (Lawrence, Stevenson, Oxley & Logan, 2015).

KDE has some limitations. One limitation is that it assumes a two-dimensional (planar) distribution whereas crashes are constrained to the one-dimensional road network. To overcome this limitation, Network-Constrained Kernel Density Estimation (NKDE), in which the distance measure is based on network distance, not Euclidian distance, could be used. Another limitation is that KDE (and NKDE) do not identify which clusters are statistically significant (Nie et al., 2015; Truong & Somenahalli, 2011). However Bíl, Andrášik & Janoška (2013) have developed a method of testing the significance of clusters output from KDE analysis. This method is implemented in the KDE+ application (Transport Research Centre CDV, 2020).

Getis-Ord Gi* Statistic

The Getis-Ord Gi* statistic is a local measure that can be used on link-based or area-based data. It measures the degree of association between weighted points over a given distance (Getis & Ord, 1992). The choice of distance is important. If it is too small or too large, then the assumption of normality is lost (Getis & Ord, 1992). The Getis-Ord Gi* statistic can be used to identify hot spots. Being a local statistic, it can be used to assess each feature in relation to its neighbours and to compare the local and global situations (Esri, n.d.-c).

A drawback of Getis-Ord Hot Spot analysis is that it requires the aggregation of data, which can lead to the modifiable area unit problem – that is, different results being produced depending on how the data was aggregated (O'Sullivan & Unwin, cited in Plug et al., 2011). There is a network-constrained version of Getis-Ord Gi* (GLINCS) which can be used to measure spatial autocorrelation and concentration of crashes on a network (Nie et al., 2015).

Although the Getis-Ord Gi* statistic can be used for local spatial analysis, it cannot diagnose local instability in global measures of association (Anselin, 1995). It is harder to detect local clusters when there is global autocorrelation as this significantly impacts the distribution of local statistics, therefore it is important to consider both the local and global statistics when undertaking spatial analysis (Ord & Getis, 1995). Used in conjunction with global statistics, the Getis-Ord Gi* statistic gives a better understanding of spatial association and allows local 'pockets' of dependence (clusters or hot spots) to be identified (Getis & Ord, 1992).

Findings from previous studies using spatial analysis

There have been many studies of crashes undertaken internationally using techniques such as the Moran's I statistic, the Getis-Ord Gi* statistic and KDE individually and in combination. In some studies the crashes were spatially and/or temporally partitioned (Chance Scott et al., 2016; Prasannakumar et al., 2011). Some studies used severity indices, as well as actual counts, with more severe crashes being given a higher weighting (Choudhary, Ohri & Kumar, 2015; Soltani & Askari, 2017). The results of the studies showed significant clustering of crashes, especially on arterial roads and near urban activity centres, but found that in certain locations the distribution of crashes was random (Chance Scott, Sen Roy & Prasad, 2016; Prasannakumar et al., 2011; Soltani & Askari, 2017). Benedek, Ciobanu and Man (2016) used network-based analysis to identify crash hot spots and found that the number of crashes was directly proportional to the traffic volume, and that the hot spots were in locations where traffic was high.

Studies into the relationship between crashes and explanatory variables using spatial techniques such as Geographically Weighted Regression found that length of highway had the greatest effect on the number of crashes (Erdogan, 2009) and that speed was an influential factor for single vehicle fatal crash hot spots in rural areas (Liu & Xia, 2015). Other findings were that networks centred on major roads had less pedestrian and cyclist crashes due to less conflicts on local roads between these road users and motorised vehicles (Zhang, Bigham, Ragland & Chen, 2015) and that freeway kilometres and road density were negatively correlated with fatal crashes whilst population density and under 18 population were positively correlated (Li, Wang, Liu, Bigham & Ragland, 2013).

There have only been a limited number of studies of crashes in Australia that have used spatial analysis techniques. Most of the studies used a combination of KDE and Moran's I statistic and some studies used Getis-Ord Gi* statistics. Lawrence et al. (2015) undertook geospatial analysis using KDE to understand the spatial trend in cycling crashes in Melbourne. Pour et al. (2017) undertook spatial analysis of vehicle-pedestrian crashes in metropolitan Melbourne, using KDE to identify areas with high crash risk and Moran's I to determine spatial dependency, and found a positive spatial correlation between time and location of crashes. Truong and Somenahalli (2011) undertook spatial analysis of pedestrian-vehicle crashes in Adelaide to identify and rank unsafe bus-stops, using the Moran's I statistic to examine spatial patterns and measure spatial autocorrelation, and the Getis-Ord Gi* statistic to identify clustering. They identified unsafe bus stops by overlaying bus stop data onto the hot spots and ranking the bus stops based on the severity index of the pedestrian-vehicle crashes. Plug et al. (2011) investigated single vehicle crashes in Western Australia using spider-plots for the temporal analysis and KDE for the spatial analysis. By arranging the KDE surfaces sequentially, they illustrated the variation in spatial distribution over the day. Gudes et al. (2017) used the Emerging Hot Spot tool (a space-time implementation of Getis-Ord Gi*) to identify and categorise concentrations of articulated heavy vehicle crashes in Western Australia. The categories included 'new hot spot' or 'persistent hot spot' and the study used KDE applied to network data to analyse the hot spots.

Methods

Analysis was undertaken on 2012-2016 crash data for metropolitan Melbourne. The crash data was sourced from the publicly-available VicRoads Crash Stats data extract. Due to incompleteness of 2017 and 2018 data at the time the analysis was undertaken, these years were excluded. As well as spatial clustering of total casualty crashes, the analysis looked at spatial clustering by temporal characteristics (individual year and time period), crash severity, crash type and vehicle type.

Microsoft Excel (Office16) and ESRI ArcGIS 10.3.1 for Desktop were used for the preparation, organisation and analysis of the data. The exploratory and explanatory analyses carried out on the data are briefly described below. For more details, refer to the Appendix.

Exploratory spatial statistical analysis (spatial autocorrelation and spatial clustering)

The Spatial Autocorrelation (Morans I) tool was used to explore clustering of crashes globally (for the entire study area). As crashes are event-based, an important consideration when identifying local clustering was how to aggregate the data since different aggregation methods can lead to different results. The methods and aggregation levels investigated included the following.

- Kernel Density Estimation (KDE). Two cell sizes were tested (100m and 500m). Each crash was counted only once, the area units were square kilometres, the output values were densities and the method was planar.
- The Getis-Ord Gi* hot spot analysis method. Alternative aggregation methods were tested, including aggregation to grid of fixed size (100m, 500m and 1000m), aggregation to point with no integration (that is, aggregation of crashes at coincident points), aggregation to point with integration (that is, aggregation of crashes within a specified distance of each other – distances from 10m to 100m were tested).

The 'Integrate' tool (with a 10m tolerance) and the 'Collect Events' tool was used on each of the categories of interest to convert event data (crashes) into weighted point data for further analysis. The 'Spatial Autocorrelation (Morans I)' tool was then used to identify global clustering, with 'Inverse Distance' conceptualisation, Euclidean distance method and a threshold distance of 1000m (other threshold distances, up to 10,000m, were also tested). The 'Hot Spot Analysis (Getis Ord Gi*)' tool was then used to identify statistically significant hot spots and cold spots, with 'Fixed Distance Band' conceptualisation, Euclidean distance method and a distance band of 1000m. To visualise the results, the 'IDW' tool was used to interpolate a raster surface from the 'GiZScore' from the hot spot analysis point layer for each category and symbology was applied to show the clusters.

Explanatory spatial statistical analysis

In this part of the analysis, polygons were created (using the 'Aggregate Point' tool) around each cluster of hot spots that were identified in the Getis-Ord Gi* Hot Spot Analysis. The criteria use in this analysis to define a cluster was an area that had three or more hot spot locations with a confidence level of 95 per cent or above. The polygons were merged to create a single feature class and, after testing various buffer sizes, a 200m buffer was applied to ensure that abutting land use was included in the polygons.

This process was repeated for each cold spot cluster to create a cold spot feature class (with a 200m buffer). The ‘Aggregate Point’ tool was used to create a feature class of random (non-significant) points, a 200m buffer was applied and the ‘Erase’ tool was used to remove overlaps with the hot spot and cold spot polygons. The large Melbourne hot spot polygon was split into smaller polygons by the ABS SA2 level.

The length of road for each road classification (based on the CLASS_CODE field from the TR_ROAD layer) and the land use area for each land use type (based on MB_CAT16 field from the MB_2016_VIC layer) was calculated for each hot spot, cold spot and random (non-significant) polygons using the ‘Intersect’ tool, the ‘Summary Statistics’ tool, and table joins based on attributes. The number of intersections was also calculated for each polygon using the ‘Unsplit Line’ tool, the ‘Intersect’ tool (with Output Type set to ‘Point’), the ‘Integrate’ tool (with a 10m tolerance) and the ‘Collect Events’ tool and a join based on spatial location.

Mesh Block non-spatial attributes were added to the hot spot, cold spot and random (non-significant) polygons. As some Mesh Blocks areas were only partially within the polygons, the ‘Clip’ tool was used and then the proportion of the clipped area to original area was calculated and the attribute values such as population were recalculated based on the proportional area. For example, if the Mesh Block has a population of 200 and the clipped Mesh Block area is 80 per cent of the original Mesh Block area, then the adjusted population is 0.8*200 = 160. This assumes a uniform distribution of the attribute in the whole area (e.g. Mesh Block) however this may not necessarily be the case. The tables were then joined based on spatial location. The data was exported and comparative statistics for population density, intersection density, land use and road classification were calculated in Excel for the hot spots, cold spots, random (non-significant) locations and the total metropolitan Melbourne area. As ‘Water’ made up only 0.5 per cent of the total land use, it was added to ‘Other Land Use’.

Results and Discussion

Metropolitan Melbourne comprises of 31 local government areas covering an area of 8,800 square kilometres. It has over 30,000 kilometres of roads, 5,000 kilometres of which are freeways, highways and arterial roads. The population of metropolitan Melbourne has increased from 4.2 million in 2012 to 4.6 million in 2016 and is now 4.9 million (as at 30 June 2018; Australian Bureau of Statistics, 2019).

Between 2012 and 2016, there were 50,305 casualty crashes in metropolitan Melbourne (VicRoads, 2018). This represents 71 per cent of the total casualty crashes in Victoria for this period. Figure 1 shows the location of the casualty crashes in metropolitan Melbourne. Of the 50,305 casualty crashes:

- 565 were fatal crashes where one or more persons were killed;
- 14,394 were serious injury crashes, where one or more persons required hospitalisation;
- 35,346 were other (minor) injury crashes.

Exploratory spatial statistical analysis: spatial autocorrelation and spatial clustering

The Spatial Autocorrelation (Moran’s I) tool identified statistically significant clustering for 2012-2016 metropolitan Melbourne casualty crashes. Running the tool for each of the crash categories found that crash clustering was statistically significant at a global level for all the crash categories analysed ($p < .001$) except for fatal crashes ($p = .569$) and crashes involving light commercial vehicles ($p = .286$), buses ($p = .185$) and trams ($p = .224$) indicating

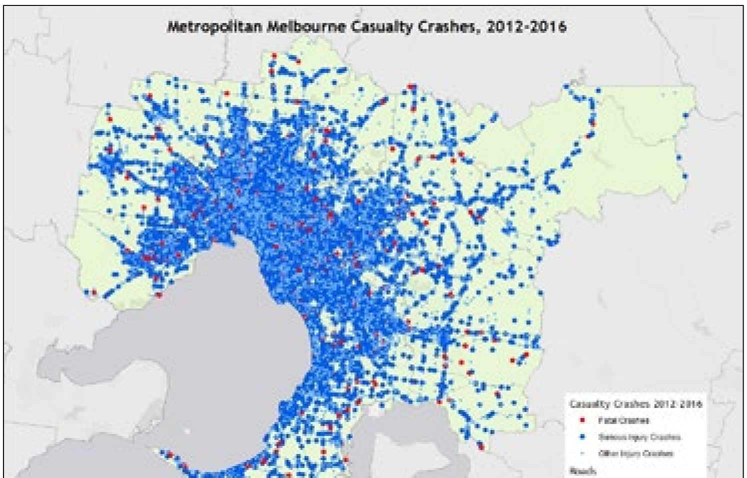


Figure 1. Metropolitan Melbourne casualty crash locations – 2012 to 2016

a random global pattern for these four crash categories. Increasing the distance threshold reduced the p-values for these four crash categories, however even with a distance threshold of 10,000m the p-values were greater than 0.1. This method however could not identify local clustering.

Comparison of analysis and aggregation methods for local clustering

The KDE method was able to show areas with local crash clustering. The map in Figure 2 shows the results of the KDE analysis method using a 100m cell size (the 500m cell size gave similar results but the output was coarser). Density was calculated using a kernel function and the output (casualty crashes per square kilometre) was classified using 'Natural Breaks (Jenks)' with darker areas representing higher crash densities.

The classification method chosen to symbolise the results was an important consideration as different classification methods led to different interpretations of the results. The 'Natural Breaks (Jenks)' classification resulted in a high-density area in inner Melbourne, with decreasing density away from inner Melbourne. In comparison, other than for the inner Melbourne area, 'Equal Interval' classification resulted in low density for most of metropolitan Melbourne (refer to Figure 3) whilst 'Quantile' classification resulted in a very extensive high-density area radiating out from the inner Melbourne area, extending into middle Melbourne and decreasing in intensity in outer metropolitan Melbourne (refer to Figure 4).

Whilst the KDE method was able to show areas where there was crash clustering, it was not able to show the statistical significance of the crash clusters (at the time of this analysis KDE+ was not available). In addition, the spatial extent of the density categories in the KDE was large, which led to local patterns being hidden.

