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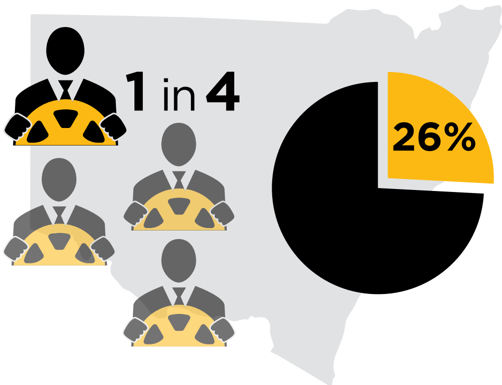
Journal of Road Safety

Drive safe. Work safe.

In NSW, around 1 in 4 workplace deaths occur while the person is driving or riding for work



and 26% of fatalities on our roads involve a vehicle used for business.

It's important to recognise that when driving or riding for work, employees are in their workplace and safety is the highest priority. Road safety at work is a shared responsibility, and starts with a conversation between employers and workers.

Transport for NSW's Road Safety in Your Workplace program and website provide tools to support both employers and workers.

For employers

The online resource helps employers protect their workers by embedding road safety within their Work Health and Safety framework.

The employer toolkit provides practical tools to:

- Develop, implement and maintain a road safety policy
- Purchase and maintain a safe and roadworthy fleet
- Better monitor and supervise work-related travel
- Ensure workers are competent to travel and are not impaired
- Schedule travel time to account for speed limits, weather, traffic, and fatigue management
- Review and address all crashes, near misses and infringements relating to work-related travel.

For workers

The online learning tool includes a 30-minute interactive session for workers to refresh or update their knowledge of road safety risks and safe behaviours.

The Road Safety in Your Workplace program is led by Transport for NSW and is partially funded by the State Insurance Regulatory Authority and Insurance and Care NSW, with input from SafeWork NSW, Western NSW Local Health District and other partner agencies.

To learn more about the program scan the QR code or visit **towardszero.nsw.gov.au/workplace**

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ACRS Updates

Cover image

Speed management is vital for a safer road system. A review in consideration of the Safe System Approach was undertaken in the Islamic Republic of Iran where the fatality rate is particularly high at 20.5 per 100,000 population. Learn the process and outcomes of this review in the Road Safety Policy & Practice article: Mooren, L., Shuey, R., Hamelmann, C., Mehryari, F., Abdous, H., Haddadi, M., Ranjbar, M., Zakeri, H., Hosseinizadeh, S. (2021). "Speed Management in Iran: A Review Process" Journal of Road Safety, 32(3), 31-42. https://doi.org/10.33492/JRS-D-21-00011 Photo kindly provided by Dr Ray Shuey, Strategic Safety Solutions.

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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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Original Road Safety Research

Characteristics of Fatal Road Traffic Crashes Associated with Alcohol and Illicit Substances in Queensland (2011-2015)

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Key Findings

- Alcohol was overrepresented in fatal crashes
- Higher range BAC levels were common
- Combinations of high BAC and illegal drugs were frequent
- Alcohol and polydrug detections were overrepresented in single vehicle crashes

Abstract

Psychoactive substances affect driver behaviour in different ways, some of which can increase the risk of traffic crashes. This study investigated coroners findings for fatal road traffic crashes in Queensland for crash factors and driver behaviours associated with and without the presence of alcohol or illicit drugs. A total of 701 coroners reports for the period of 2011 to 2015 were analysed revealing 306 fatal incidents involving the detection of either alcohol or target illegal drugs (e.g., methamphetamine, THC [cannabis], cocaine or MDMA). Alcohol was most often detected (223 cases; 72.9% of the drug and alcohol sample and 31.8% of the entire sample), and a majority of fatalities involving alcohol (n = 114, 51% of alcohol cases) were at high range BAC levels (> .150g/100ml). Of these, 37 (32.5% of high range and 16.6% of alcohol cases) were detected with illicit drugs. Single vehicle and multi-vehicle crashes were evenly represented, although males were overrepresented in all crash types. Alcohol and poly-drug consumption were more likely to be associated with single vehicle crashes (81.7% and 64.6% respectively), while detections of methamphetamines and THC in isolation without other substances were slightly overrepresented by multi-vehicle crashes (58.6% and 59.4% respectively). Single vehicle crashes usually involved speeding, loss of control and failure to negotiate a curve while multi-vehicle crashes were disproportionately represented by reckless driving and misjudging traffic conditions. Overall, an important theme to emerge was the contribution of illicit drugs and alcohol to the majority of single vehicle crashes, highlighting the increased risk of this type of crash for drivers who are positive with these substances.

Keywords

Fatal crashes, alcohol, drugs, coroner, Queensland

Introduction

The increasing utilisation of authority-based road traffic crash (RTC) databases is providing greater insight into the origins of different types of fatal road crashes. Analysis of crash characteristics and toxicology findings within these databases, can provide new scientific knowledge regarding the personal/environmental/legislative factors contributing to (or associated with) fatal crashes, not least the increased risk of crash involvement for motorists who consume

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alcohol prior to driving (Martin, Gadegbeku, Wu, Viallon, & Laumon, 2017; Moskowitz & Fiorentino, 2000; Rao, et al., 2013; Stringer, 2018; Voas, Tippetts, & Fell, 2000). For example, a recent French study reported that drivers who exceeded the legal blood alcohol limit were 17.8 times more likely to be responsible for a fatal crash compared to those who did not drive above the legal limit (Martin, et al., 2017), and a recent study in Australia reported similar findings (16 times more likely to be responsible) for all alcohol concentrations combined (Drummer, et al., 2020).

Similar crash outcome results have been identified for motorists who consume illicit substances. In regards to the latter, a growing body of research has demonstrated the link between fatal crashes and cannabis (Drummer, et al., 2020; Martin, et al., 2017; Palamara, 2015; Romano, Torres-Saavedra, Voas, & Lacey, 2014; Romano, Voas, & Camp, 2017), amphetamine-based substances (Drummer, et al., 2020; Hels, Lyckegaard, Simonsen, Steentoft, & Bernhoft, 2013) and opioids (Drummer, et al., 2020; Martin, et al., 2017). However, it is also noted that considerable debate has been outlined in the literature regarding the exact impairing effects of different illicit substance types (Rogeberg, 2019), particularly in regards to cannabis use (Rogeberg & Elvik, 2016). Put simply, conclusive evidence regarding the exact causal relationship between fatal crash risk and illicit substance consumption (through meta-analytic studies) has yet to be obtained (Rogeberg, 2019; Rogeberg & Elvik, 2016). At the very least, there is some evidence to suggest that the risk of fatal crash involvement is less for illicit substances, compared to that of alcohol (Martin, et al., 2017). The first paper from the current program of research revealed that alcohol remained the most common substance associated with fatal crashes (Davey, Armstrong, Freeman, & Parkes, 2020), incidentally, these findings were similar to recent investigations of non-fatal crashes in Australia (DiRago, et al., 2019). However, questions remain regarding the associated crash risk of alcohol combined with illicit substance consumption (Chihuri, Li, & Chen, 2017; Sewell, Poling, & Sofuoglu, 2009), including the combination of various illicit substances when driving. While the research is in its infancy, there is growing evidence to suggest combining alcohol with low levels of cannabis may increases crash risk, due to the impairing effects of these substances (Li, Brady, & Chen, 2013; Li, Chihuri, & Brady, 2017; Romano, et al., 2017) with one study reporting a fivefold increase in fatal two-vehicle crashes compared to non-impaired drivers (Li, et al., 2017). However, a recent study by (Drummer, et al., 2020), indicated that while the crash risk for THC combined with alcohol was much higher than the risk for THC alone, it was still lower than the crash risk for all alcohol concentrations. This suggests the effects may be additive rather than compounding. Taken together, this combination of different substances warrants further research, not least, in regards to the development of effective policies and legislation to combat impaired driving. Furthermore, there is a need to consider how substances can influence specific driving performance (e.g., speeding) or exacerbate negative effects (e.g., fatigue), although numerous challenges exist in regards to disentangling effects that may be cumulative in nature.