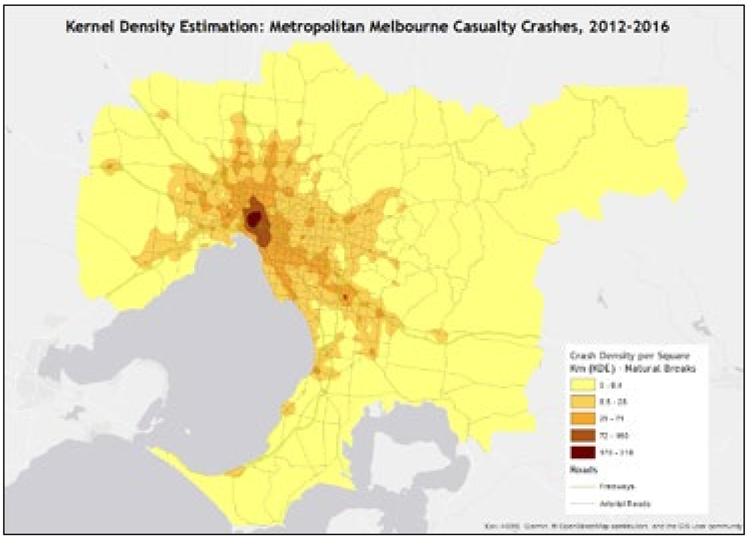


Figure 2. Kernel Density Estimation method, using Natural Breaks for classification

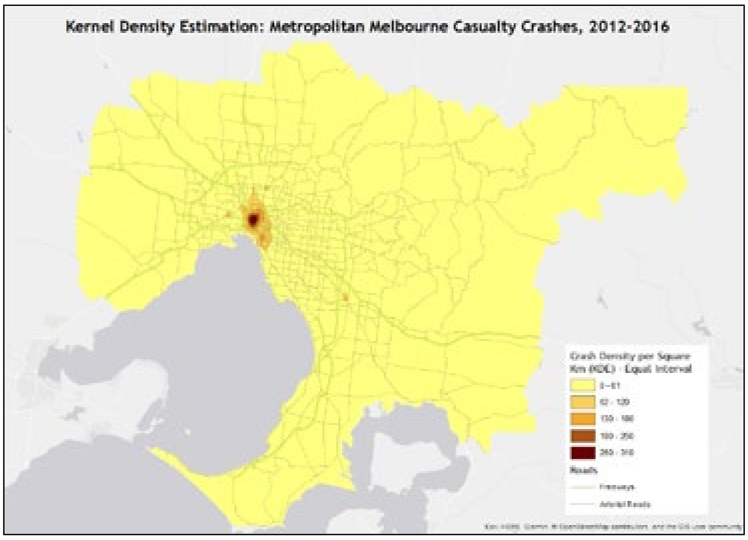


Figure 3. Kernel Density Estimation method, using Equal Intervals for classification

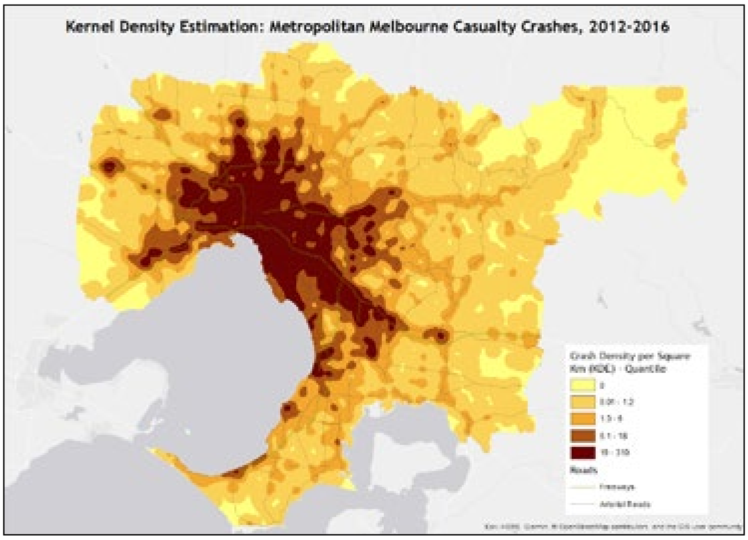


Figure 4. Kernel Density Estimation method, using Quantiles for classification

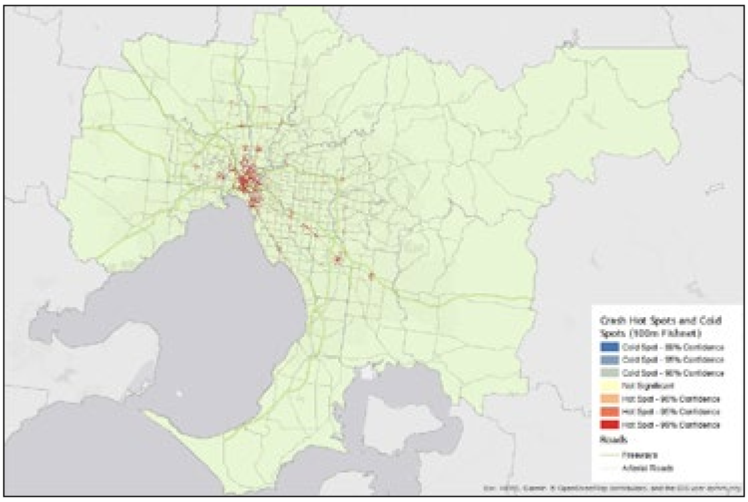


Figure 5. Metropolitan Melbourne casualty crash hot spots and cold spots, 2012-2016 - based on Getis-Ord Gi* analysis using 100m fishnet aggregation

The Getis-Ord Gi* hot spot analysis method was able to identify statistically significant crash clusters. As this method works with aggregated data but crash data is event-based, an important consideration was how to aggregate the data since different aggregation methods can lead to different results. Aggregation to fishnet (a grid of fixed size) and aggregation to point were investigated. The aggregation to administrative boundaries, such as the ABS SA1 areas, was not pursued due to problems in determining which area to allocate boundary crashes (the administrative boundaries generally coincide with the road network and the majority of crashes are assigned to the centreline of the road). Both aggregation to 1000m fishnet and aggregation to 500m fishnet were too coarse, especially when normalised by kilometre of road. Aggregation to 100m fishnet gave good results but took a long time to process. Point aggregation with no integration gave reasonable results, however the point aggregation with 10m integration identified more statistically significant hot spots.

The maps in Figures 5 and 6 show the output of the Getis-Ord Gi* hot spot analysis method with aggregation to 100m fishnet (grids). The map in Figure 7 shows the output of the Getis-Ord Gi* hot spot analysis method with point aggregation and 10m integration. Both methods gave similar results in terms of locations and extent, especially for the larger clusters (see Figures 8 and 9). Although both methods gave good results in terms of identifying areas where there were statistically significant hot spot and cold spot clusters, the latter analysis ran much faster and had the advantage in that it identified actual hot spot and cold spot points as distinct to areas. This was the method chosen for the subsequent crash analysis, using a distance band of 1km.

A limitation with this analysis is that all the methods tested assumed a planar (two-dimensional) distribution of crashes however crashes are constrained to a one-dimensional road network. When spatial analysis methods designed for planar surfaces are applied to network-constrained

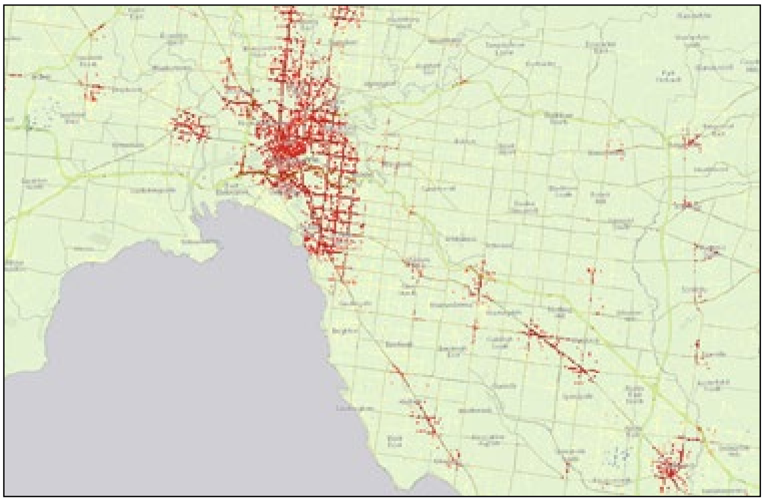


Figure 6. Metropolitan Melbourne casualty crash hot spots and cold spots, 2012-2016 - based on Getis-Ord Gi* analysis using 100m fishnet aggregation – Melbourne zoom-in

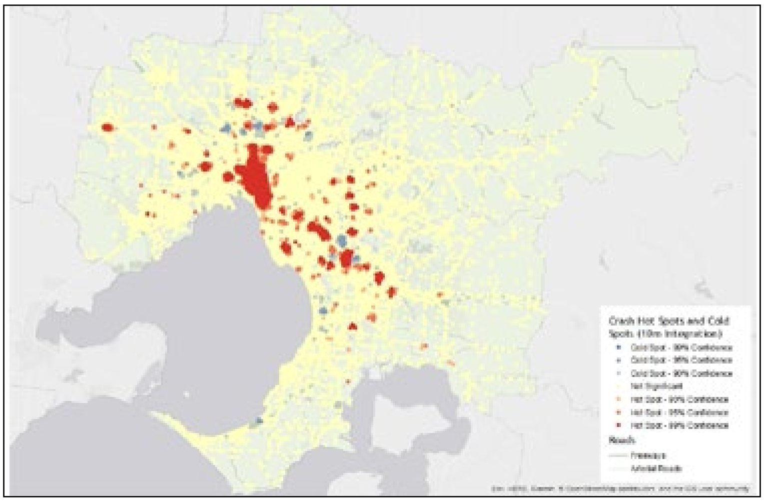


Figure 7. Metropolitan Melbourne casualty crash hot spots and cold spots, 2012-2016 - based on Getis-Ord Gi* analysis and point aggregation with 10m integration

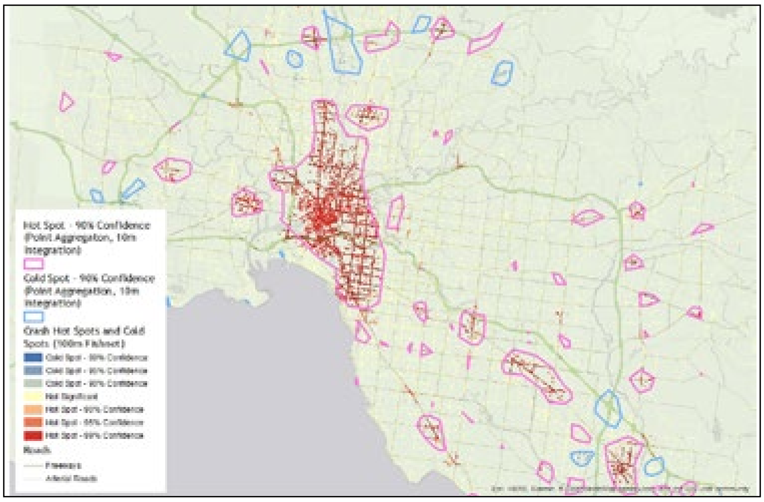


Figure 8. Comparison of aggregation to 100m fishnet with point aggregation with 10m integration for identification of hot spots and cold spots for metropolitan Melbourne 2012-2016 casualty crashes

Figure 9. Comparison of aggregation to 100m fishnet (shown as areas) with point aggregation with 10m integration (shown as dots) for identification of hot spots and cold spots for metropolitan Melbourne 2012-2016 casualty crashes – Dandenong zoom

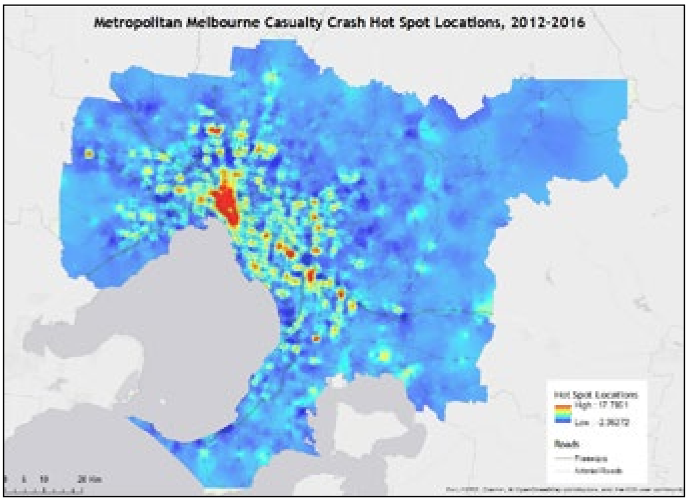


Figure 10. Casualty crash hot spots in metropolitan Melbourne, 2012 to 2016

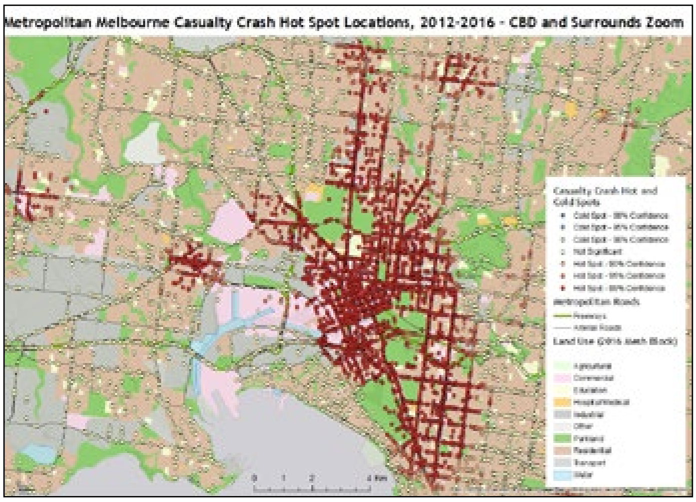


Figure 11. CBD and surrounds, Footscray, Sunshine and Preston zoom: casualty crash hot spots in relation to land use and arterial road network, 2012 to 2016

phenomena such as crashes, it is possible for a crash cluster to be identified just because the network is clustered (Yamada & Thill, 2007) therefore network-based analysis may be useful for identifying crash hot spots and cold spots. One network-based analysis tool is the SANET (Spatial Analysis on a NETwork) tool (Okabe, Okunuki. & Shiode, 2005).

Local clustering (Getis-Ord Gi* statistical method): metropolitan Melbourne casualty crashes

The Hot Spot Analysis (Getis-Ord Gi*) tool identified 4,523 locations (15.7% of total crash locations) as hot spots at the 0.05 significance level. Hot spots were located in areas where there is high trip attraction, such as the Melbourne CBD and its surrounds, and major activity centres such as Dandenong and Footscray (refer to Figures 10 and 11). For more examples of hot spot locations for the different crash categories, refer to the Appendix.

Local clustering (Getis-Ord Gi* statistical method): temporal analysis

Temporal differences were found in the level, location and extent of clustering (see Figure 12). Some locations such as the CBD have remained hot spots from year to year, whilst other locations were hot spots in a particular year, or years, only (e.g. Bundoora), some hot spots decreased over time (e.g. Campbellfield) and other hot spots emerged over time (e.g. Caroline Springs, Carrum Downs). Understanding which hot spots are persistent or emerging, and why, is important in determining which sites to treat and what treatments to apply. Similarly, understanding the characteristics of the declining hot spots is beneficial as the learnings could be applied to the persistent and emerging hot spots.

Weekdays were found to have a higher percentage of locations that exhibited statistically significant clustering compared to weekends (refer to Figure 13). The extent of clustering in the CBD and in Dandenong (both commercial locations) was greater on weekdays than it

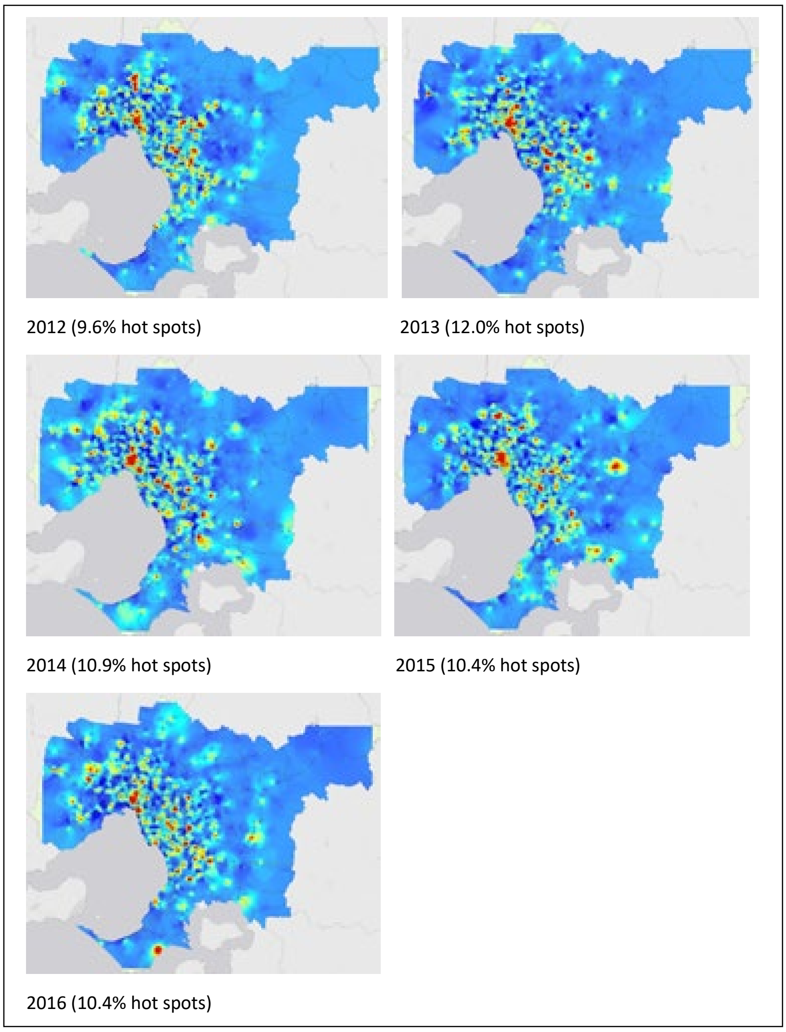


Figure 12. Comparison of metropolitan Melbourne casualty crash hot spots by year: percentage of locations that are hot spots (95% confidence level)

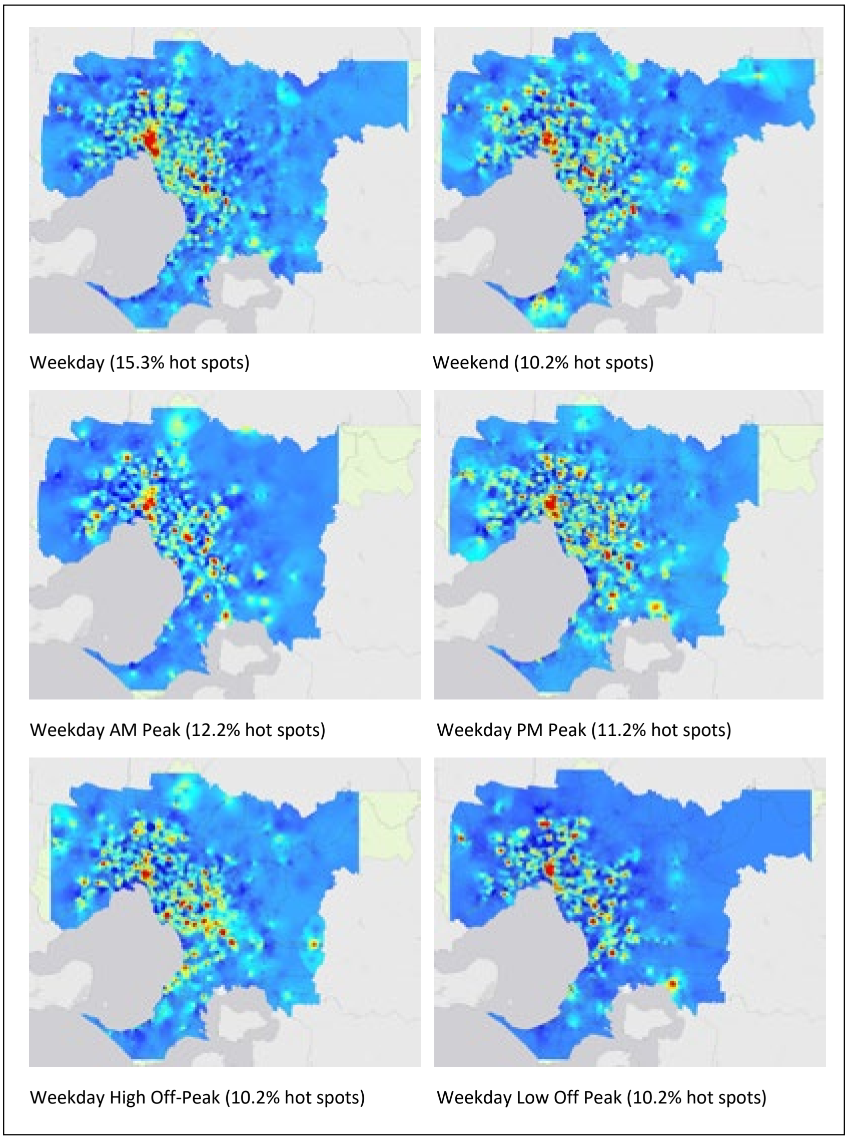


Figure 13. Comparison of metropolitan Melbourne 2012-2016 casualty crash hot spots by weekday, weekend and weekday time-periods (95% confidence level)

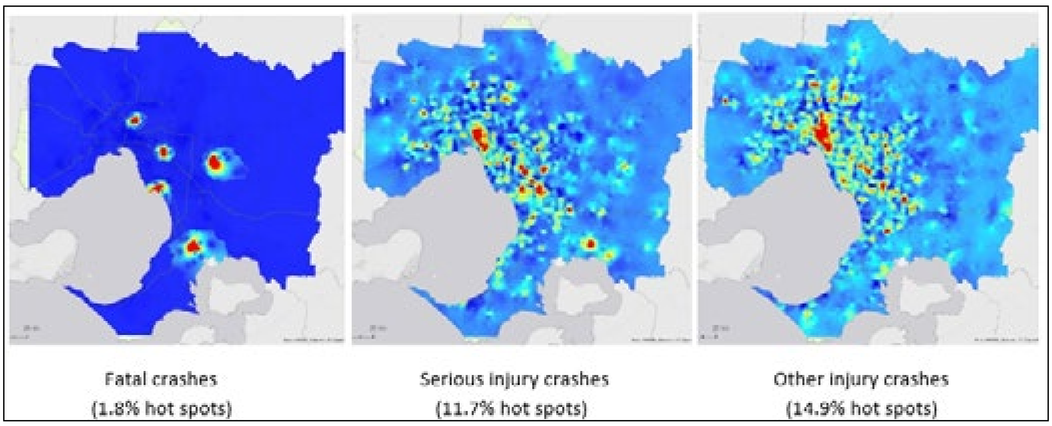


Figure 14. Comparison of metropolitan Melbourne 2012-2016 casualty crash hot spots by crash severity (95% confidence level)

was on weekends. Some locations, such as the Mornington Peninsula and Brighton (coastal locations popular for recreational activities and tourism), were hot spots on weekends but not on weekdays whilst others, such as Footscray and Wantirna (commercial locations), were hot spots on weekdays but not on weekends. Some locations had clustering in some of the periods but not in the others. For example, Melton had crash clustering in the weekday PM peak period and low off-peak period but not during the other periods.

Local clustering (Getis-Ord Gi* statistical method): crash severity

The analysis showed differences in the hot spot locations and the level of clustering between fatal crashes, serious injury crashes and other (minor) injury crashes (refer to Figure 14). Fatal crashes had the lowest level of clustering.

For serious injury crashes and other injury crashes, some locations were hot spots for both severities, whilst other locations were hot spots for only one of these severities. Narre Warren is an example of a location that had no clustering for serious injury crashes but did have clustering for other injury crashes. Caroline Springs is an example of a location that had clustering for serious injury crashes but no clustering for other injury crashes.

Local clustering (Getis-Ord Gi* statistical method): crash type

Differences were found in the hot spot locations and level of clustering for the different crash types (refer to Figure 15). The pedestrian crash type has the highest clustering, more than double that of run off road crashes, head on not overtaking crashes and rear-end crashes and nearly double that of side impact at intersection crashes. Lane change / side swipe crashes had the next highest clustering.

- Pedestrian crash hot spots were located mainly in the inner and middle suburbs of Melbourne and included the CBD and other high pedestrian activity areas such as St Kilda and Richmond.

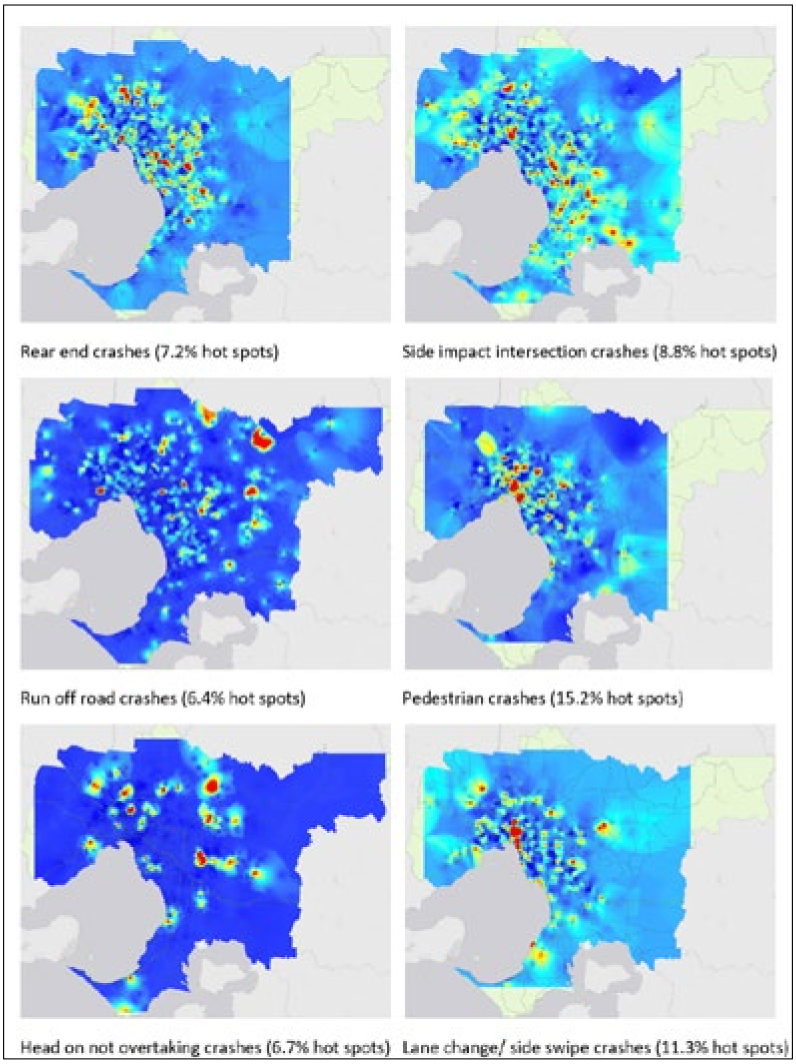


Figure 15. Comparison of metropolitan Melbourne 2012-2016 casualty crash hot spots by crash type (95% confidence level)

- Run off road crash hotspots were clustered in the outer suburbs and some middle suburbs of Melbourne and included areas such as Melton and Belgrave.
- Similarly head on not overtaking crash hot spot clusters were mainly located in the middle and outer suburbs. The head on not overtaking hot spot clusters were often located on sections of roads rather than over an area and included roads like Belgrave-Hallam Road and Maroondah Highway. Many of these roads were curved, although some like Barry Road were straight.
- Rear end crash hot spot clusters are mainly located around major intersections and on motorways (freeways and tollways) within a radius of 20km north and west and a radius of 45km south and east from the CBD. Rear end crash hot spot clusters included roads such as Dandenong Road, the Monash Freeway, the West Gate Freeway and Hume Highway.
- Side impact at intersection hot spot clusters included intersections in the CBD and surrounds, and in middle and outer metropolitan Melbourne areas such as Clayton and Mornington.
- Lane change and side swipe crash hot spot clusters are mainly located in the inner metropolitan Melbourne area including the CBD, and areas such as South Melbourne. There was also a cluster at Brighton.

Local clustering (Getis-Ord Gi* statistical method): vehicle type

Differences were found in the hot spot locations and level of clustering for the different vehicle types (refer to Figure 16). Crashes involving bicycles had the highest clustering, nearly double that of crashes involving passenger cars. Crashes involving light commercial vehicles and crashes involving buses / coaches had the lowest clustering of the vehicle types.

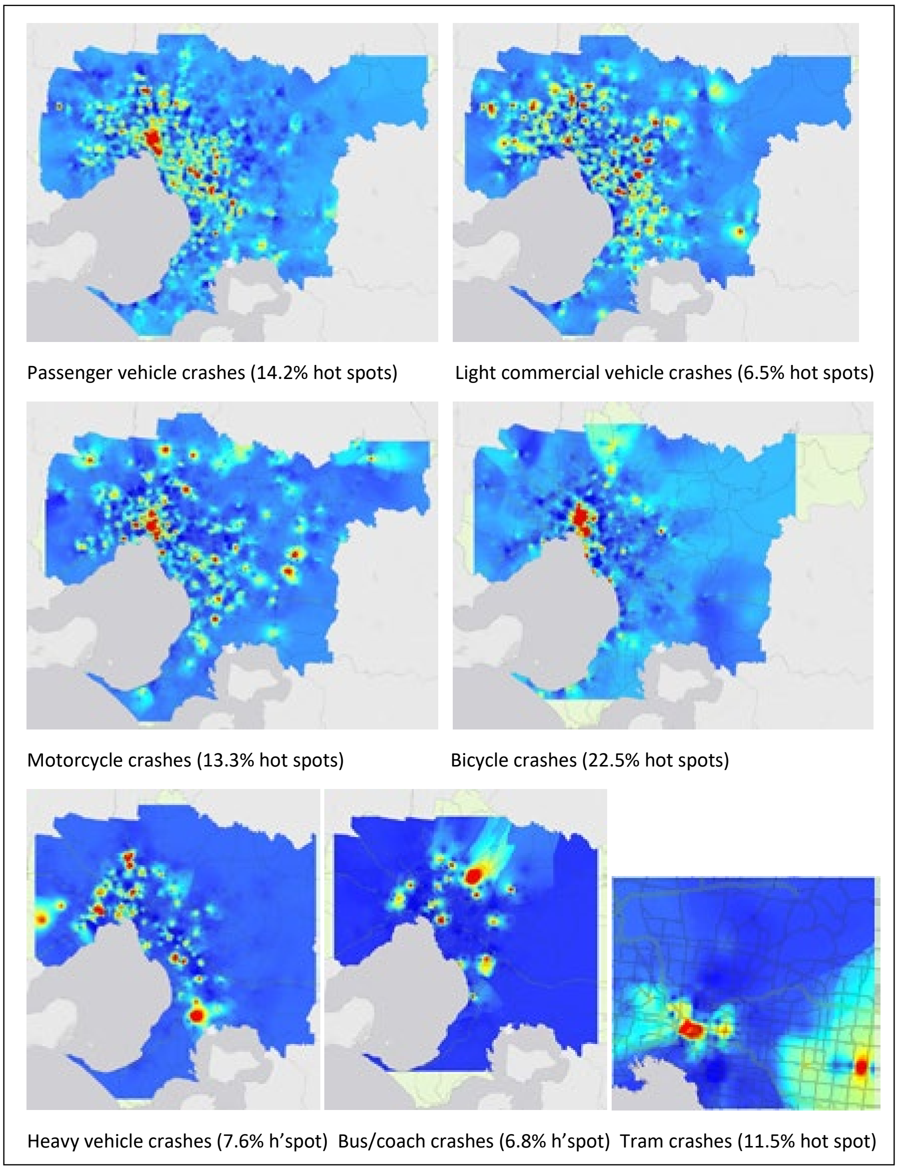


Figure 16. Comparison of metropolitan Melbourne 2012-2016 casualty crash hot spots by vehicle type (95% confidence level)