In regards to driving behaviours, there is a sizeable body of research that has examined a range of additional factors associated with crash outcomes, such as time of day (Huang & Lai, 2011; Kim, Ulfarsson, Kim, & Shankar, 2013; Regev, Rolison, & Moutari, 2018), driver demographics (Lam, 2002; Ma & Yan, 2014; Regev, et al., 2018; Skyving, Berg, & Laflamme, 2009), geographic region (Li, et al., 2013), freeway types (Gaweesh, Ahmed, & Piccorelli, 2019), weather conditions (Wang, Liang, & Evans, 2017; Wu, Zaitchik, & Gohlke, 2018), driving manoeuvres/driving tasks associated with crashes (Martensen & Dupont, 2013) etc. However, such research has primarily been undertaken to ascertain the utility of in-vehicle technology systems such as Advanced Driver Assistance Systems to avoid collisions (Aust, Fagerlind, & Sagberg, 2012) or explore the characteristics of single versus multiple vehicle crashes (Martensen & Dupont, 2013) (Martensen & Dupont, 2013), rather than links to licit or illicit substances. For example, (Aust, et al., 2012) examined factors associated with 28 fatalities in the Driving Reliability and Error Analysis Method (DREAM) and found that speed, drugs and/or alcohol as well as inadequate driver training contributed to almost half of all fatalities in the sample (although no clear links between substance type and driving were identified). Taken together, research has yet to extend to examine whether clear links can be found between different psychoactive substances (both legal and illegal) and the subsequent driving manoeuvres/tasks that led to fatal outcomes.

As a result, the current program of research focused on conducting an in-depth analysis of coroners findings for all fatally injured drivers (found to have consumed either alcohol or illicit drugs that are enforced in roadside drug testing in Australia) in the state of Queensland between the years 2011 to 2015. This paper is an extension of an earlier area of investigation that focused on: (a) the overall prevalence of alcohol and four illicit substances enforced for drivers in Australia (delta-9-tetrahydrocanabinol [THC], 3,4-Methylenedioxymethamphetamine [MDMA], methamphetamine [meth] and cocaine), (b) rate of crashes across the five-year time period and (c) the sociodemographic characteristics associated with such crashes. The specific research aims of the current paper were to:

1. Investigate the substance types (alcohol and illicit substances enforced for drivers in Queensland Australia) associated with single versus multi-vehicle crashes; and
2. Identify which fatal driver actions (e.g., speeding, losing control of the vehicle and dangerous driving) occurred more frequently with target substances and single or multi vehicle crashes.

Methods

Sample

All persons fatally injured in an RTC in Queensland (Australia) for the period 1 January 2011 to 31 December 2015 were initially included in the current study. A fatal crash is defined by any person who is killed on a public road (or individual who dies within 30 days from the injuries sustained in the crash). In total, records were received pertaining to 1355 cases (which may not reflect the total RTC fatality count for the period due to discretionary release of records by the Coroners Office). From this data repository 654 records (48.3 %) were excluded that were out of scope of this study. Specifically, exclusion criteria were, fatal crashes/collisions occurring off the road (e.g., residential driveways, private property, etc) or stemming from natural causes (e.g., sudden, fatal coronary event deemed to be resulting from a pre-existing condition) or deliberate self-harm (e.g., a suicide finding by the coroner), as well as cyclists, passengers and pedestrians.

Procedure

In Queensland, all details of a fatal traffic crash are filed with the state Coroners Court, this includes a toxicology analysis conducted from an ante-mortem or post-mortem sample in all cases, where possible (in some instances toxicology analysis may not be conducted due to a denatured sample, as in the case of incineration). Coroners summary reports for all fatal road traffic crashes (RTCs) that occurred in Queensland for the period of 2011 to 2015 were requested from the Office of the Sate Coroner Queensland. Coroners Findings and the Notice of Completion of Coronial Investigation (Form 20A) summary reports and associated toxicology certificates from the Queensland Health Forensic and Scientific Services, Forensic Toxicology Laboratory were reviewed for each case (where available). More specifically, the summary report often contains contextual information involving the circumstances relating to the death, including cause of death, location and time of death and sociodemographic information e.g., age, gender, etc. The toxicology certificate also provides contextual information regarding the sample (e.g., blood, urine, serum, other organ tissue, etc) and amount detected. In the majority of cases, the sample was taken from bloods however, in eight cases, liver samples were used and in six cases only urine was available. There were no illicit drugs or alcohol detections found in the urine or liver samples. Alcohol was measured as milligrams per 100 millilitres (reported in text as grams per 100 millilitres), while drugs were measured by milligrams per kilogram.

Drug testing was performed by the Forensic Toxicology Laboratory and involved full drug screening utilising gas chromatography involving mass spectral detection (CG/MS) as well as high performance liquid chromatography that included diode array detection (HPLC/DAD), and was accompanied by high-performance liquid chromatography with mass spectral detection (LC/MS/MS). For episodes involving the person initially surviving the crash that required medical assistance (e.g., 33 cases), ante mortem blood samples were analysed in the laboratory to achieve toxicology screening. The time period for antemortem analysis post-crash ranged from 45 minutes to 3 and a half hours, although the specimen was obtained from one case after approximately 5 hours post-crash. However, it was not possible to identify the length of time for post-mortem samples (from the toxicology certificate) of the delay between death and when the sample was obtained. All this time period was usually less than 3 days. A full drug analysis was completed for 95.6% of the sample, with 31 cases being excluded due to limited availability of a fluid sample. Toxicology analysis involved a variety of drugs/substances including alcohol, illicit drugs (e.g., cannabis) as well as prescription medication. However, this study focused only on substances that can be detected on the roadside through oral fluids (e.g., 3.4-methylenedioxymethamphetamine [MDMA], Δ9-tetrahydrocannabinol [THC], methamphetamine, and cocaine).

Results

Sample Characteristics

The final sample consisted of 701 cases pertaining to the deaths of controllers of motor vehicles. The mean age of the sample was 42.8 (*SD* = 18.8) and contained 578 males (82.5%) and 123 females (17.5%). The vehicles involved were classified as passenger vehicles (including utility vehicles and vans; *n* = 463, 66.2%), motorcycles (including mopeds and quad bikes; *n* = 197, 28.1%), and heavy vehicles (trucks, tractors, cranes; *n* = 41, 5.8%). In total, 306 drivers (43.7%) tested positive for alcohol and or target drugs (e.g., THC, methamphetamine, MDMA or cocaine). Table 1. outlines the frequencies of drug and alcohol detection (including a more extensive list of combinations initially outlined in (Davey, et al., 2020). This analysis further indicates alcohol was the most commonly detected substance both in isolation as well as combined with other substances.

As described in Table 1., alcohol was detected in 223 (31.8%) of all fatalities and was found to be present exclusively without the target drugs in 159 (71.3%) of these cases. Alcohol was detected at blood alcohol concentration (BAC) levels ranging from .001 to .393g/100ml with a median of 137.5. Figure 1 provides a depiction of cases grouped by BAC level in .05 g/100ml increments, including cases where alcohol was detected exclusively or with target drugs. The most frequently occurring alcohol concentration was a BAC between 0 and 0.05 g/100ml (*n* = 57, 8.1% of the total sample) followed by .200 to .249 g/100ml (*n* = 48; 6.8% of the entire sample) and .150 - .199 g/100ml (*n* = 47; 6.7% of the entire sample). THC was the