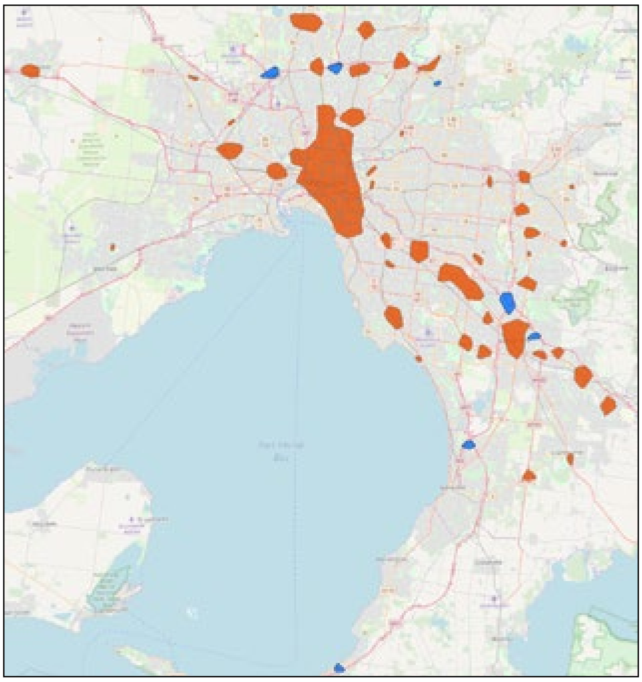


Figure 17. Polygons of statistically significant (95% confidence level) hot spot crash clusters (shown in brown) and cold spot crash clusters (shown in blue) for metropolitan Melbourne 2012-2016 casualty crashes

- Bicycle crash hot spot clusters were mainly located along popular bicycle routes in inner Melbourne (including the CBD) and along St Kilda Road, Chapel Street and Beach Road.
- Heavy vehicle crash hot spot clusters were mainly located around industrial areas such as Laverton, and Campbellfield. The clusters were also located on roads leading to ports, such as Western Port Highway, or on roads connecting ports with industrial areas such as the West Gate Bridge.
- Motorcycle crash hot spot clusters were mainly located in inner and middle metropolitan areas such as the CBD, North Melbourne, Brunswick and Clayton. There were also some clusters in the outer metropolitan Melbourne areas, particularly on windy roads.
- As passenger vehicles were involved in 84 per cent of casualty crashes, the hot spot clusters for crashes involving this vehicle type were almost identical to that for total casualty crashes. One exception was Box Hill which was identified as a hot spot crash cluster for crashes involving passenger vehicles but not for total casualty crashes.
- Light commercial vehicle hot spot crash clusters were mainly located in North Melbourne and Docklands and in middle and outer metropolitan suburbs. They were mainly located on freeways , the approaches to freeways, along major arterial roads (including highways) and around industrial and commercial areas.
- Only 34 locations were identified as hot spots for bus crashes, with most clusters comprising of one or two sites only. Dandenong, Wantirna South, Mordialloc, Toorak, Preston and Epping had hot spot clusters of three or more sites.
- For tram crashes, the CBD, St Kilda Road between Flinders Street and Southbank Boulevard and Carlton were locations that had a cluster of hot spots. Burwood East had one site that was a tram hot spot, as did East Melbourne.

Explanatory spatial statistical analysis

There were 42 clusters with three or more statistically significant hot spot locations (at the 95% confidence level) and seven clusters of three or more statistically significant cold spot locations (at the 95% confidence level) identified from the Getis-Ord Gi* analysis of metropolitan Melbourne 2012-2016 casualty crashes. Figure 17 shows the clusters of hot spots (brown) and cold spots (blue).

A comparison of the characteristics of the hot spot and cold spot clusters is shown Table 1. Both hot spot and cold spot clusters had a higher density of population, road network, intersection and casualty crashes than the total metropolitan Melbourne area. The lower density in the total metropolitan Melbourne area is not surprising as a large proportion of Melbourne is comprised of parkland and agricultural areas. Although road density and, to a

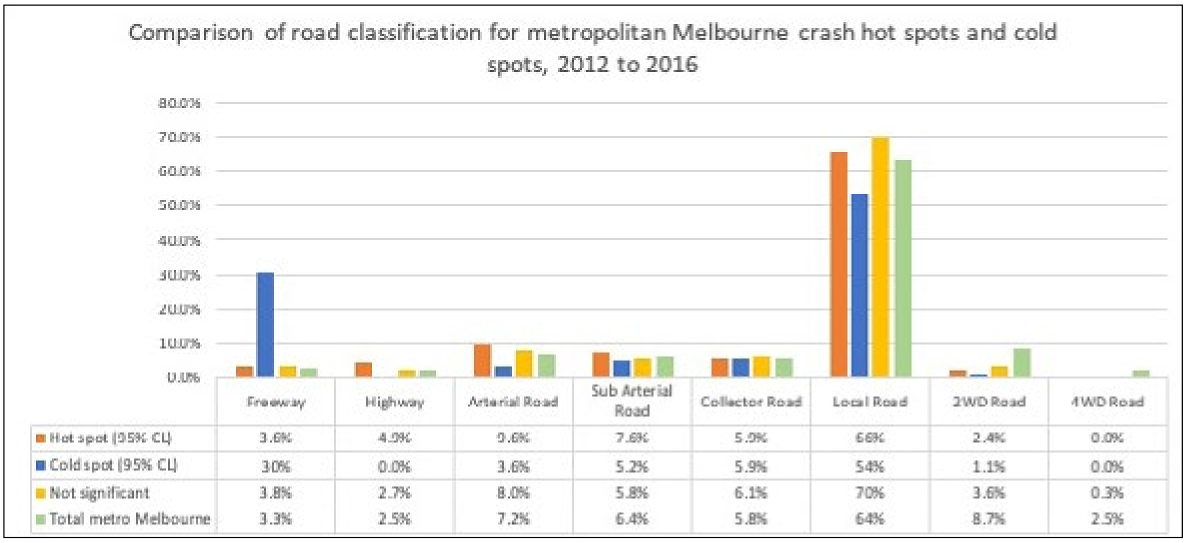
Table 1. Comparison of characteristics of hot spot clusters, cold spot clusters and the total metropolitan Melbourne area

	Hot Spot Clusters	Cold Spot Clusters	Total Metropolitan Melbourne
Population density: persons per square kilometre (based on 2016 ABS data)	3,427	1,833	527
Road density: kilometre road per square kilometre	14	14	3.8
Intersection density: number of intersections per kilometre of road	4.6	3.7	3.3
2012-2016 casualty crashes per kilometre of road	5.6	2.0	1.5
2012-2016 casualty crashes per square kilometre	78	28	5.7

lesser extent, intersection density were similar between the hot spot and cold spot clusters, hot spot clusters had a much higher population density (nearly double) and a much higher crash density (nearly three times higher) than cold spot clusters.

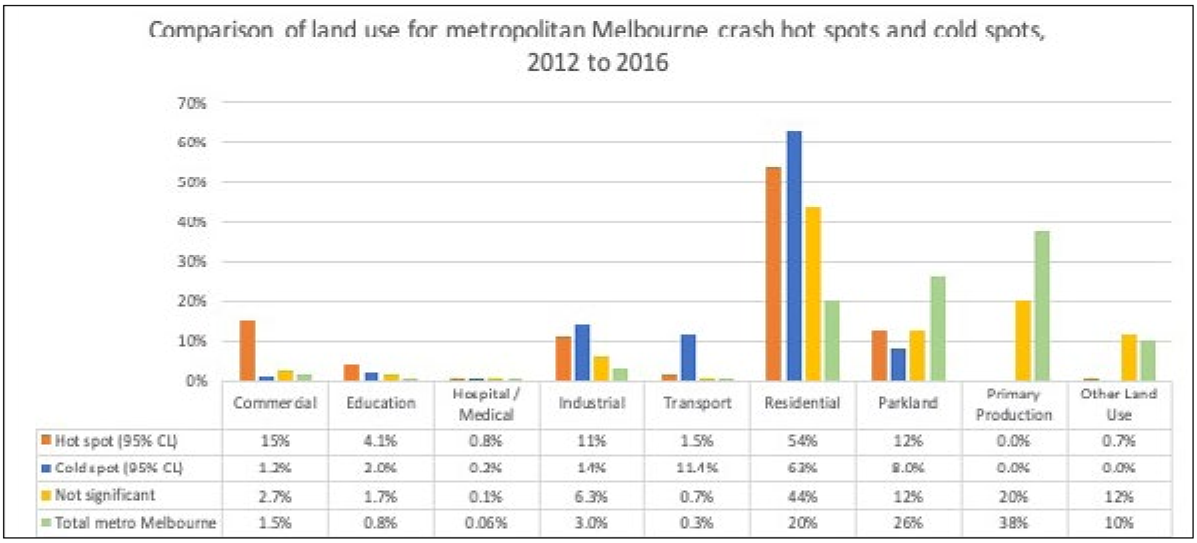
Road classification

Local roads make up the highest proportion of the road network in metropolitan Melbourne, and in the hot spot and cold spot clusters (refer to Figure 18). Highways, arterial roads and sub-arterial roads made up only 16 per cent of metropolitan road network, yet they made up 22 per cent of the road network in the hot spot clusters. This is not surprising as these road types carry high volumes of traffic. Normalising crashes by traffic volume could be undertaken prior to running the spatial analyses to identify hazardous locations without the influence of traffic volumes and is a recommendation for future research. Although freeways carry even higher volumes of traffic, they only made up 3.6 per cent of the road network in the hot spot clusters, slightly higher than in the total metropolitan area (3%). However, in the cold spot clusters they represented 30 per cent of the road network. One potential reason for that is that freeways are built to high safety standards, are divided, and have restricted entry which limits some vehicle-to-vehicle interactions and vehicle-to-pedestrian (and cyclist) interactions, and as a result are safer (in terms of crash rates per vehicle kilometre travel) compared to other road types. Freeway crashes tend to be more evenly dispersed as they are often related to the traffic conditions rather than to the infrastructure itself (Hovenden, Zurlinden & Gaffney, 2020).



	Freeway	Highway	Arterial Road	Sub Arterial Road	Collector Road	Local Road	2WD Road	4WD Road
Hot spot (95% CL)	3.6%	4.0%	9.6%	7.6%	5.0%	66%	2.4%	0.0%
Cold spot (95% CL)	30%	0.0%	3.6%	5.2%	5.9%	54%	1.1%	0.0%
Not significant	3.8%	2.7%	8.0%	5.8%	6.1%	70%	3.6%	0.3%
Total metro Melbourne	3.3%	2.5%	7.2%	6.4%	5.8%	64%	8.7%	2.5%

Figure 18. Comparison of percentage of roads in casualty crash hot spot clusters, cold spot clusters, non-significant (random) crash locations and total metropolitan Melbourne area by road classification, 2012-2016



	Commercial	Education	Hospital / Medical	Industrial	Transport	Residential	Parkland	Primary Production	Other Land Use
Hot spot (95% CL)	15%	4.1%	0.8%	11%	1.5%	54%	12%	0.0%	0.7%
Cold spot (95% CL)	1.2%	2.0%	0.2%	14%	11.4%	63%	8.0%	0.0%	0.0%
Not significant	2.7%	1.7%	0.1%	6.3%	0.7%	44%	12%	20%	12%
Total metro Melbourne	1.5%	0.8%	0.06%	3.0%	0.3%	20%	26%	38%	10%

Figure 19. Comparison of percentage of roads in casualty crash hot spot clusters, cold spot clusters, non-significant (random) crash locations and total metropolitan Melbourne area by land use, 2012-2016

Land use

Metropolitan Melbourne is primarily made up of primary production (agricultural) land use (38%), parkland (26%) and residential land use (20%). Only three per cent of Melbourne's land use is industrial, one per cent is commercial and less than one per cent each is education, medical or transport related (refer to Figure 19).

Exploratory analysis of the relationship between statistically significant crash clusters and land use found that hot spot clusters were in areas with a higher percentage of commercial land use (15%) compared to both cold spot clusters (1.2%) and to the total metropolitan Melbourne area (1.5%), suggesting a relationship between crash cluster location and level of activity. Although numbers are small, hot spot clusters also had a higher percentage of education land use and hospital / medical land use, further supporting this observation. As mentioned earlier, normalising crashes by traffic volume could be undertaken prior to running the spatial analyses to identify hazardous locations whilst taking into account the level of activity.

Both hot spot clusters and cold spot clusters had a higher percentage of industrial land use compared to the total metropolitan Melbourne area (11% and 14% respectively compared to 3%). As industrial areas have a strong temporal component, the percentage of this land use in hot spot clusters could be even higher during certain times and this is an area for further investigation.

Cold spot clusters had a much higher percentage of transport (rail and road) land use (11%) compared to both the total metropolitan Melbourne area (0.3%) and to hot spot clusters (1.5%). It should be noted that transport land use includes freeways, which are discussed in the Road Classification section above.

Further work is required to test the statistical significance of the relationship between the clusters, road classification and land use. It is recommended that spatial techniques including Exploratory Regression analysis, Ordinary Least Squares and Geographically Weighted Regression analysis be undertaken to identify the factors influencing the location of the clusters and explore the relationships between these factors and the clusters.

Conclusions

Metropolitan Melbourne is a rapidly growing area in terms of population and has a sizeable casualty crash problem. Whilst much research of metropolitan Melbourne crashes has been conducted using traditional statistical methods, there has been limited analyses of these crashes using spatial techniques. Crashes are a spatial phenomenon and patterns can be missed using traditional techniques. Without spatial analysis, it is not possible to determine whether crashes are randomly dispersed or clustered which can lead to errors in interpreting results. This research addressed this gap by providing an understanding of the influence of spatial factors on metropolitan Melbourne crashes. The techniques used in this research allowed identification of locations in metropolitan Melbourne with statistically significant crash clusters. Visualisation of the results through mapping provided a better understanding of the spatial and temporal distribution of crashes and allowed identification of persistent and emerging hot spots.

The Hot Spot Analysis (Getis-Ord Gi*) statistic method identified 15.7 per cent of casualty crash locations in metropolitan Melbourne as statistically significant hot spots at the 95 per cent confidence level. Running this method on the different crash categories found that the level (that is, percentage) of crash clustering and the location and extent of the clusters is dependent on temporal factors such as year, time of day and day of week, and on crash severity, type of crash and type of vehicle involved in the crash. Analysis of the clusters with three or more statistically significant hot spot and cold spot locations (at the 95% confidence level) found that hot spot clusters were located in areas with a higher proportion of commercial land use compared to cold spots and to the total metropolitan Melbourne area, suggesting a relationship between crashes and level of activity. Cold spot clusters were located in areas with a higher proportion of freeways, which could be explained by the high safety standards of freeway infrastructure and controlled access.

The results of this analysis can be used to inform the development of strategies, initiatives and treatments to improve road safety on metropolitan Melbourne roads. The spatial techniques used in this research have been applied to systematically identify those locations where the crash clusters are statistically significant. A targeted, evidence-based approach can be adopted to further investigate these locations, find common factors and to develop treatments. This approach can be expanded to the whole of Victoria. Future work in this area includes network-based hot spot analysis, normalisation by traffic volume, and exploration of the relationship between crash clusters and the factors influencing the location of those clusters using spatial techniques such as Exploratory Regression analysis and Geographically Weighted Regression.

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Appendix

Supplementary information to methodology section

Table A1. List of the 31 local government areas used to define metropolitan Melbourne

Banyule	Bayside	Boroondara	Brimbank
Cardinia	Casey	Darebin	Frankston
Glen Eira	Greater Dandenong	Hobsons Bay	Hume
Kingston	Knox	Manningham	Maribyrnong
Maroondah	Melbourne	Melton	Monash
Moonee Valley	Moreland	Mornington Peninsula	Nillumbik
Port Phillip	Stonnington	Whitehorse	Whittlesea
Wyndham	Yarra	Yarra Ranges	

Table A2. Categories used for crash analysis

Category	Group	Definition
Time-Period	AM peak	Weekday, 06:00 to 09:59
Time-Period	PM peak	Weekday, 15:00 to 18:59
Time-Period	High off-peak	Weekday, 10:00 to 14:59
Time-Period	Low off-peak	Weekday, 19:00 to 23:59 and 00:00 to 05:59
Crash Type	Rear end	DCA_CODE between 130 and 132
Crash Type	Side impact at intersection	DCA_CODE in (110, 111, 113, 114, 116, 121, 122) and NODE_TYPE = 'I' (intersection)
Crash Type	Run off road	DCA_CODE in (151, 170, 171, 172, 173, 180, 181, 182, 183)
Crash Type	Pedestrian	DCA_CODE between 100 and 109
Crash Type	Head on not overtaking	DCA_CODE = 120
Crash Type	Lane change or side swipe	DCA_CODE between 133 and 137
Vehicle Type	Heavy vehicle	VEHICLE_TYPE in (6, 7, 60, 61, 62, 63, 72) (includes rigid trucks > 4.5 tonnes GVM and articulated vehicles)
Vehicle Type	Motorcycle	VEHICLE_TYPE in (10, 11, 12)
Vehicle Type	Bicycle	VEHICLE_TYPE = 13
Vehicle Type	Light commercial vehicle	VEHICLE_TYPE in (4, 5, 71) (includes rigid trucks <= 4.5 tonnes GVM, utilities and panel vans)
Vehicle Type	Passenger vehicle	VEHICLE_TYPE in (1, 2, 3, 9)
Vehicle Type	Bus	VEHICLE_TYPE = 8
Vehicle Type	Tram	VEHICLE_TYPE = 15

Table A3. Datasets used in the analysis

Dataset	Source	Description	Comments
LGA_POLYGON	http://services.land.vic.gov.au/SpatialDatamart (VICMAP_ADMIN)	LGA boundaries	A metropolitan Melbourne feature class was created using this dataset, based on the 31 local government areas listed in Table A1. This feature class was then used to clip other spatial datasets to the metropolitan Melbourne boundary.
Crash Stats – Data Extract: • NODE table • ACCIDENT table • VEHICLE table	https://www.data.vic.gov.au	Crash data	The NODE, ACCIDENT and VEHICLE tables were used to create a master crash dataset. Crash locations within metropolitan Melbourne were selected from the NODE table using the 'Intersect' tool and the metropolitan Melbourne feature class. The ACCIDENT table was then filtered using the NODE table. Variables in the ACCIDENT table were grouped to make querying easier. The VEHICLE table was used to select specific vehicle categories (e.g 'heavy vehicles') and this was applied to the ACCIDENT table to identify crashes that involved the particular vehicle category.
TR_ROAD	http://services.land.vic.gov.au/SpatialDatamart (VICMAP_TRANSPORT)	Road network	To exclude roads not open to the public and paths, the following definition query was used: "CLASS_CODE" IN (0, 1, 2, 3, 4, 5, 6, 7) AND "RESTRICTN" NOT IN ('1', '4', '5').
MB_2016_VIC	http://www.abs.gov.au	Mesh block data – includes land use (MB_CAT16)	
2016 Census Mesh Block Counts	http://www.abs.gov.au 2074.0 - Census of Population and Housing: Mesh Block Counts, Australia, 2016	Mesh block population and household data	The 2016 Census Mesh Block Counts (aspatial) dataset was joined to the MB_2016_VIC (spatial) dataset. The attributes used in the analysis included 'MB_CAT16' (land use category), 'Dwelling' and 'Person'.

Results of Getis-Ord Gi* statistic analysis of metropolitan Melbourne casualty crashes

Category	Hot Spots 99%CL	Hot Spots 95%CL	Hot Spots 90%CL	Not Significant	Cold Spots 90%CL	Cold Spots 95%CL	Cold Spots 99%CL	Total Locations	Percentage Hotspots >=95%CL	Percentage Hotspots >=90%CL
Casualty Crashes 2012-2016	3456	1067	768	23030	392	125	0	28838	15.7%	18.3%
Casualty Crashes 2016	512	358	178	7264	17	0	0	8329	10.4%	12.6%
Casualty Crashes 2015	548	320	238	7264	3	0	0	8373	10.4%	13.2%
Casualty Crashes 2014	612	292	203	7165	10	0	0	8282	10.9%	13.4%
Casualty Crashes 2013	617	332	219	6732	5	0	0	7905	12.0%	14.8%
Casualty Crashes 2012	431	333	302	6880	6	0	0	7952	9.6%	13.4%
Weekday Crashes	2672	911	659	18696	315	114	0	23367	15.3%	18.2%
AM Peak Crashes	608	253	236	5930	15	1	0	7043	12.2%	15.6%
PM Peak Crashes	733	394	347	8537	55	0	0	10066	11.2%	14.6%
High Off Peak Crashes	487	290	210	6599	7	1	0	7594	10.2%	13.0%
Low Off Peak Crashes	442	172	164	5213	0	0	0	5991	10.2%	13.0%
Weekend Crashes	613	366	293	8349	17	0	0	9638	10.2%	13.2%
Fatal Crashes	10	0	0	550	0	0	0	560	1.8%	1.8%
Serious Injury Crashes	959	381	321	9812	25	0	0	11498	11.7%	14.4%
Other Injury Crashes	2322	890	564	17515	242	74	1	21608	14.9%	17.5%
Rear End Crashes	359	257	252	7679	7	0	0	8554	7.2%	10.1%
Side Impact Crashes	359	183	149	5377	63	9	0	6140	8.8%	11.3%
Run off Road Crashes	262	116	74	5418	0	0	0	5870	6.4%	7.7%
Pedestrian Crashes	460	159	110	3331	0	0	0	4060	15.2%	18.0%
Head On Crashes	50	35	24	1151	0	0	0	1260	6.7%	8.7%
Lane Change Crashes	259	38	56	2275	0	0	0	2628	11.3%	13.4%
Heavy Vehicle Crashes	96	42	61	1610	0	0	0	1809	7.6%	11.0%
Motorcycle Crashes	532	219	146	4735	0	0	0	5632	13.3%	15.9%
Bicycle Crashes	925	116	76	3496	12	0	0	4625	22.5%	24.2%
Light Commercial Veh Crashes	267	187	167	6382	11	0	0	7014	6.5%	8.9%
Passenger Vehicle Crashes	2503	1016	737	20258	291	51	0	24856	14.2%	17.1%
Bus Crashes	15	19	4	461	0	0	0	499	6.8%	7.6%
Tram Crashes	13	13	7	194	0	0	0	227	11.5%	14.5%

Figure A1. Number of hot spots, cold spots and non-significant location resulting from Getis-Ord Gi* analysis of metropolitan Melbourne 2012-2016 crashes

Example of locations (suburbs and/or roads) in metropolitan Melbourne with the highest number of hot spots (at the 95% confidence level) for various crash categories

Casualty crash hot spots:

- Melbourne CBD and its surrounds (from Coburg in the north to St Kilda in the south, and Flemington in the west to Toorak in the east);
- Dandenong, Clayton, Springvale, Footscray, Preston, Sunshine, Narre Warren, Roxburgh Park, Broadmeadows, Cheltenham, Bundoora, Chadstone, Epping, Melton, and Ringwood.

Fatal crash hot spots:

- Coburg East, Ashwood, Mentone, Upper Ferntree Gully and Pearcedale.

Pedestrian crash hot spots:

- Mainly in the inner and middle suburbs of Melbourne;
- Included areas such as the CBD, Docklands, North Melbourne, Carlton, Fitzroy, Brunswick, Coburg, Preston, Glenroy, Heidelberg, St Kilda, Prahran, Windsor, South Yarra, Kensington, Flemington, East Melbourne, Abbotsford, Richmond, Mitcham, Nunawading, Burwood, Ashburton, Chadstone, Clayton and Seaford.

Run off road crash hot spots:

- Outer suburbs and some middle suburbs of Melbourne;
- Included areas such as Melton, Laverton, Roxburgh Park, Mitcham, Ringwood, Belgrave, Lysterfield, Ferny Creek, Gembrook and Cranbourne North.

Head on not overtaking crash hot spots:

- Mainly in the middle and outer suburbs of Melbourne;
- Often located on sections of roads rather than over an area;
- Included roads like Belgrave-Hallam Road in Belgrave, Barry Road in Coolaroo, Maroondah Highway in Lilydale, Yan Yean Road in Plenty and Sydney Road in Coburg.

Rear end crash hot spots:

- Mainly located around major intersections and on motorways (that is, freeways and tollways) within a radius of 20km north and west and a radius of 45km south and east from the CBD;
- Included roads such as Dandenong Road, North Road and Clayton Road in Clayton, North Road and Wellington Road in Rowville, Monash Freeway, Warrigal Road and Dandenong Road in Chadstone, Springvale Road and Burwood Highway in Burwood East, Monash Freeway, Narre Warren North Road, Cranbourne Road and Princes Freeway in Narre Warren, Dandenong Road and Burke Road in Malvern East, West Gate Freeway and Western Link Tollway in Port Melbourne, Ballarat Road between Anderson Street and Duke Street in Sunshine, and Western Ring Road, Hume Highway, Camp Road, Barry Road, Somerton Road and Pascoe Vale Road in Campbellfield-Coolaroo;
- Also included areas such as Mentone, Taylors Lakes, Epping, Thomastown, Ringwood, and Ferntree Gully.

Side impact at intersection hot spots:

- Included intersections in the CBD and surrounds;
- Also located in middle and outer metropolitan Melbourne areas such as Clayton, Springvale, Noble Park, Dandenong, Cranbourne, Narre Warren, Wantirna, Wantirna South, Preston, Somerton, Meadow Heights, Burnside Heights, Melton, Sunshine, Truganina (Leakes Road), Heatherton, Highett (Bay Road), Springvale South, Carrum Downs, Langwarrin and Mornington.

Lane change and side swipe crash hot spots:

- Mainly located in the inner metropolitan Melbourne area including the CBD, Carlton, North Melbourne, Brunswick, Collingwood, South Melbourne, South Yarra and St Kilda;
- There is also a cluster at Brighton.

Bicycle crash hot spots:

- Mainly located in the inner metropolitan Melbourne areas including the CBD and extending from Brunswick in the north to South Melbourne in the south, and from North Melbourne in the west to Collingwood in the East;
- There was also a cluster on St Kilda Road (from the CBD to Alma Road in St Kilda) and on Chapel Street and surrounding areas (from East Richmond in the north to Windsor in the South);
- There were three clusters on Beach Road, a well-known riding spot for cyclists. These were at Brighton Beach, Black Rock and Mordialloc.

Heavy vehicle crash hot spots:

- Mainly located around industrial areas such as Laverton, Sunshine West, Altona North, the Melbourne Docks area, Sunshine North, Campbellfield, Somerton, Thomastown and Keysborough.
- The clusters were also located on Western Port Highway which leads to the Port of Hastings and on the West Gate Bridge between Williamstown Road and Todd Road which connect two industrial areas and leads to the Port of Melbourne.
- Other locations included the South Melbourne industrial area and the Brunswick industrial area.

Motorcycle crash hot spots:

- Mainly located in the inner and middle metropolitan Melbourne suburbs;
- There were some clusters in the outer metropolitan Melbourne areas such as Gembrook Road and Gembrook-Launching Place Road in Gembrook (both windy roads), Mount Dandenong Tourist Road in Upper Ferntree Gully (windy road), Warburton-Woods Point road in Upper Yarra Valley (windy road), Diamond Creek Road in Greensborough, Gap Road and Elizabeth Drive in Sunbury, and Heaths Road in Werribee.
- Clusters in the middle metropolitan suburbs included Clayton, Gardenvale, Hawthorn, Camberwell, Kew, Footscray, Ascot Vale and Brunswick.
- The inner metropolitan hot spot clusters included the CBD and extended from Brunswick in the north to St Kilda in the south and from North Melbourne in the west to Richmond in the east.

Passenger vehicle crash hot spots:

- The hot spot cluster locations were almost identical to that for total casualty crashes.
- One exception was that Box Hill was identified as a hot spot crash cluster for crashes involving passenger vehicles but not for total casualty crashes.

Light commercial vehicle crash hot spots:

- Clusters were located in North Melbourne and Docklands and in the middle and outer suburbs of metropolitan Melbourne, including Melton, Taylors Lakes, Caroline Springs, Truganina, Campbellfield, Pascoe Vale, Thomastown, Epping, Watsonia, Preston, Greensborough, Ringwood, Bayswater, Chirnside Park, Ferntree Gully, Chadstone, Clayton, Rowville, Highett, Springvale South, Noble Park and Keysborough.
- They were mainly located on freeways and approaches to freeways, on highways and on major arterial roads including Western Freeway, Melton Highway, Hume Highway, Western Ring Road, Burwood Highway, Dandenong Road and Nepean Highway and around industrial areas and commercial areas.

Bus crash hot spots:

- Most of the bus crash hot spot clusters comprise of only one or two sites only;
- Dandenong, Wantirna South, Mordialloc, Toorak, Preston and Epping had hot spot clusters of three or more sites. Carlton;
- Niddrie and Kingsbury (La Trobe University) had hot spot clusters of two sites.

Tram crash hot spots:

- The CBD, St Kilda Road between Flinders Street and Southbank Boulevard and Carlton were locations that had a cluster of hot spots;
- Burwood East had one site that was a tram hot spot, as did East Melbourne.