Table 1. Frequencies of target drug and alcohol detection among fatally injured motor vehicle controllers

	n	% D&A	% N	Level range	Mean (SD)
Total N	701	-	100%	-	-
Drug and alcohol negative	395	-	56.3%	-	-
Total drug & or alcohol (D&A)	306	100%	43.7%	-	-
Total alcohol positive (g/100ml)	223	72.9%	31.8%	.010 - .393	.128 (.92)
*Total alcohol only	159	52%	22.7%	.010 - 2.20	.527(.592)
*Alcohol > .05% only	115	37.6%	16.4%	-	-
*Alcohol < .05% only	58	19%	8.3%	-	-
Total drug positive drivers	147	48%	21.0%	-	-
Total THC positive (mg/kg)	109	35.6%	15.5%	.001- .110	.016 (.018)
Total Meth positive (mg/kg)	63	20.6%	9.0%	.010 - 3.10	.483 (.664)
*THC only	37	12.1%	5.3%	.001 - .082	.018 (.019)
*Methamphetamine only	30	9.8%	4.3%	.010 - 2.20	.527 (.593)
Total poly substance	80	26.1%	11.4%	-	-
†Alcohol + THC	37	12.1%	5.3%	-	-
†Alcohol + Meth	5	1.6%	0.7%	-	-
†Alcohol + THC + Meth	6	2.0%	0.9%	-	-
†Alcohol + THC + Cocaine	2	0.7%	0.3%	-	-
†Alcohol + Ecstasy + THC	1	0.3%	0.1%	-	-
THC + Meth	16	5.2%	2.3%	-	-
THC + Alcohol <.05	6	2%	0.9%	-	-
Meth + Alcohol <.05	2	0.7%	0.3%	-	-
THC + Meth + Alcohol <.05	4	1.3%	0.6%	-	-
Ecstasy + Alcohol <.05	1	0.3%	0.1%	-	-

Note: Alcohol level = g/100ml; * = detected exclusively without other substances; † = alcohol ≥ .05; Poly substance = any combinations of target drugs and or alcohol, THC = tetrahydrocannabinol, Meth = methamphetamine; motor vehicle includes, light and heavy vehicles and motorcycles.

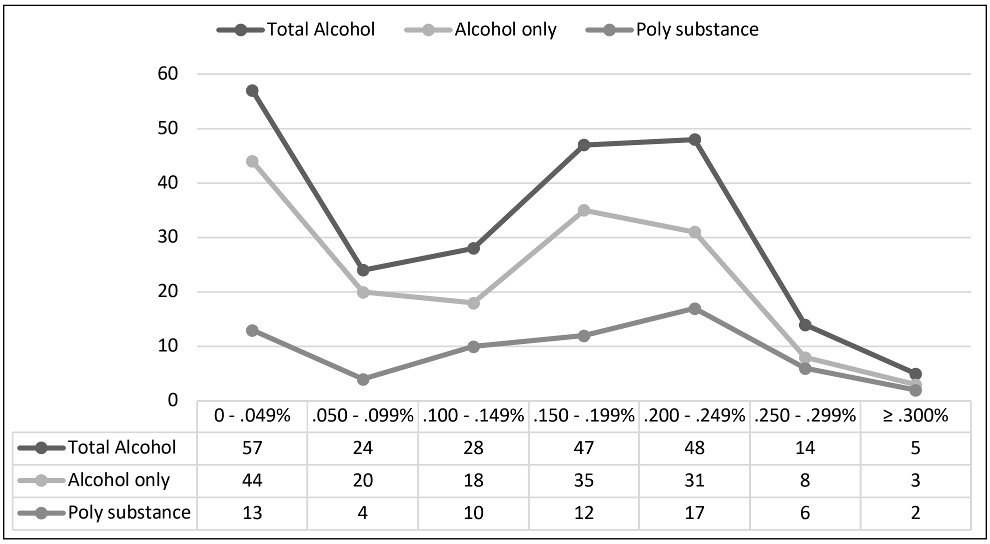

Fig 1. Blood alcohol levels with and without illicit drug positive detection. % = Blood Alcohol Concentration (g/100ml); Alcohol only = detected exclusively without the presence of target drugs (n = 223); Poly substance = THC, meth, MDMA or cocaine detected with alcohol.

most frequently detected substance in conjunction with alcohol and was most often detected at higher BACs (e.g., .150 – .249 g/100ml; n = 28; 4.0% of the entire sample and 25.7% of the THC positive sample). In total 114 drivers were detected with a high range BAC (≥ .150 g/100ml) representing 16.3% of the entire sample. Furthermore, 37 (32.5%) of these drivers also had target drugs detected, which is suggestive of high levels of intoxication at the time of the fatal accident.

Crash Characteristics: Single Versus Multiple Vehicle

Single vehicle (SV) and multiple (MV) crashes were analysed independently with consideration for achieving greater predictive utility from independent models due to the unique features of the two crash types (Geedipally & Lord, 2010). Table 2 presents frequencies and results of chi square tests of independence for substance type by crash type. SV crashes constituted only a slightly larger proportion of crash incidences (n = 353, 50.4%) compared to MV (n = 332, 47.4%) and 16 crashes involved hitting a pedestrian or were classified as other (e.g., hit animal). A statistically significant association was found for alcohol, poly substance and male drivers overrepresentation among SV in comparison to MV crashes. In contrast, higher representations of single target drugs were found among MV crashes, however only the distribution of THC was statistically significant. Finally, independent samples t-tests revealed that drivers who were killed in SV crashes were statistically significantly younger (M = 40.6, SD = 18.6) than driver fatalities of MV incidents (M = 45.1, SD = 19; $t(679) = -2.99$, p = .003) and, drivers who were detected with illegal concentrations of alcohol or target drugs were also statistically significantly younger (M = 34.6, SD = 11.8) compared to drivers who tested negative for target drugs or alcohol concentration (M = 47.7, SD = 20.5; $t(694)$ = 9.44, p < 001). However, it should be noted that the mean ages of both groups suggest the fatally injured drivers were experienced drivers e.g., mean age greater than 40.

Further analyses were conducted to determine the prevalence of single and multi-vehicle crashes at each of seven levels of alcohol concentration. A trend was observed whereby higher rates of MV crashes tended to occur within the legal range of alcohol concentration (< .05g/100ml) and above this level of concentration SV crashes were substantially more prevalent. The higher ranges of alcohol concentration (e.g., 150 – 249g/100ml) showed the greatest differences in higher SV crash rates (See Figure 2.).

The data was further examined for noticeable interactions between crash type (e.g., SV and MV crashes) and crash factors (e.g., driver behaviour or environmental features) and factors that contribute to fatal injury (e.g., not wearing a seatbelt) as well as the detection of target drugs or alcohol (see Table 3 for reported statistics). Interestingly, when comparing groups of drug and alcohol positive with drug and alcohol negative drivers across the most prevalent driver error (e.g., failure to negotiate a curve, n = 176),

Table 2. Analyses of Single versus Multiple Crash Types

		Total		Single Vehicle		Multiple vehicle		Chi Square	
		N	***%***	***n***	***% N***	***n***	***% N***	***χ2***	***p***
Alcohol ≥ .05	**Yes**	115	16.4%	94	36.3%	21	6.3%	50.49	< .001***
	No	586	83.6%	259	73.4%	311	93.7%		
THC	**Yes**	37	5.3%	13	3.7%	22	6.6%	3.06	0.08*
	No	664	94.7%	340	96.3%	310	93.4%		
Meth	**Yes**	30	4.3%	12	3.4%	17	5.1%	1.24	0.264
	No	671	95.7%	341	96.6%	315	94.9%		
Poly Substance	**Yes**	80	11.4%	53	15.0%	26	7.8%	8.65	0.003**
	No	621	88.6%	300	85.0%	306	92.2%		
D&A or A	**Yes**	258	36.8%	172	48.7%	86	33.3%	37.95	< .001***
	No	427	60.9%	181	51.3%	246	57.6%		
Sex	**Male**	562	80.2%	310	79.1%	252	85.4%	5.08	0.024*
	Female	125	17.8%	82	20.9%	43	14.6%		

Note: Alcohol level = g/100ml; D&A = drugs and (alcohol ≥ .05g/100ml); *p = < .05; **p = < .01; ***p = < .001; $\chi2$ = Pearson Chi-Square; 16 cases had missing data for the SV/MV variable; THC = tetrahydrocannabinol, Meth = methamphetamine.