Contributed Articles

Perspective on Road Safety

Exemption of behind-the-wheel driving test for novice young drivers: A serious public health concern

Imran Bari[1], Nino Paichadze[1] and Adnan A. Hyder[1]

[1]*Center on Commercial Determinants of Health, Milken Institute School of Public Health, the George Washington University, Washington, District of Columbia, United States of America*

Corresponding Author: Imran Bari; 950 New Hampshire Avenue, N.W. Washington, DC 20052; imranbari@gwu.edu; +1 571 269 2002

Key Findings

- Road traffic injuries (RTIs) are highest among USA adolescents (15-19 years of age).
- During COVID-19, the State of Georgia waived driving test for novice young drivers.
- Though temporary, such driving test exemption can lead to increases in RTIs.

Road traffic injuries (RTIs) continue to emerge as a serious public health issue across the world; according to the World Health Organization, every year, almost 1.35 million individuals lose their lives, and approximately 25 million injuries are caused by road traffic crashes (World Health Organization, 2018). These RTIs are the leading cause of death for children and young adults between 5-29 years of age (World Health Organization, 2018).

Under the current situation of COVID-19 pandemic, there have been reports suggesting a profound decline in RTIs because of reduced traffic on the world's roads (Job, 2020); however, amid this pandemic, some states in the United Sates have proposed controversial road traffic policies that can jeopardize road safety. The Governor of the State of Georgia, the United States, recently, through an executive order, waived the behind-the-wheel road test requirement for novice drivers who had held a driving permit for a year (The State of Georgia Government, 2020). Through this wavier, almost 20,000 teenagers were granted full driving privileges last month (Taylor, 2020). While the decision was made to address the backlog of driving tests created by the COVID-19 pandemic, and also to practice social distancing (Taylor, 2020), many public health experts are now concerned that this decision will have catastrophic consequences on road safety.

When compared to other age groups, teenagers drive fewer miles per year, but they are usually overrepresented in car crashes (Das, Minjares-Kyle, Wu, & Henk, 2019). Young drivers make up about 5.4% of all licensed drivers in the United States; however, they account for around 8% of all drivers that are involved in fatal crashes (National Highway Traffic Administration, 2019). According to recent statistics, road traffic crashes are among the leading cause of deaths and injuries among youth (aged 15-20) in the United States, with almost 3,159 teenagers having lost their lives in road traffic crashes last year (Institute for Health Metrics and Evaluation, 2018). In 2017, there were 4,361 young drivers involved in fatal crashes in the United States, with 202 of those occurring in the state of Georgia (National Highway Traffic Administration, 2019).

Almost 13.1% of Georgia traffic fatalities involved young drivers (Table 1), which is among the highest in the nation and above the national average of 12.8%. The road traffic death rate among population between the ages on 15-19 in Georgia was 17.1 deaths per 100,000 population which is above the national average of 14.6 (Institute for Health Metrics and Evaluation, 2018) (Figure 1). These young drivers have a higher risk of vehicular crash due to many factors which include driving inexperience, immaturity, and a tendency to engage in high-risk driving behaviours (Williams, 2003). Studies have found that increase in both the driver's age and motor vehicle driving experience are found to be inversely proportional to road traffic crashes (McCartt, Mayhew, Braitman, Ferguson, & Simpson, 2009). Crash risk was found to be significantly lower when young drivers are learning to drive with an adult

Table 1. Fatalities in crashes involving young drivers (ages 15-20 years) in the state of Georgia and its neighboring states, 2017

State	Young Drivers	Total Fatalities in Crashes Involving Young Drivers	Percentage of State Traffic Fatalities Who Were Killed in Crashes Involving Young Drivers
Georgia	**71**	**202**	**13.1%**
Alabama	57	124	13.1%
Florida	148	399	12.8%
South Carolina	37	134	13.6%
Tennessee	45	124	11.9%
United States	**1,830**	**4,750**	**12.8%**

Source: NHTSA, 2017

in the vehicle, however a 10-fold increase in crash risk was identified when teens begin driving independently (Mayhew, Simpson, & Pak, 2003).

In the United States, Graduated Driver Licensing (GDL) programs have become increasingly prominent (National Highway Traffic Administration, 2006; A. F. Williams, 2017) to provide beginner drivers experience behind the wheel under conditions that minimize risk. Although Georgia, along with few other states, does allow some exemptions to this GDL system, the behind-the-wheel test has always been a standardized and mandated condition to obtain full driving privileges, assessing their fitness to drive vehicles in the real world.

Research has shown that driver's license tests help in reducing crash rates not only by increasing knowledge about road safety but, more importantly, by merely delaying licensure (National Highway Traffic Administration, 2011). Stricter testing has two main advantages – firstly, identifying those who fail because they are not prepared to drive on public roads and, secondly, motivating applicants to spend more time preparing. This extra preparation time not only enhances driving experience but also furthers delay (National Highway Traffic Administration, 2011). Previous studies have shown that teenagers who stayed in a restricted license phase for a longer duration remained at a steady crash risk potential. Therefore, delaying licensure ensures that youth are slightly older and better-informed drivers when they obtain their licenses (Mayhew et al., 2003). The order exempting the behind-the-wheel test in Georgia stands in direct contradiction to this scientifically proven system.

This also seems to be a worrying trend as Georgia is not the only state revising its licensing process. Wisconsin has also announced plans to issue a driver's license to those under 18 who have completed their training with the consent of a parent but without a road test (Taylor, 2020; The State of Georgia Government, 2020). Texas is also amending its licensing process for learners seeking a provisional license. However, there are better ways to manage the social distancing requirements of the pandemic while keeping drivers safe, as observed in California, Michigan and New Jersey which have extended the validity of existing learner's permits by several months, kept the in-person driving tests on hold and are not granting licenses during this time (Taylor, 2020).

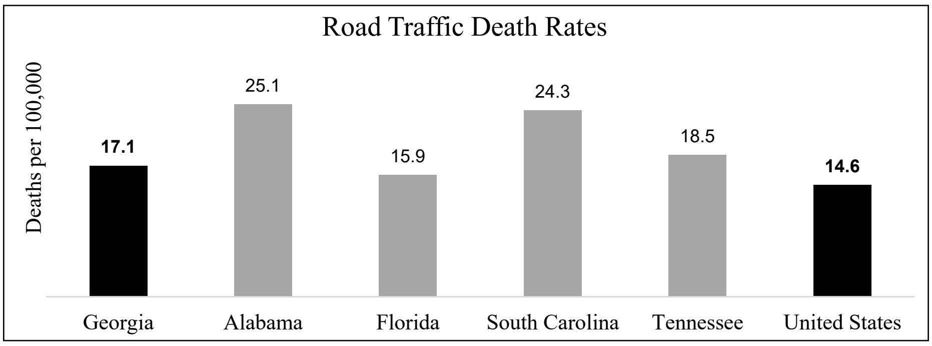

Figure 1. Road traffic death rates among individuals aged 15-19 years in the state of Georgia and its neighboring states, 2017

Source: Institute for Health Metrics and Evaluation, 2018

Although these amendments in licensing are temporary, the consequences of even a few weeks of inexperienced drivers on the roads can be disastrous. Even though involving parents or guardians in the process might be important, they cannot be held responsible for their child's driving safety outcomes. In regard to dealing with the backlog, that is simply not enough of a reason, since most States already operate under heavy backlog without compromising safety (as noted in the examples of California, Michigan and New Jersey above). During a pandemic, it is of major concern that we are putting drivers on the road without proper testing especially when it has been well established that the initial few months of driving are quite perilous (Curry, Pfeiffer, Durbin, & Elliott, 2015). This is crucial to prevent an increase in hospitalization particularly when hospitals are already massively overburdened due to COVID-19. Neglecting this essential check on the preparedness of these novice young drivers can lead to a further spike in already high road traffic crashes and related deaths and injuries.

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Subjectivity in Road Safety and Traffic Engineering

Peter Harris[1]

[1]*Road Safety Audits P/L, Melbourne, Australia*

Corresponding Author: Peter Harris, Road Safety Audits P/L, 8/79 Manningham Road, Bulleen, Victoria, 3085, peterh@rsaudits.com, 0413481980.

Key Findings

- Subjectivity is infrequently discussed within road design guidelines
- Subjectivity is inherent within traffic and road safety engineering decision-making

Introduction

This paper discusses subjectivity in road design guidelines, and examples of it within practice from the perspective of a professional road safety auditor.

Background

Subjectivity was alluded to when linking crash interventions and contributing factors within a recent study (Doecke et al, 2020). This paper acknowledged that subjectivity was present even amongst a panel of experts advising on a link derived from an 'evidence base'. This inspired an examination of subjectivity within road safety and traffic engineering, how it is discussed in common road guidelines, and how it manifests within a practitioner's assessment.

Definition

'Subjective' refers to personal feelings, tastes, ideas and opinions, and is often described as the opposite of 'objective'; clear-cut with a universal truth.

Guidelines

The word 'subjective' appears 47 times within Austroads' Guides to Traffic Management, Road Design and Road Safety (all parts and series combined). As a comparison, another non-empirical term, 'judgement', appears 169 times. Of the 47 appearances of 'subjective', approximately half (23) did not refer to road design/road safety engineers, but described 'local community opinions' (AGTM 8) and 'driver subjective risk' (AGRS8). The majority of the remaining 24 described designer considerations:

- Path widths in AGRD6A S4.3;
- Modelling categories in AGTM3 S8.0;
- Safety treatment options in AGRD6 S5.3;
- Scores for likelihood and severity in AGTM6 S3.3.3;
- The extent of the normal design domain in AGRD2 S2.2;
- Crash data quality and use in AGRS7 S5.5.

Practice

Road designers, traffic and road safety engineers are humans that walk, ride and drive on roads and paths, accumulating experiences, feelings and opinions over many years. They are also potentially influenced by the views and experiences of friends, family and industry professionals. Furthermore, practitioners are rarely experts in more than one area, often having a focus or strength in specific areas such as:

- Human behaviour;
- A specific road user group;
- Emerging practices, treatments, or paradigms such as safe system;
- Standards and guidelines or road rules;
- Historic practices and jurisdictional differences;
- Technical areas e.g. signs, line marking, safety barriers, drainage, geometry, lighting, traffic signals.

Therefore, although an experienced practitioner requires strong technical and industrial knowledge, it is likely that subjectivity plays a strong role in identifying an issue and assigning risk.

Examples

Existing Condition

As the audit team approached an unfamiliar intersection at night (Figure 1) and daytime (Figure 2), they had some difficulty understanding where the road actually goes: *left* or *right*. This was due to the geometric layout, dirt tracks on the road, minimal intersection delineation, and tree shadowing.

Here, the 'subjective' response of the drivers to the road and the relationship with human factors was more relevant than 'experience' and 'judgement'.

Figure 1. Night approach to intersection (Source: P. Harris)

Figure 2. Day approach to intersection (Source: P. Harris)

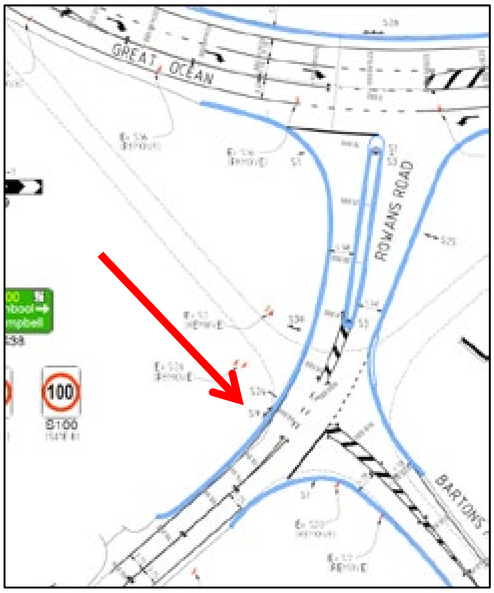

Figure 3. Road Design Drawing (Source: VicRoads drawing number 77558, Issue 0, Contract 9912: Sheet 50 of 52)

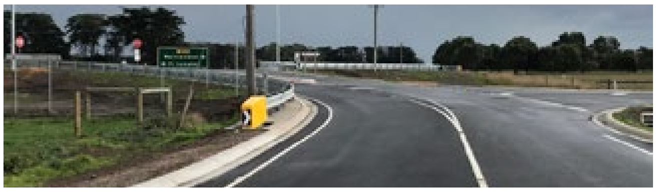

Figure 4. Day approach to the curve (Source: P. Harris)

Figure 5. Night approach to the curve (Source: P. Harris)

Contemporary Design – Post Opening

The dashed median line marking was installed as per the plans (Figure 3).

However, the auditors determined that in this environemnt, the dashed line marking eroded delineation at this critical curved approach to the high-speed intersection (Figure 4 and 5). Also, it was not required by the road rules (to make the turns legal). Finally, the guidelines of the relevant road authority show the dashes as a possible treatment type, but do not require them.

The relevance of subjectivity:

- 'Experience' was required to consider the potential issue relating to road readability / delineation.
- 'Judgement' was required to understand that the relevant design guidance on this treatment is not strong or prescriptive, and offers the dashed line treatment as a guide only (Vicroads Supplement to AS1742.2 Section 5.3.6 (a) dot-point (4), and section 5.5.5.1 and Figure 64).
- Ultimately however, whether to raise this type of delineation / road readability issue and how to rate the risk is largely 'subjective'.

Design – Safe System

A current major project is replacing a footpath with a shared path (Figure 6 - left).

Although this is a welcome facility, the existing on-road bicycle lane (Figure 7) is being removed, leaving two lanes of traffic, no on-road bicycle lane, and no shoulder.

The auditors firmly believed that 'on road-*only*' cyclists will stay on the road rather than depart the road and join a shared path with pedestrians, dogs, speed reduction, waits at multiple road crossing points, and travelling in front of driveways with a compromised user envelope (Figure 6 - right). And, this project will leave the relatively high volume of 'on road-*only*' recreational cyclists sharing a traffic lane, which is a reduction in safety to that user group. The relevance of subjectivity is as follows:

Figure 6. Proposed Design: Shared path with on-road bicycle lane removed (Source: Arcadis Road Design Plan NWA_C1042A and P. Harris)

The Safe System Assessment undertaken for this design had the difficult task of determining the change in 'likelihood' of cyclist crashes overall. In doing so, the assessors would have needed to consider issues such as: all bicycle user group types; future volumes and patterns; user behaviour; and all cyclist design imrpovements and deteriorations across the project.

The assessment determined that the likelihood of crashes would be reduced, which consequently reduced the cyclist risk score from 27 out of 64 to 18 out of 64 (as per Table 3 of Safe System Assessment Matrix – Austroads AP-509-16).

It is expected that experience and judgement were important in this decision, but decisions such as these are highly subjective due to their sheer nature. Indeed, another set of experienced practitioners could have just as easily *increased* the likelihood based on the 'on road-*only*' volumes and travel patterns.

Discussion

Most road design / intervention guidance is driven by an evidence-base. Data driven studies help form a consensus which eventually feeds into guidelines, and give practitioners something to anchor their decisions to.

Figure 7. Existing Condition: On-road bicycle lane (Source: P. Harris)

Conversely, subjectivity is routinely part of design and road safety but is unempirical, unscientific, seldom discussed in guidelines and in general practice (in the experience of the author).

It is unlikely to be possible or desirable to remove subjectivity from human decision making. However, the extent to which subjectivity can influence the identification of an issue or the risk assigned to it might vary considerably.

Conclusions

The influence of subjectivity within decision making is a valid question for future analysis and consideration.

Acknowledgements

To the individual auditors who work with the author to form a team and help balance subjectivity with judgement, experience, and evidence-based interventions.

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Vicroads Supplement to AS1742.2 2009 Manual of Uniform Traffic Control Devices: Traffic Control Devices for General Use, Section 5.3.6 (a) dot-point (4), and section 5.5.5.1 and Figure 64).

ACRS updates

From the President

College members strongly value the national level advocacy of road safety and this has been an important year for this in Australia. Significant policy positions have been developed and are being fed into the Federal Parliament, through submissions to the Joint Select Committee on Road Safety, to the Transport and Infrastructure Council of Ministers (TIC), chaired by Deputy Prime Minister Hon Michael McCormack MP, and to the Commonwealth Office of Road Safety.

The next national strategy is a critical point of reflection on the past and leverage for the future, and our focus has been on expressing our policy position on this.

Setting Ambitious Targets to Realise our Ultimate Vision

ACRS strongly endorsed TIC's commitment last year to zero deaths by 2050, and we understand that this will be extended to cover serious injuries, as we sought in response. We now must focus on the interim targets that will be set. If our goal is to achieve zero road deaths and serious injury by 2050, the only reasonable interim target for the national road safety strategy is for 50% reductions in fatal and serious injury by 2030. We recognise that these targets are challenging, but we know they are achievable, and have been endorsed by the United Nations General Assembly (A/74/L.86 "Improving Global Road Safety"). If matched in 2040 and in 2050, Australia will at least be on the cusp of realising our ultimate vision. With national 2030 targets for fatalities and serious injuries in place, supporting performance and delivery targets can be established to identify what will be done to achieve our targets.

Collating, Communicating and Acting upon Essential Public Safety Information

ACRS has called on TIC to lead federal, state and territory governments and immediately commence work on the following national strategic initiatives and include them in the forthcoming NRSS:

- The Commonwealth to publish consistent infrastructure safety star ratings (covering occupants, pedestrians, cyclists and motorcyclists) in easily consumable form on behalf of all governments – this is fundamental to establishing a common understanding within communities about where the real safety problems exist on our road networks and the potential solutions.
- Prepare and begin implementation of a three-year infrastructure safety investment plan, and a ten-year national safety investment budget to achieve 2030 infrastructure safety targets (there are 2020 targets of 3-star AusRAP ratings or better for 80% of travel on state roads and 90% of travel on national highways) – implementation can then begin on the highest priority improvements for all users and communities.

These two national actions will lay a critical foundation for road safety over this decade and the next. Infrastructure safety star ratings are essential public safety information and the implementation of actions to increase the star safety ratings of the worst roads in the network will do a great deal towards achieving the challenging road safety targets.

A Renewed National Regulatory Reform Program

The ACRS has also called on TIC to lead federal, state and territory governments and immediately commence work on the following national strategic initiatives and include them in the forthcoming NRSS:

- Prepare a national Regulatory Impact Statement for lowering the default speed limits for urban and for rural roads. The safety of road users cannot be assured with default limits of 100 kmh in rural areas and 50 kmh in urban areas. A Regulatory Impact Statement addressing this major public safety regulation issue, properly conducted through the National Transport Commission, would provide State and Territory governments with vital information, and options for how they wish to realise vision zero in their jurisdiction.
- Initiate the regulatory processes to keep pace with European vehicle safety regulation, especially intelligent speed adaptation and autonomous emergency braking. It is inconceivable that autonomous vehicles may be released into the market without the ability to comply with speed limits (intelligent speed assist), and without the ability to stop (autonomous emergency braking). These technologies must be locked into the regulatory baseline for Australia's vehicle fleet as an urgent strategy implementation priority, and a vital interim step towards future technology.

Strengthening National Institutions

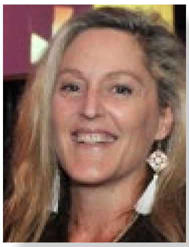
We have also made clear that the strategy development process must take the opportunity to address the significant management issues which have been a sustained problem in Australia. These issues were the focus of the independent inquiry report commissioned by the Australian Government and by the Governance Review undertaken by the Australian Government itself. There are many funding, legislative, capacity building, monitoring and evaluation and research and development tasks ahead. To help drive forward this road safety leadership agenda, we have called for:

- The establishment of a parliamentary Standing Committee on Road Safety to hold the Australian Government of the day to account for achievement of safety results for the people of Australia.
- The establishment of the Office of Road Safety as a statutory body with clear functional responsibilities, and resourcing commensurate with its role of leading the national effort to eliminate serious road trauma by 2050.

We have sought to focus our contribution on high value actions which are appropriately addressed through a national road safety strategy, which in turn is supported by State and Territory strategies. We think this is actually a relevant agenda across Australia and New Zealand, and indeed many other countries seeking to tackle their road safety problem. The purpose of the Australasian College of Road Safety is to support our members in your efforts to eliminate serious road trauma through advocacy, knowledge sharing, professional development, and networking. Your support and advocacy of these positions, as members of the College, will further reinforce our capacity to support you.

Martin Small
ACRS President

From the CEO



By the time members receive this Issue of the *Journal of Road Safety* we will have less than 2 months of 2020 remaining, and what an extraordinary year we have all been navigating.

When Austroads' David Bobbermen talked about the '*Seven Worldwide Disruptions and their Influence on Roads and Transport*' during the plenary session at the *2019 Australasian Road Safety Conference* in Adelaide last September, I'd hazard a guess very few listeners in the audience could have predicted the profound disruption the world would be facing in less than 6 months – a global pandemic that has impacted every facet of our lives, including road trauma outcomes.

The flow-on effect from the pandemic to the College has been extensive. Despite this, the operational team, with the support of our members, has been able to achieve major milestones this year. The first of these has been to develop, ratify and subsequently implement the College's 2020 Business Plan. This Plan was formulated under the umbrella of the *ACRS Strategic Review*, itself a relatively recent Report having been completed in 2019.

As a reminder for members, the purpose of the Strategic Review was to:

- Acknowledge and consolidate the significant progress made by the ACRS over the last decade in particular;
- Identify and address issues that could present a barrier to future progress; and
- Recommend a refreshed governance structure to support a collectively agreed future direction for the ACRS.

The significantly increased level of activity (including our response to the effects of the pandemic), financial turnover, and risk profile of the College is accepted as having outgrown our now 30-year-old governance structure. As a result of the Strategic Review, the AGM this year saw the ratification of several immediate updates to our Constitution to better align with current activities, as well as agreement to undertake a much broader re-draft of the full document to support the complete raft of Review outcomes. This comprehensive re-draft is now well underway and will be ratified by our governing Executive

Committee before it is put to members before a Special General Meeting over the course of the coming year.

In the interim, several changes are being implemented at a governance and operational level to support the Review outcomes:

- A Management sub-Committee introduced, consisting of Executive Committee office bearers, to undertake direct oversight of and provide support for College operations;
- A Finance & Risk sub-Committee established to provide detailed oversight of risk within the College; and
- A Chapter sub-Committee formed to discuss and share ideas which nurture Chapter activities.

In addition to interim updates to our governance document, there is a great deal of work being undertaken to support activities detailed within our (pre-COVID-19) Business Plan, including most importantly continuing to deliver the member benefits we know you value so highly. These activities include our conference and awards, advocacy at the national level, communications including media releases and submissions, the ACRS Weekly Alert, the *Journal of Road Safety*, supporting the work of our Chapters, and of course continuing the work of our international outreach program which is supported by federal grant funding.

Significant additional work, that wasn't envisaged in our Business Plan, has included ensuring we maximise benefits to the College and our valued staff via available federal support packages including JobKeeper and the Business Cash Boost, managing a review of our major knowledge-sharing and networking platform, the ARSC conference, and re-scheduling our major awards. With the conference now moved to 2021 and set to include at least a partial if not full virtual component, a rescheduling of our 2020 Awards has been achieved, with these announcements to be made at the also re-scheduled National Road Safety Week Opening Ceremony on 15 November 2020 in Sydney. Other changes include a re-scoping of our International Outreach Project to reflect the travel restrictions that are now in place, and a re-purposing of part of the federal government's conference grant to support multiple upcoming Ministerial Roundtable meetings.

Last but not least we are making strong headway with the review of the *Journal of Road Safety*. Thanks to the driving force of Managing Editor Dr Chika Sakashita, Editor in Chief Professor Raphael Grzebieta and their Editorial Board team, and with substantial assistance from the Canberra-based operations team, major JRS improvements are afoot! You will have seen the move to an online e-Alert for each issue which commenced in May, which has achieved a much broader circulation for the life-saving papers in each issue. We are looking at circulation in the region of 3-4,000 rather than the hundreds previously achieved.

Thanks to the survey which many of you have participated in, we are implementing other changes to support an even higher uptake of our published research. You will notice for example that in this issue peer-reviewed articles are given top billing, followed by contributed research and then the ACRS news section. This is to ensure that the life-saving research material, that has been critically peer-reviewed, is front and centre.

I'd like to take this opportunity to thank my staff and the many volunteers who work for us all to support best road trauma reduction outcomes, and especially all of you, our extraordinary members, for your continued support of the College while we navigate this evolving environment. Your work continues to be greatly appreciated, and your support for the College remains vital. I especially look forward to connecting with you virtually and in person in the coming months as we transition to our 'new normal'.

In the meantime, and as always, stay safe.

Best wishes,
Claire Howe
Chief Executive Officer - ACRS

ACRS Chapter reports

Chapter reports were sought from all Chapter Representatives. We greatly appreciate the reports we received from NSW, Qld, SA and Victoria.

New South Wales (NSW)

Committee

The NSW Chapter held their 2020 NSW Annual General Meeting on Tuesday 9 June 2020 via video conference. At the AGM the 2020 Chapter Committee was elected. The Committee positions were finalised at the subsequent Committee meeting and are as follows:

Chair, NSW Chapter	Mr Duncan McRae
Vice Chair	Dr. Prasannah Prabhakharan
Treasurer	Mick Timms
Seminar Coordinator	Dr. Anna Chevalier
Stakeholder Liaison	Mr David McTiernan
Secretary	Ms Robyn Preece
2019 Fellow	Professor Michael Regan
Executive Committee	Dr. Liz De Rome
Committee Member	Dr. Cassandra Gauld

This year's Committee has a particularly diverse range of backgrounds, skills and experiences, with representation from road safety researchers, regulators, policy professionals, practitioners, educators and enforcement. The depth and breadth of road safety knowledge puts the Chapter in an excellent position for the way forward.

2020 Direction

At the first Committee meeting, it was agreed that there would be a focus for 2020 on collaboration, consultation, and communications. In recognition of this commitment a new position of Stakeholder Liaison was established on the Committee. David McTiernan (previous past Chair) accepted the new roll and will help the Committee build on the relationships he established as Chair. These relationships include, TfNSW, the IPWEA and Local Government. These relationships combined with existing connections across road safety will support a united, strategic push to reduce road trauma.

Seminars series

Each year the NSW Chapter delivers a series of seminars designed to support road safety professionals. The seminars examine new research, emerging issues, strategy development and fresh initiatives. Topic are chosen based on memberships surveys conducted from time to time. Historically seminars were delivered 'face to face' with supporting video links for online participation, however this year has seen a move to online delivery only. Recently two seminars have be conducted.

Strategies For Delivering Safer Fleets – 9 June 2020

Presented by Tim Roberts (Principal Consultant, fleet strategy) and Jerome Carslake (Professional Leader of the National Road Safety Partnership Program (NRSPP). Delivered online via Zoom with ~60 registered attendees

Driver distraction and camera-detected mobile phone use – 19 August 2020

Presented by Bernard Carlon (Centres for Road Safety and Maritime Safety) and
Alexander Jannink (Acusensus).
Delivered online via Zoom with ~300 registered attendees

Details of these and previous seminars are available on the Chapter webpage -

https://acrs.org.au/chapters/nsw/

NSW Chapter Chair
Mr Duncan McRae

Queensland (QLD)

The Queensland Chapter held its quarterly meeting on 15 September, to coincide with the webinar on the Post-COVID Future of Road Safety Research. A number of members attended the webinar, which was followed by a separate online meeting of the Chapter. The Chapter indicated its willingness to contribute to the International Outreach Project being conducted with Malaysian road safety professionals. There was also discussion of plans for sub-chapter activity on the Sunshine Coast, following on from a decision made at the last Chapter meeting before the COVID-19 restrictions commenced. The next quarterly meeting and seminar are planned for 1 December, and the intended topic is workplace road safety, with speakers from academia and industry. The event will be accessible online.

QLD Chapter Chair
Dr Mark King

South Australia (SA)

Chapter Committee update

A members meeting was held via Zoom on 20 August 2020. The chapter committee office holders remain unchanged with Jamie Mackenzie (CASR) - Chair, Matthew Vertudaches (RAA) - Deputy Chair, Philip Blake - Secretary and Jeff Dutschke - Treasurer. The committee welcomed new member Andrew Rasch (Keys2Drive).

Safe Systems Road Assessments webinar, 28 August 2020

The SA Chapter held a successful lunchtime webinar with about 50 attendees on Friday 28 August. The webinar commenced with Chris Stokes (CASR, University of Adelaide) giving a great presentation on the benefits of undertaking safety assessments of road infrastructure with a focus on the iRAP methodology. He highlighted some of the considerations required to align to Safe System-driven strategies when using potential treatments to improve iRAP ratings.

Russell King (City of Prospect) provided an informative outline of practical approaches to improve the safety of road infrastructure using proactive assessments and incorporating safety improvements with road maintenance and renewal funding and activities by local government.

Martin Small (President ACRS) concluded the webinar outlining the ACRS policy position, making a very strong case for road authorities to fully utilise the iRAP tools and publically release road infrastructure star ratings. He used New Zealand as an example where star ratings have been made available by a government / motoring club partnership (KiwiRAP). Martin emphasised that taxpayers and road users fund road infrastructure and as funders and consumers, should have safety star ratings for the roads they fund and use easily available from road authorities.

Attendees posted many questions to the webinar making for very informative Q&A sessions after each presentation. Thank you to the three presenters and to the University of Adelaide for hosting the Zoom platform utilised for the webinar.

Next Webinar

The Chapter committee is working towards hosting a webinar on the upcoming 2021 South Australian Road safety Strategy. The webinar is tentatively scheduled for November 2020.

SA Chapter Chair and Secretary
Jamie MacKenzie and Phil Blake

Victoria (VIC)

Victorian Chapter Webinar – Thursday 17 September 2020 - new National Road Safety Strategy 2021 to 2030 and the Social Model Approach. The Victorian Chapter arranged its first webinar using the GoTo platform on the 17 September. Over 180 people attended online to see Gabby O'Neill, Head of the National Office of Road Safety, discuss the next National Road Safety Strategy (2021 to 2030) and the new Social Approach to actions for improving Road Safety.