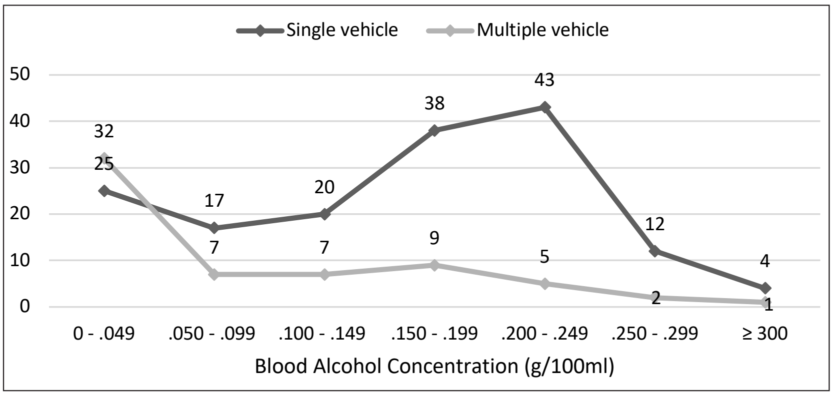

Fig 2. Single and multiple vehicle crash distribution across levels of blood alcohol concentration.

Table 3. Crash Type by Driver Actions and Drug or Alcohol Toxicology

	Total		SV		MV		Chi Square	
Crash Factor [drugs/alcohol]	**N**	**% N**	***n***	**%**	***n***	**%**	**$\chi 2$**	***p***
Failure to negotiate a curve	176		121	68.8%	55	31.3%		
[Negative]	101	57.4%	57	32.4%	44	25.0%	16.729	<.001***
[Positive]	75	42.6%	64	36.4%	11	6.3%		
Speeding	159		103	64.8%	56	35.2%		
[Negative]	62	39.0%	32	20.1%	30	18.9%	7.722	.005**
[Positive]	97	61.0%	71	44.7%	26	16.4%		
Lost control	75		60	80.0%	15	20.0%		
[Negative]	34	45.3%	24	32.0%	10	13.3%	3.443	0.064
[Positive]	41	54.7%	36	48.0%	5	6.7%		
Fatigue	52		27	51.9%	25	48.1%		
[Negative]	31	59.6%	15	28.9%	16	30.8%	0.384	0.535
[Positive]	21	40.4%	12	23.1%	9	17.3%		
Reckless driving	37		16	43.2%	21	56.8%		
[Negative]	15	40.5%	6	16.2%	9	24.3%	0.108	0.742
[Positive]	22	59.5%	10	27.0%	12	32.4%		
Failure to secure a seatbelt	88		74	84.1%	14	15.9%		
[Negative]	31	35.2%	27	30.7%	4	5.4%	0.323	0.57
[Positive]	57	64.8%	47	53.4%	10	13.5%		
Failure to spot/misjudge traffic	49		0	0.0%	49	100.0%		
[Negative]	40	81.6%	0	0.0%	40	81.6%	7.14	.
[Positive]	9	18.4%	0	0.0%	9	18.4%		
Distraction	26		13	50.0%	13	50.0%		
[Negative]	16	61.5%	6	23.1%	10	38.5%	2.6	0.107
[Positive]	10	38.5%	7	26.9%	3	11.5%		
Road conditions - weather	31		18	58.1%	13	41.9%		
[Negative]	22	71.0%	10	32.3%	12	38.7%	4.949	.026*
[Positive]	9	29.0%	8	25.8%	1	3.2%		

Note: Alcohol level = ≥ .05g/100ml; in some cases, MV and SV data was not included in the coroners report and therefore total *N* may not reflect the total *N* reported elsewhere the majority of crashes did not involve target drugs or alcohol (*n* = 101, 57.4%) and, for target drug and alcohol negative drivers, the distribution between single and multi-vehicle crashes was more evenly distributed than in cases of the same error where target drugs or alcohol were detected (e.g., 65.2% of drivers detected with target drugs or alcohol that failed to negotiate a curve were SV crashes). The factors that were also overrepresented by drivers unaffected by target drugs or alcohol were fatigue (*n* = 31; 57.0%), failing to spot/misjudge traffic (*n* = 40; 81.6%), distraction (*n* = 16; 61.5%) and road conditions affected by the weather (*n* = 22; 71.0%). Whereas drivers who were detected with alcohol or target illegal drugs were more commonly involved in crashes involving speeding (*n* = 97; 61.0%), failing to secure a seatbelt (*n* = 57; 64.8%), losing control of the vehicle (n = 41; 54.7%) and reckless driving (*n* = 22; 59.5%). Single vehicle crashes were more likely to occur in cases of failing to negotiate a curve (*n* = 121; 68.8%), speeding (*n* = 103; 64.8%), failing to secure a seatbelt (*n* = 74; 84.1%), losing control of the vehicle (*n* = 60; 80.0%) and road conditions affected by weather (*n* = 18; 58.1%). In contrast, multivehicle crashes involved a greater proportion of cases of reckless driving (*n* = 21; 56.8%) and, failing to spot or misjudging traffic (*n* = 49; 100%). Distracted drivers were equally involved in SV and MV crashes. A series of chi square analyses between all three variables (crash type, crash factor and substance detection) revealed statistically significant interactions for crash type and toxicology associated with the following crash features: failure to negotiate a curve ($p < .001$), speeding ($p = .005$) and road conditions affected by weather ($p = .026$).

A more detailed analysis of substance type across the most common pre collision driver actions, did not indicate a clear pattern of association (refer to Table 4.). Within the D&A related sample, alcohol was the most common substance detected in conjunction with the majority of driver behaviours and errors. However, poly substance was most common in cases of speeding (*n* = 41, 47.7% of D&A cases), fatigue (n = 7, 35% of D&A cases), overtaking (*n* = 5, 50% of D&A cases), failure to wear a helmet (*n* = 4, 50% of D&A cases) and driving through a red light (*n* = 2, 100% of D&A cases). For the following driver errors, THC was the most common within the D&A sample: failing to spot or misjudged traffic (*n* = 6; 66.7% of D&A cases), failing to spot a stationary or slow vehicle (*n* = 3, 30.0% of D&A cases) and hitting an object on the road (*n* = 4; 57.1% of D&A cases). Methamphetamine was the most detected substance in cases of veering into oncoming traffic (*n* = 8; 33.3% of D&A cases).

Regional Analysis

A final analysis was conducted to review regional differences in SV and MV crash types and substance related crashes. Crash locations were divided into five groups using the Accessibility and Remoteness Index of Australia (ARIA+; Australian Bureau of Statistics [ABS], 2020). Of the 692 reports that contained crash locations (98.7% of all cases), slightly more occurred within major cities (*n* = 236, 34.1%) than inner regional areas (*n* = 234, 33.8%) followed by outer regional areas (*n* = 171, 24.7%), while remote and very remote crashes accounted for 27 (3.9%) and 24 (3.5%) of ARIA grouped fatalities respectively. In regard to crash type, SV crashes were found to have a higher representation in major cities (*n* = 125, 53%), outer regional (*n* = 90, 52.6%), remote (*n* = 22, 81.5%) and very remote areas (*n* = 20, 83.3%), whereas inner regional crashes had a greater percentage of MV crashes (*n* = 137, 58.5%). In a comparison of drug and alcohol negative with drug or alcohol positive crashes, the representation of fatalities across the ARIA classifications was generally comparable, with the exception of the non-drug/alcohol group being substantially over represented (*n* = 150, 63.8%) in inner regional ARIAs than fatalities with drug or alcohol detection (*n* = 85, 36.2%).