Gabby gave an excellent overview of the process that was being followed to develop the new strategy, and the key elements that were shaping the new strategy and action plan. This included an explanation of how a social model approach will contribute to achieving the goals of the new strategy. The social model approach involves reaching beyond traditional transport agencies to leverage broader sectors of the community to improve road safety. Road safety is not solely a transport or government problem. It questions the starting point of context, environment and existing influences through a layered approach to society. As a result, the social model opens up the way for more effective collaboration across society to achieve our Vision Zero goals.

This presentation was followed by a question and answer session covering a wide range of topics from attendees. Thank you to the ARRB group for hosting the webinar on their Zoom platform, and to Victorian Chapter committee member Tia Gaffney for her work in organising the event. The webinar was considered a success and the Chapter is considering further webinars in future.

The Victorian Chapter wold also like to congratulate our Tasmanian committee member, Craig Hoey, who was awarded a Churchill Fellowship to investigate how Sweden and leading European countries are eliminating road trauma. Craig will explore how Tasmania could adapt the lessons from the success of European political and policy-making processes to better implement Vision Zero.

VIC Chapter Chair
Jeff Potter

ACRS News

JOURNAL OF ROAD SAFETY(JRS) SURVEY RESULTS & RESULTANT IMPROVEMENTS: THANK YOU FOR YOUR VALUED INPUT HELPING US ALL TO SAVE MORE LIVES AND INJURIES ON OUR ROADS

Thank you to all those who completed "*Have your say on the future of the Journal of Road Safety: Vital 10 min survey*". It closed on 29th July 2020 with 125 responses.

The key results are as follows:

1. More than 50% respondents supported to 'preferably/definitely keep' each of the existing contents (i.e. ACRS Updates [Messages, Chapter Reports, News, Diary]; Peer-reviewed papers; Contributed articles) and article types.
2. More than 50% supported adding two new article types: Road Safety Best Practice Guidance and Road Safety Theory.
3. 76% said impact factor was 'important' or 'very/extremely important', and 31.5% selected JRS not having an impact factor as a reason for not choosing to publish in the JRS.
4. Some comments reflected opposing views, suggesting that there may be a perception that JRS is not academic enough but at the same time that the JRS is too academic and not open enough to practitioners' contributions to road safety. (Such varied views is a healthy reflection of the breadth of membership, which is one of the strengths of the ACRS.)
5. Some comments suggested that there may be a perception that the Editorial Board consists only of academics and no practitioners.

We greatly appreciate your input and, in response to our member and reader feedback, we will be implementing the following improvements:

- Keep all existing contents and article types.
- Continue all our ongoing actions to help JRS attain an impact factor.
- JRS has a unique feature of the contributed article (non peer-review) stream that other scientific journals do not offer. We will continue the contributed article stream especially to welcome evidence sharing from practitioners. The Author Instructions and JRS web pages have been updated to more clearly communicate how the peer-review papers and contributed articles differ and highlight more practitioner based topics in the descriptions of the article types.
- Display contents in the printed copies and digital mail out of the JRS in the order of Peer-reviewed papers - Contributed Articles - ACRS Updates. This emphasises upfront that the JRS is a scientific journal and deserving of an impact factor while keeping the other contents valued by many members and readers. This change is implemented from this Issue.
- Add Road Safety Best Practice Guidance and Road Safety Theory to our collection of article types.
- The JRS Editorial Board consists of diverse road safety experts from highly credentialed academics to highly experienced practitioners in road safety delivery. Some are ex-academics with many years of practical experience in road safety. This is now highlighted in the Editorial Board section of the ACRS website.
- Consider over time including more practitioners on the Editorial Board and listing the general roles each member plays in their road safety work.

We look forward to continue bringing the best possible road safety Journal to you, all ACRS members and the broader road safety stakeholder community to support your valuable work towards road trauma reduction and growing the JRS with you.

Dr Chika Sakashita
JRS Managing Editor
Australasian College of Road Safety
journaleditor@acrs.org.au

FEDERAL (AUSTRALIAN) BUDGET: ACRS CEO CLAIRE HOWE COMMENDS ANNOUNCEMENTS OF "$2 BILLION CONDITIONAL FUNDING FOR STATES AND TERRITORIES TOWARDS ROAD SAFETY INITIATIVES OVER 18 MONTHS" + "AUSTRALIAN-FIRST NATIONAL ROAD SAFETY DATA HUB"

ACRS Chief Executive Claire Howe said the Federal budget delivered last night by the Australian Government was a welcome step forward for road safety, and that the College, on behalf of members, would continue to actively pursue further detail on the funding announcements. Deputy Prime Minister Michael McCormack together with Assistant Minister for Road Safety Scott Buchholz have been explicit in their budget statements this morning, specifying the following significant road safety funding programs:

- **Acknowledgement that road crashes kill around 1,200 people and seriously injure tens of thousands every year**, cause immeasurable suffering for affected families, and cost the national economy approximately $30 billion every year.
- **Working towards zero fatalities and serious injuries** on Australian roads is a core priority for the government.
- **Directly investing $2 billion in the 2020-21 Budget towards road safety initiatives**.
- Committing this **$2 billion over 18 months under a new Road Safety Program** to deliver an estimated 3,000 kilometres of lifesaving road improvements and support thousands of jobs across the country.
- The **Road Safety Program** will deliver works such as new shoulder sealing, rumble strips to alert drivers they are moving out of their lane, median treatments to prevent head-on collisions and barriers to prevent run-off-road crashes and protect against roadside hazards.
- The **Road Safety Program** will be delivered in three, six-month tranches and on a **'use it or lose it' basis**.
- **Road Safety Program** funds that States and Territories do not spend will be re-allocated to those that can, with **jurisdictions required to provide road safety data as a key condition of funding.**
- Investing **$5.5 million over four years to establish an Australian-first National Road Safety Data Hub** to ensure investments are driven by quality data and road safety improvements are accurately monitored and evaluated.
- The **National Road Safety Data Hub** will create the **first nationally available road safety data collection to assess the effectiveness of road safety efforts by all Australian governments**

Claire said the College was looking forward to further information around mechanisms being implemented to support these funding announcements, and will continue to work with all stakeholders to support these important initiatives aimed at saving lives and injuries on our roads.

The College will also be continuing to support members and the broader community through targeted advocacy of our policy positions. These policies are being fed into Federal Parliament through submissions to the Joint Select Committee on Road Safety (Chaired by Pat Conaghan MP), to the Transport and Infrastructure Council of Australian federal and jurisdictional Ministers (TIC - chaired by Deputy Prime Minister Hon Michael McCormack MP), and to the Australian federal Office of Road Safety (led by Ms Gabby O'Neill).

The next National Road Safety Strategy (2021-2030) is a critical point of reflection on the past and leverage for the future. ACRS is strongly advocating for this strategy to incorporate the following key elements:

- Ministers' 2050 vision for the elimination of fatalities on the road to be extended to include serious injuries;
- 2030 targets set to reduce fatal and serious injuries by 50% (both raw numbers and as a population rate), backed by related performance and delivery targets;
- Publication in easily consumable form for the public of infrastructure safety star ratings for all road users;
- Safety investment plans and budgets developed to achieve targeted improvements in safety star ratings;
- National Regulatory Impact Statement developed for lowering the speed limits for urban roads and for rural roads; and
- An agreed aim to maintain pace with European vehicle safety regulation that encourages evidence-based driver assistive technologies, especially intelligent speed assist and autonomous emergency braking.

It is essential that the new strategy is:

- Strongly led by each level of government, with adequate organisational capability;
- Funded with substantial new money which is secure through to at least 2030;
- Backed by further investment in crash investigation, data and research; and
- Implemented thoroughly during all stages including policy and program development, monitoring, evaluation and reporting.

We look forward to keeping members updated as further details are made on current and future funding and programs.

Claire Howe
Chief Executive Officer - ACRS

UPDATE FROM THE AUSTRLAIAN OFFICE OF ROAD SAFETY: 13 SEPTEMBER 2020

National Road Safety Strategy 2021-2030 - Update

The Office of Road Safety continues to work closely with State and Territory Governments, the Australian Local Government Association, Austroads and other former Transport and Infrastructure Council (TIC) bodies to draft the new National Road Safety Strategy 2021-30. This includes developing the priority areas, actions in support of the priorities, performance measures and targets for the new Strategy.

The Office extends its thanks to all who were engaged in our targeted consultations and meetings with the Cross-jurisdictional Working Group, testing and refining

the key priorities for the Strategy. Over 50 national stakeholders across road safety, freight and logistics, research institutions, Indigenous representative groups, health and education organisations have participated in the process. Targets in the next Strategy are being developed encompassing stakeholder positions from this process.
In collaboration with the Australia Local Government Association, we have also recently undertaken targeted consultation with some local councils.
The Strategy will adopt a long term vision of zero deaths and serious injuries by 2050. This is in step with the United Nations approach to global road safety through its Sustainable Development Goals and the second Decade of Action on Road Safety. The Strategy will also align with broader government policies such as the Closing the Gap National Plan and the National Injury Prevention Strategy, while also having regard to the Joint Senate Committee on Road Safety's final report, due in October this year.

Detailed work is underway to finalise the draft Strategy and first Action Plan. The Department anticipates that there will be further opportunities for to provide input on the Strategy before final approval in early 2021.

Road Safety Data

The Bureau of Infrastructure and Transport Research Economics has released its August 2020 Fatality Figures. There were 100 road deaths during the month of August 2020. The current figure is 9.6 per cent lower than the average for August over the previous five years. For more information on road safety statistics, visit: https://www.bitre.gov.au/statistics/safety

ANCAP and the Australian Design Rules (ADRs

ANCAP safety ratings and the ADRs play a different but complementary role in vehicle safety. ADRs are the national regulatory standards for safety, anti-theft and environmental performance of road vehicles when first supplied to the Australian market. The Commonwealth mandates around 75 ADRs, most of which are aligned (harmonised) with UN Regulations.

Non-regulatory systems, including ANCAP Safety Ratings, play a consumer-influence role in encouraging a high standard of vehicle safety, generally beyond what is set out by the ADRs. ANCAP uses a rating system of 0 to 5 stars to encourage manufacturers to supply safer vehicles and vehicle buyers to choose the safest vehicles. ANCAP Safety Ratings are not mandatory.

ANCAP's role is complementary to regulation. While the ADRs ensure all vehicles meet a minimum regulatory standard, the ANCAP rating system encourages vehicle brands to introduce the latest vehicle safety technology as soon as it becomes available. ADR development is prioritised under the National Road Safety Strategy and associated Action Plans. One example of this is the action for the Commonwealth to finalise a new ADR for Autonomous Emergency Braking (AEB) on light vehicles under the current National Road Safety Action Plan 2018-2020.

Implementation of priority new ADRs is subject to the Australian Government Regulation Impact Statement requirements. For more information on ADR development, visit: https://www.infrastructure.gov.au/vehicles/design/index.aspx. For more information on ANCAP Safety Ratings, visit: https://www.ancap.com.au/frequently-asked- questions

Biggest reform to Australia's Vehicle Standards legislation in over 30 Years

The Road Vehicle Standards (RVS) legislation, which is replacing the Motor Vehicle Standards Act 1989 (MVSA), will provide a strong, modern regulatory framework that will maintain and improve vehicle safety, provide more choice for specialist and enthusiast vehicles and be responsive to emerging technologies.
The department continues to roll out the RVS legislation this year, with applications for a testing facility approval having been available since May.
The ability for individuals and organisations to apply for a component type approval commenced this week. This provision, as well as the upcoming vehicle type approval provision commencing in mid- 2021, will help streamline road vehicle approvals, by consolidating import and supply pathways.

The changes being implemented will strengthen the Australian Government's regulatory powers to ensure Australia continues to deliver world-leading standards in vehicle safety and environmental outcomes. For further information, please visit our RVS legislation implementation webpage or contact the team at RVSAimplementation@infrastructure.gov.au.

Drive safely these school holidays

As school holidays begin across the country, Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development Michael McCormack and Assistant Minister for Road Safety and Freight Transport Scott Buchholz are urging Australians to drive safely on our roads.

For more information and to view the media release, visit: https://minister.infrastructure.gov.au/mccormack/media-release/drive-safely-these-school-holidays

Your Speed is our Safety Campaign

All road users have a responsibility to slow down, pay attention and drive safely at road works. The Australian Government is proud to support the Traffic Management Association of Australia's Your Speed is Our Safety campaign, encouraging us all to respect traffic managers and road workers by following the rules and slowing down to the posted speed limits around roadwork sites. Your Speed is Our Safety is proudly supported by the Office of Road Safety through the Road Safety Awareness and Enablers Fund. To view the campaign videos, visit: https://www.youtube.com/channel/UCgZT9x1irnTTn04HybRtjhg

For more information on the Office of Road Safety's programs, visit: www.officeofroadsafety.gov.au/programs.

Diary

These events may change due to COVID-19 situation. Please check directly with the event website for latest updates.

15 November 2020
World Day of Remembrance for Road Traffic Victims
https://worlddayofremembrance.org/

15 November 2020
2020 ACRS Awards Ceremony
Sydney, Australia
https://theaustralasianroadsafetyawards.com.au/

15 – 22 November 2020
National Road Safety Week 2020
https://www.roadsafetyweek.net.au/road-safety-week
Australia

January 2021
TRB 100th Annual Meeting
A virtual event over a series of dates throughout January 2021
http://www.trb.org/AnnualMeeting/AnnualMeeting.aspx

National Road Safety Week 2020

15-22
NOVEMBER
2020

GET INVOLVED THIS NATIONAL ROAD SAFETY WEEK

From 15 – 22 November, we remember those we have lost on our roads and commit to #DriveSoOthersSurvive.

Show support by checking out your local buildings and bridges lit up in yellow, displaying a yellow ribbon on your vehicle, taking a pledge to drive without distraction, participating in socially distanced or virtual events and talking about safe driving.

roadsafetyweek.com.au

Introducing Road Safety Victoria and the Department of Transport

The Department of Transport (DoT) brings together all transport modes to design, plan, deliver and operate Victoria's transport system. We're focused on outcomes that deliver more choice, connections and confidence in our travel, ensuring the whole transport network works as one to deliver better services.

DoT's vision is to meet the aspirations of Victorians and businesses for a transport system that is simple, connected, accessible, reliable, safe and supports a productive, growing economy.

Victoria has a proud history of road safety innovation and within the Department, Road Safety Victoria (RSV) has recently been established to provide a dedicated office to improving safety for all Victorian road users.

RSV works closely with road safety partners – Transport Accident Commission, Victoria Police, the Department of Justice and Community Safety, and the Department of Health and Human Services – to deliver strategic and coordinated road safety policies, programs and initiatives.

Find out more at **transport.vic.gov.au**

VICTORIA State Government | Department of Transport

Journal of Road Safety (JRS)

Visit the JRS website at:
https://acrs.org.au/publications/journals/

Australasian College of Road Safety Inc.

ACRS, PO Box 198, Mawson ACT 2607 Australia
Tel 02 6290 2509
Fax 02 6290 0914
Email ceo@acrs.org.au
Head Office
Pearce Centre, Collett Place, Pearce ACT Australia
Visit the College website at www.acrs.org.au

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