Discussion

The current study undertook a deeper examination into coroners findings between 2011 and 2015 in order to: (a) investigate the personal and environmental factors associated with single versus multi-vehicle substance related crashes and (b) explore what links exist between driving tasks and substance types that were associated with different types of fatal crashes. As outlined in (Davey, et al., 2020) alcohol was the most commonly detected substance (e.g., 72.9% of the drug and alcohol sample and 31.8% of the entire sample), which is consistent with previous research (Chen & Jou, 2018; National Highway Traffic Safety Administration, 2017; Romano, et al., 2017). However, the current study involved a deeper exploration that revealed: (a) as expected, low levels of alcohol were also associated with 57 fatal crashes (and combined with illicit substances for 18.1% of that sample), (b) alcohol was most commonly associated with THC consumption (11.6% of the substance sample), (c) alcohol was the most common drug type associated with other substances (e.g., common denominator) and (d) the proportion of THC and methamphetamine fatalities increased with excessive alcohol consumption (as outlined in Figure 1.). Due to the current zero tolerance enforcement approach for the targeted illicit substances, a detailed analysis of substance levels was not conducted. However, it was noted that high levels of target drugs were detected with alcohol and similarly, high levels of alcohol detected with target drugs (depicted in Table 1). A future area of enquiry might provide a comprehensive analysis of drug levels with associated crash features. On the one hand, the findings further reinforce the on-going problem of inappropriate alcohol consumption creates for road safety. On the other hand, the results suggest further research is warranted into the possible synergistic effects of low level alcohol consumption with other psychoactive substances, which has recently been found to be demonstrated (Romano, et al., 2014; Romano, et al., 2017; Sewell, et al., 2009).

Table 4. Substance Type and Pre-Collision Driver Action

	Total		D & A Negative		D & A Positive		*Alcohol		*Meth		*THC		Poly-substance	
	N	%	n	% N	n	% N	n	% N	n	% N	n	% N	n	% N
Failure to negotiate a curve	178	25.4%	103	57.9%	75	42.1%	35	19.7%	5	2.8%	8	4.5%	27	15.2%
Speeding	162	23.0%	64	39.5%	98	60.5%	39	24.1%	12	7.4%	8	4.9%	39	24.1%
Veered off road	115	16.4%	65	57.0%	50	43.0%	28	24.6%	4	3.5%	5	4.4%	13	11.4%
Veered into oncoming traffic	90	12.8%	66	73.3%	24	26.7%	5	5.6%	8	8.9%	7	7.8%	4	4.4%
Failure to secure seatbelt	89	12.7%	32	36.0%	57	64.0%	34	38.2%	5	5.6%	5	5.6%	13	14.6%
Lost control	75	10.7%	34	45.3%	41	54.7%	25	33.3%	4	5.3%	0	0.0%	12	16.0%
Fatigue	52	7.4%	31	59.6%	21	40.4%	6	11.5%	6	11.5%	2	3.9%	7	13.5%
Failure to spot/misjudged traffic	49	7.0%	40	81.6%	7	14.3%	1	2.0%	2	4.1%	4	8.2%	2	4.1%
Reckless driving	37	5.3%	15	40.5%	22	59.5%	10	27.0%	4	10.8%	1	2.7%	7	18.9%
Road conditions (weather)	31	4.4%	22	71.0%	9	29.0%	2	6.5%	1	3.2%	3	9.7%	3	9.7%
Failure to spot stationary vehicle	30	4.3%	22	73.3%	8	26.7%	2	6.7%	1	3.3%	4	13.3%	1	3.3%
Overtaking	29	4.1%	20	69.0%	10	34.5%	2	6.9%	2	6.9%	1	3.5%	5	17.2%
Failure to give way to vehicle	26	3.7%	24	92.3%	2	7.7%	0	0.0%	1	3.9%	0	0.0%	1	3.9%
Distraction	26	3.7%	16	61.5%	10	38.5%	3	11.5%	2	7.7%	3	11.5%	2	7.7%
Mechanical issue	25	3.6%	13	52.0%	12	48.0%	7	28.0%	1	4.0%	2	8.0%	2	8.0%
Object on road	19	2.7%	12	63.2%	7	36.8%	1	5.3%	1	5.3%	4	21.1%	1	5.3%
Road configuration (structural)	17	2.4%	11	64.7%	6	35.3%	5	29.4%	1	5.9%	0	0.0%	0	0.0%
Failure to wear a helmet	14	1.7%	6	42.9%	8	57.1%	4	28.6%	0	0.0%	0	0.0%	4	28.6%
Drove through red light	7	1.0%	5	71.4%	2	28.6%	0	0.0%	0	0.0%	1	14.3%	1	14.3%
Total *n*	701	100.0%	507	72.3%	234	33.4%	115	16.4%	30	4.3%	34	4.9%	83	11.8%

Note: Alcohol level = ≥ .05g/100ml; D&A = Drugs and (alcohol ≥ 50); *Detected exclusively without the presence of other substances; THC = tetrahydrocannabinol, Meth = methamphetamine.

A comparative analysis of single and multiple vehicle crashes revealed that alcohol was more commonly associated with single rather than multiple vehicle crashes e.g., 81.7% vs 18.23%. This was one of the clearer themes to emerge from the research. This finding supports a growing body of evidence that indicates alcohol is disproportionately represented in single vehicle crashes (Öström & Eriksson, 1993; Rao, et al., 2013). Taken together, and similar to recommendations made by Mørland, et al. (2011), the majority of single vehicle crashes (in the current sample) appear to be clearly preventable.

In contrast, few clear trends appear to emerge regarding multi-vehicle crashes (apart from multi-vehicle crashes likely to be associated with failing to spot or judge traffic which was attributed to driver error without the presence of drugs or alcohol in 81.6% of cases). While the current study indicated a slightly higher proportion of fatally injured drivers in multi-vehicle accidents had consumed either cannabis or methamphetamines, further research is required to explore the reliability of this result (as the cell sizes are quite small). A clearer trend (similar to that of alcohol), was that poly substance use was also over-represented in single vehicle crashes e.g., 64.6% versus 35.4%. While the current methodology limits exploration into synergistic effects, the result is consistent with previous research that has indicated a possible deleterious impact of poly substance consumption on the driving task (Chihuri, et al., 2017; Li, et al., 2017).

Additionally, single vehicle crashes were also more likely to be associated with male drivers, speeding, losing control of the vehicle, failure to negotiate a curve and alcohol consumption. As noted above, while examination of the extent and factors associated with suicides was beyond the scope of the current study, future research could benefit from identifying the characteristics of crashes stemming from deliberate self-harm (not least to ensure that such events do not spuriously affect road toll calculations). As outlined in Milner and De Leo (2012's) seminal study, there are a multitude of challenges associated with identifying and separating numerous personal and environmental factors that interact to create a road crash. This is in addition to the personal/familial consequences of identifying an episode of deliberate self-harm that involves a multi-vehicle crash e.g., collision with a truck. In regards to gender, a central theme to emerge from this program of research is that males are over represented in substance related crashes, which is consistent with research that has demonstrated males have historically been overrepresented in crash databases (Mayhew, Ferguson, Desmond, & Simpson, 2003; Palamara, Broughton, & Chambers, 2013). In regards to speeding and losing control of the vehicle, both factors are well documented to increase crash risk (Viallon & Laumon, 2013) which are likely further compounded by the impairing effects of substance use. Regardless, non-rule compliance in regards to speeding remains a major road safety concern, which can be manifested in a range of different crash types (Abegaz, Berhane, Worku, Assrat, & Assefa, 2014).

Similar to single versus multi-vehicle crashes, analysis of combined substances versus no substances revealed that while there were few differences in the "no drugs" category, motorists who tested positive to either alcohol or drugs were more likely to be in single vehicle crashes with circumstances relating to increased likelihood of: (a) failure to negotiate curve, b) speeding, (c) not wearing a seat belt, (d) reckless driving and (e) losing control of the vehicle. The results again suggest that the ingestion of substances can create a range of impairing effects in regards to recognising (and responding appropriately) to risk. A corresponding examination of drug type by crash type (single versus multiple) revealed: drinking alcohol was more associated with single vehicle crashes whereas THC and methamphetamine related crashes had a higher propensity to involve multiple vehicles. While research has indicated that alcohol creates driving impairments (Ogden & Moskowitz, 2004), cannabis creates driving skill impairments (Hartman & Huestis, 2013) and body of research indicates that methamphetamine consumption increases risk taking (Brecht & Herbeck, 2014), the current study's methodology does not permit for such effects to be clearly identified or disentangled (including specific drug levels). Additionally, it should be noted that identifying the presence of a drug does not equate to clear existence of impairment, particularly in regards to levels of tolerance (e.g., frequency/pattern of past consumption) and the problem of quantifying a level of impairment based on blood concentrations of a substance (Reisfield, Goldberger, Gold, & DuPont, 2012). That is (and in contrast to breath alcohol concentration levels), a linear relationship between identified levels of a drug and corresponding levels of impairment does not currently exist within the scientific literature (which has clear implications for roadside drug driving detection and prosecution). This matter is further complicated via post-mortem re-distribution that involves the changes that occur in drug concentrations after death. At the very least, the relationship between drug levels and impairment deserves further research, particularly within the area of novel psychoactive substances (e.g, 6AM morphine for heroin users etc.) wherein published data may be less substantiated. Another limitation of the study is that time of crash was not included in the analyses (as 25% of the coroners' summary reports omitted such information), which precluded analyses regarding the interaction between day/night and substance type as well as crash type.

In the final analysis of crash types and substance related crashes by regional ARIA classification, the findings for the distributions of fatal crashes across each region were comparable to data published by Steinhardt, Sheehan, and Siskind (2009) for an earlier period, suggesting a somewhat stable distribution across time. Not surprisingly, SV crashes were overrepresented in remote and very remote areas, which is indicative of the lower volume of traffic on these roads. A noteworthy finding regarding substance related crash distributions across regions, was that a lower representation of drug and or alcohol related crashes occurred in inner regional areas. A plausible explanation for this result may be the lower frequency of alcohol vendors in these areas as a percentage of the population (Morrison, Ponicki, Gruenewald, Wiebe, & Smith, 2016). However, this particular area of research warrants further investigation.

Conclusion

The current study represents an extension of the first published in-depth analysis of coroners findings in the state of Queensland (Davey, et al., 2020), with a focus on the circumstances surrounding substance impaired crashes. Consistent with the impairing effects of substances, examination into the origins of crashes remains complex and likely includes a range of personal and environmental factors. Nevertheless, clear trends emerged regarding links between: (a) excessive alcohol consumption and crash involvement, (b) excessive alcohol consumption combined with illicit substances (which indicates motorists' failure to acknowledge escalating risk) and (c) illicit substance consumption and multi-vehicle crashes e.g., head on collisions. While only preliminary, the results suggest further scientific effort is needed to understand and prevent impaired driving (both for alcohol and illicit substance use), not least because of the possible decriminalisation of some substances in the future and the multiple challenges this will present in regards to understanding and negotiating risk of impairment.

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Identifying Future Vehicle Safety Priority Areas in Australia for the Light Vehicle Fleet

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Key Findings

- Three light vehicle crash types are projected to be the largest contributors to fatalities and the least addressed by active and passive technologies in 2030 for the light vehicle fleet:
  - fatal pedestrian crashes,
  - single vehicle frontal crashes with fixed objects, and
  - front-to-front vehicle crashes both at intersections and midblocks, and front-to-side impacts at intersections including straight crossing path and right turn across path crash types.
- Future vehicle safety policy priorities should address these crash types through the development of additional or enhanced vehicle safety technologies and other countermeasures that address the key crash types remaining in the system.

Abstract

Formulating priorities for future road safety strategies requires supporting analysis to predict what the future crash population will look like and to assess how the countermeasures either already in place or planned will address the crash problems forecast. This analysis aimed to identify future priority action areas for light vehicle safety by identifying crash types that will not be fully addressed in the future by projected improvements in active and passive safety in the Australian light vehicle fleet. The future crash profile was modelled from 2017 to 2030 using crash data from 5 Australian jurisdictions overlayed with available evidence on vehicle safety feature fitment and effectiveness. The methodology can be applied to larger sets of safety technologies when sufficient evidence and supporting crash data become available. Three future vehicle safety priority areas were identified from the analysis: (i) fatal pedestrian crashes, (ii) single vehicle frontal crashes with objects, and (iii) front-to-front vehicle crashes both at intersections and midblocks, and front-to-side impacts at intersections including straight crossing path and right turn across path crash types. These crash types were projected to be the largest contributors to fatalities by 2030. Projections showed that remaining crash types in 2030 will be poorly addressed by current vehicle safety technologies such as autonomous emergency braking, lane departure warning and electronic stability control. Future vehicle safety policy priorities should address these crash types through the development of additional or enhanced vehicle safety technologies and where vehicle safety technology proves inadequate other countermeasures such as road infrastructure treatments and appropriate speed limit setting for high risk environments that address the key crash types remaining in the system.

Keywords

Active vehicle safety technology injury mitigation

Glossary

Active Safety Vehicle Technology

A vehicle safety technology which initiates a human or autonomous response which may result in crash avoidance.

Those included in this analysis are:

Electronic Stability Control (ESC)
Autonomous Emergency Braking (AEB)

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Ped AEB (AEB with specific pedestrian detection capability)
Blind Spot Detection (BSD)
Lane Departure Warning (LDW)
Lane Keep Assist (LKA)
Blind Spot Detection (BSD)
Side View Assist (SVA)
Adaptive or Active Headlamps (ADHL)
Rear Cross Traffic Alert (RXA)
Reversing or Rear Camera (RC)
Telematic intelligent transport systems

Light vehicle injury crash

Any crashes involving at least one light vehicle and at least one injured person and unless otherwise stated the term 'injuries' referred to any person injured in a crash: pedestrian, bicyclist, rider or vehicle occupant. If the injury resulted in hospital admission, it was considered 'serious'.

First event of a crash

The first collision event of a crash. It may involve one or two motor-vehicles only.

Introduction

There is a significant body of research that can inform policy development and advocacy on vehicle crash risk and occupant injury outcomes and their relationship with new vehicle safety technologies. Formulating approriate priorities for future road safety strategies requires analysis to predict what the future crash population will look like and to assess how the countermeasures either already in place or planned will address the crash problems forecast. This allows unaddressed crash problems to be identified and in response, allows strategies to be modified or expanded to address these problems including the development of new countermeasures. The need to develop new countermeasures for unaddressed problems also assists in defining the requirements for fundamental research to inform countermeasure development. This approach can be used for all aspects of the safe system including safe vehicles and has been used here to identify the likely residual crash problems unaddressed by active and passive vehicle safety technologies that are currently permeating the light vehicle fleet.

The aim of this project was to identify future vehicle safety priorities in Australia through an integrated analytical approach based on mass data records from police reported crashes. Firstly, future crash population profiles were predicted based on past trends. Projections considered the categorisation of crash trends by factors relevant to vehicle safety countermeasures including crash type, vehicle type and location. The next phase of the project considered vehicle safety countermeasures already in place including emerging new vehicle safety technologies and their expected impact on projected future road trauma levels. From this analysis the likely residual unaddressed road safety problems were identified. The final stage of the project was a review with recommendations of potential future vehicle safety countermeasures which could address the residual road safety problems identified but are not yet proven. The project focussed on the light vehicle fleet in Australia.

Method

The analysis estimated potential crashes avoided by active safety technologies in the Police reported Australian light vehicle crash fleet projected from 2017 to 2030. Prior to making projections, the presence of current crash and injury trends by crash type, vehicle type and location were explored over the years 2006 to 2016 to characterize the baseline. The 2016 crash year was the base from which the natural fitments of ESC, AEB, Ped AEB, LDW/LKA, BSD/SVA, ADHL, RC, RXA and telematic intelligent transport systems over 2017 to 2030 were modelled. These technologies were selected on the basis of having sufficient, yet incomplete fleet penetration and having availabiliy of fitment and effectiveness data. Technologies which address driver intention, fatigue and inattention, as well as vehicle speed at the time of the crash could not be included because these causes were not universally recorded in the available crash data and real world effectiveness was either unavailable or required identification of crashes these causes. The distributions of crashed vehicle age and market group, crash characteristics and crash involved person traits were maintained at the baseline level, so that the crash and injury mitigation effects of vehicle fitment and future crashworthiness could be isolated. This methodology has purposefully been kept simple as it is primarily being used to identify future safety priorities. The estimates of crashes avoided by active safety technology in light vehicles are not the net average overall expected crash reductions, but rather the reductions specific to the technologies studied, under a specific set of crash conditions.

The probabilities of standard fitments (Automotive Data Services PL, 2014) of the selected active safety vehicle technologies, by year of manufacture and market group were projected from current fitment trends using logistic regression. Projected crashes potentially mitigated by each vehicle active safety technology were estimated from the involved vehicle rates of fitment and effectiveness. The effectiveness of crash avoidance technology was taken from published studies benchmarked by statistical evaluations of real-world data (Scully and Newstead 2010, Cicchino 2017a, Cicchino 2017b, Keall, Fildes et al. 2017, Sternlund, Strandroth et al. 2017, Strandroth, Lie et al. 2017, Cicchino 2018a, Cicchino 2018b, Cicchino 2019, Newstead, Budd et al. 2020) . Where real-world crash analyses were unavailable, meta-analysis, or studies using simulations, combined with in-depth crash data analyses were used (Jermakian 2011, Kusano and Gabler 2014, Doecke, Grant et al. 2015, NHTSA 2016, Sander 2017, Scanlon, Sherony et al. 2017, Silla, Rämä et al. 2017, Toshiyuki and Yukou 2017).

When multiple technologies were available for a crashed vehicle, crash avoidance was calculated in an additive hierarchical manner, by effectiveness. This technique has been widely accepted and used in literature (Corben, Logan et al. 2009, Elvik 2009). In this analysis, effects have been considered independent, because only active technologies were being applied, and each of the chosen active technologies work in a different manner and on crashes with different causation and type. The methods used were conservative and likely to under-estimate the crashes avoided, because with each application of a crash effectiveness, the remaining un-avoided crashes were in reality likely to be better matched to the next technology. If the remnant becomes more concentrated with crashes sensitive to the next technology, then the applied effectiveness will under-estimate the crashes avoided.

Models of projected crashworthiness ratings (Newstead, Watson et al., 2018) were used to estimate the additional benefits of advancements in vehicle design and passive safety systems. Fatal and serious injuries from the remaining crashes not estimated to be avoided by active vehicle safety technology were further reduced if the injury was to a light vehicle occupant. The product of these fatal and serious injuries, and the ratio of the average annual crash fleet crashworthiness rating to the average 2016 crash fleet crashworthiness rating, gave the estimate of injuries that were not avoided by passive safety and vehicle design. The crashes and injuries, which were not avoided by active or passive safety technologies, informed the assessment of future vehicle safety priority areas.

The crashes and injuries estimated to be saved in the projected crash years were analysed based on 12 (first event) collision types. Each technology was only applied to the one or two light vehicles involved in the first event of a collision. These are:

- single light vehicle crashes (no collision with bicycle/moped/pedestrian)
    1 rollover or no collision,
    2 collision to front,
    3 collision with side or rear, and
    4 collision to rear when reversing;
- light vehicle-to-bicycle/moped crashes
    5 vehicle hits bicycle/moped – front, and
    6 collision of bicycle/moped to rear/side of vehicle;
- light vehicle-to-pedestrian crashes
    7 frontal impact (vehicle not-reversing), and
    8 rear impact (vehicle reversing); and
- multi-vehicle, light vehicle-to-other motor vehicle crashes
    9 front-to-rear impact,
    10 front-to-side impact,
    11 front-to-front impact, and
    12 side-to-side impacts.

Rear-to-rear collisions were evaluated also, however their contribution was so small as to be insignificant.

Results

Projected injuries saved from the additional active and passive safety technology penetration available in 2030 amounted to 351 fatalities, 7,086 serious injuries and 12,345 minor injuries. About one third of all 2016 fatal and serious injuries were projected to be avoided in 2030 through the additional penetration of active and passive safety technologies. In 2030, 207 fatal crashes, 3,369 serious injury crashes and 8,492 minor injury crashes were projected to be avoided because of the additional penetration of active safety technologies.

Figure 1 compares the 2016 and projected 2030 distributions of types of crashes not avoided by active safety technology by crash severity and region. Active safety technologies were projected to noticeably decrease the proportion of single forward moving vehicle collisions across all severities, as well as serious and minor front-to-rear collisions. Conversely the proportions of bicycle/moped, fatal pedestrian, serious and minor front-to-front, minor front-to-side, fatal and serious rural front-to-side crashes were predicted to noticeably increase.

Figure 2 compares the number of 2016 crash injuries with those avoided from projected 2030 active and passive safety technologies, by severity and region. It shows that currently rural regions contribute to most fatalities and metropolitan regions are the locations of most non-fatal crash injuries. These trends were replicated in the injuries avoided through only active safety technologies. However, a greater proportion of serious injuries were avoided through the additional effects of passive safety technologies (on crash injuries not avoided through active safety technologies) in rural areas than in metropolitan regions. The greater proportions of vulnerable road user injuries in metropolitan areas offer an explanation for this trend reversal, since motorcyclist, pedestrian, bicyclist and moped rider injuries were not impacted by the methods used to estimate passive safety technology savings. In terms of proportion avoided, more than a third of fatalities and serious injuries were expected to be avoided in 2030, with the greatest proportions of both in rural regions. More than a quarter of all minor injuries were predicted to be avoided, with similar proportions in rural and metropolitan regions.

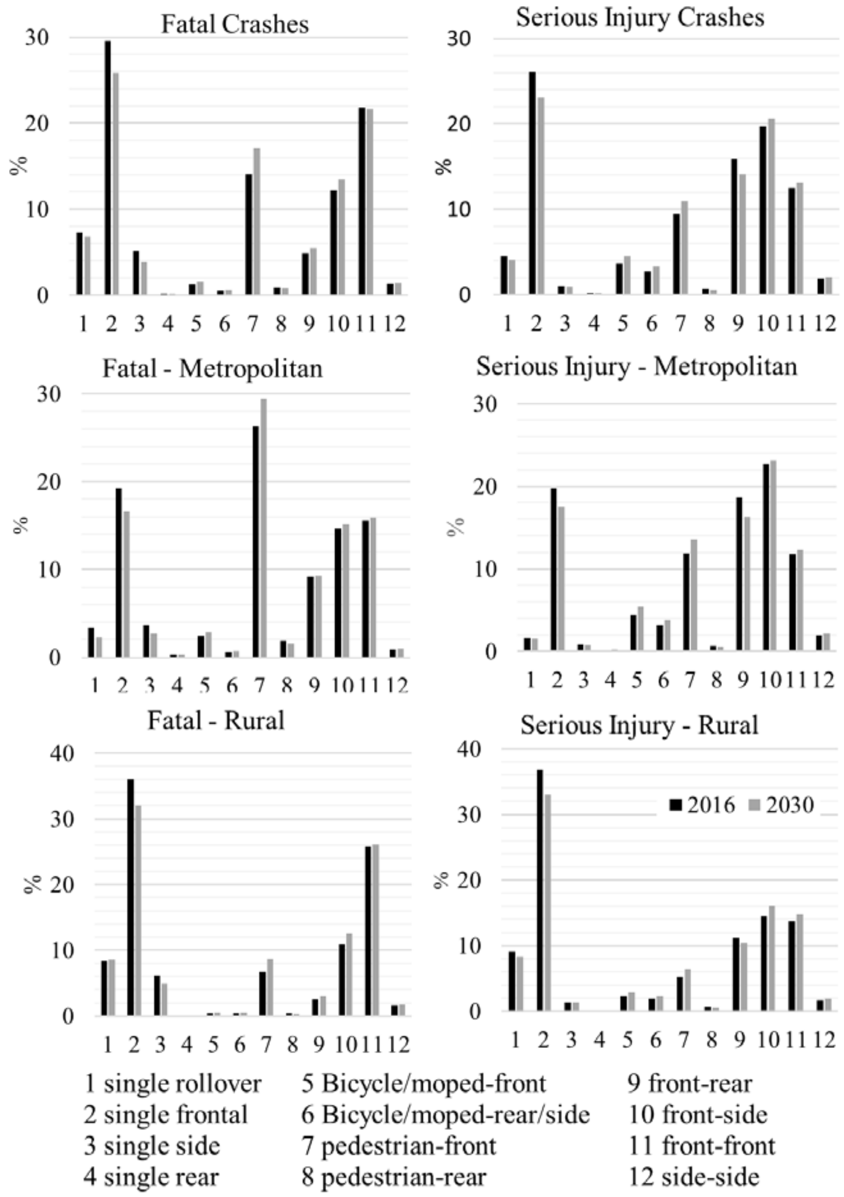

Figure 1. 2016 & projected 2030 distribution of injury crash types for fatal and serious injury crashes for all crashes and by metropolitan and rural regions

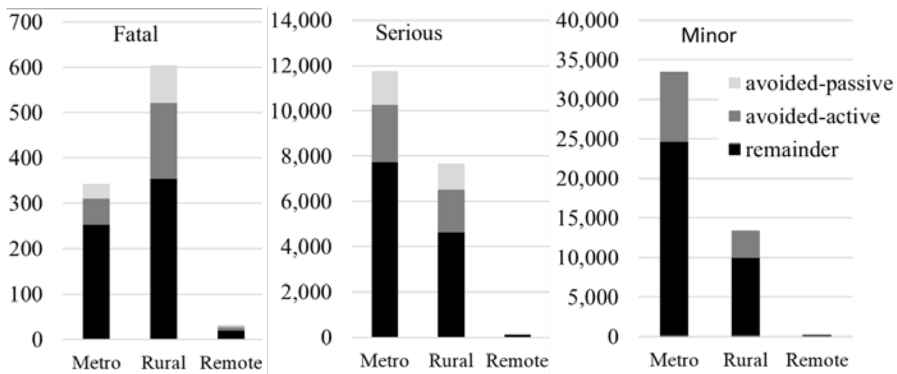

Figure 2. 2016 Crash injuries by location and severity disaggregated by vehicle safety technology projections in 2030

Figure 3 compares the 2016 injuries by severity and broad market group with 2030 projections. Large, medium and people mover markets were grouped together; crashes involving these vehicles contributed greatest number of fatalities, however, fatal crashes were over represented by SUV and LCV crashes. Small and light vehicles were grouped together; crashes involving these vehicles contributed greatest to serious and minor injuries. Small, medium and large SUVs contributed least to fatalities and commercial van and utility (LCV) crashes contributed least to serious and minor injuries. These trends were observed for injuries avoided through safety technologies with the exception of fatalities where SUV crashes ranked least as a baseline contributor, but LCV crashes ranked least in fatalities avoided through active safety technologies. This may be explained directly by the poorer penetration of active technologies expected for the light commercial vehicle market.

Figure 4 presents the injuries avoided and not avoided by active and passive technologies by crash type. Furthermore, the remaining injuries have been disaggregated by road user type: light vehicle front and rear occupants, pedestrian and other vehicle occupants/road users. It is clear that vulnerable road users make up a large proportion of the fatalities in the remaining crashes. Generally, the 'other' types from bicycle and moped crashes (crash types 5 and 6) are bicyclists or moped riders and those from crash types 9-12 are motorcyclists. Because bicyclist, moped rider and pedestrian fatalities were largely not avoided, vulnerable road users are an increased proportion of the 2030 remaining crash fatalities. Results for crashes rather than injuries show the same trends.

Figure 5 presents the projected 2030 crash reduction percentages from active safety technology by region, crash severity and crash type. This figure highlights the poorer avoidance of: reversing (4), bicycle/moped type (5 & 6), pedestrian (7), front-to-side (10) and side-to-side (12) collisions. It also clearly demonstrates that except for pedestrian and bicycle/moped crashes, most remaining fatal crashes by crash type were in rural regions and mostly from single vehicle, front-to-front and front-to-side collisions.

Vehicle Safety Priority Areas

The final stage of the project was a review of current or emerging vehicle safety countermeasures that may address the residual road safety problems identified. From this review, areas of road trauma unlikely to be addressed by any current countermeasures were identified and recommendations on future potential vehicle safety priority areas for the light vehicle fleet in Australia have been made, for which new countermeasures will need to be developed.

Vehicle Safety Priority Area One: Fatal pedestrian crashes

Fatal pedestrian crashes and non-fatal pedestrian crashes involving SUVs were observed to increase over 2006 to 2016. In metropolitan regions, pedestrian crashes were one of the largest contributors to severe trauma and this crash type is also more likely to be fatal than most other crash types. In 2030, fatal pedestrian crashes were predicted to make up a larger proportion of injury crashes than in 2016. This means that active safety technologies are not adequately addressing a crash growth area, which is a high contributor to trauma with severe injury outcomes. It is also a crash type of specific concern in metropolitan regions. Furthermore, by definition, passive safety modelled with crashworthiness has no effect on pedestrian injury, so after applying both active and passive safety measures, this crash type was the third largest crash type contributor to both fatal and serious injuries in 2030.

The technology chiefly addressing pedestrian crashes is the AEB system with pedestrian detection capability. Natural penetration of this technology was projected to be lagging and this technology is currently rarely present in light commercial vehicles.

As the greatest contributor to metropolitan road fatalities, pedestrian crashes are a crash type with serious outcomes. They have not been adequately addressed by vehicle safety technology despite 2030 projections of only 11% crash avoidance and relative growth in the crash type. By targeting pedestrian fatalities, reductions in non-fatal pedestrian crashes will also follow. Both relative and absolute estimated reductions in 2030 rural fatal crashes achieved from active and passive technologies and vehicle design, were greater for rural regions, so targeting pedestrian fatal crashes will also generally improve avoidance of fatal crashes in metropolitan regions.

Some suggested countermeasures are:

- Investigate what drives natural penetration to find out why pedestrian focused technologies are not naturally penetrating the light vehicle fleet at rates similar to other technologies.
- Encourage the increased uptake of pedestrian-AEB systems, particularly in LCVs which currently have limited fitment. This may also improve bicycle and moped crash outcomes.
- Investigate the possibilities offered by vehicle-to-pedestrian and vehicle-to-infrastructure communication technology and deploy what is found to be effective. There is a great body of research on intelligent transport systems (ITS). Silla, Rämä et al. (2017) estimated that almost half of vehicle-to-pedestrian crash injuries could be avoided with vehicle-to-pedestrian technology. An example ITS system involves interacting mobile phone technology with

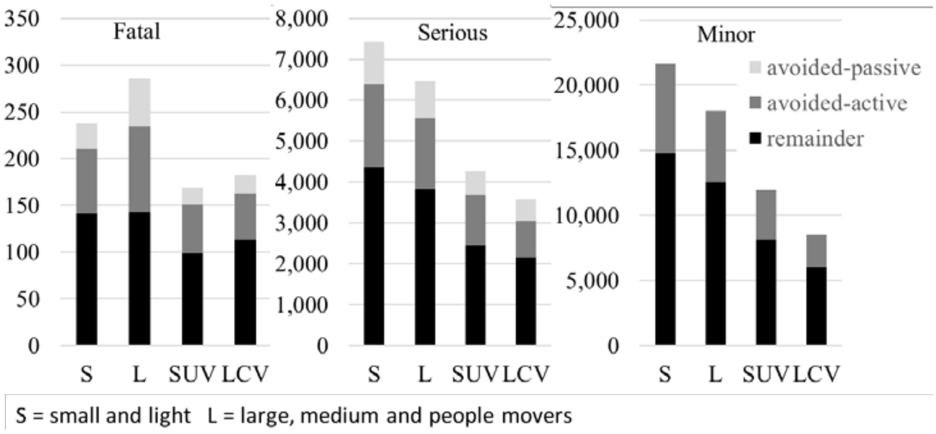

Figure 3. 2016 Crash injuries by broad market group and severity disaggregated by vehicle safety technology projections in 2030

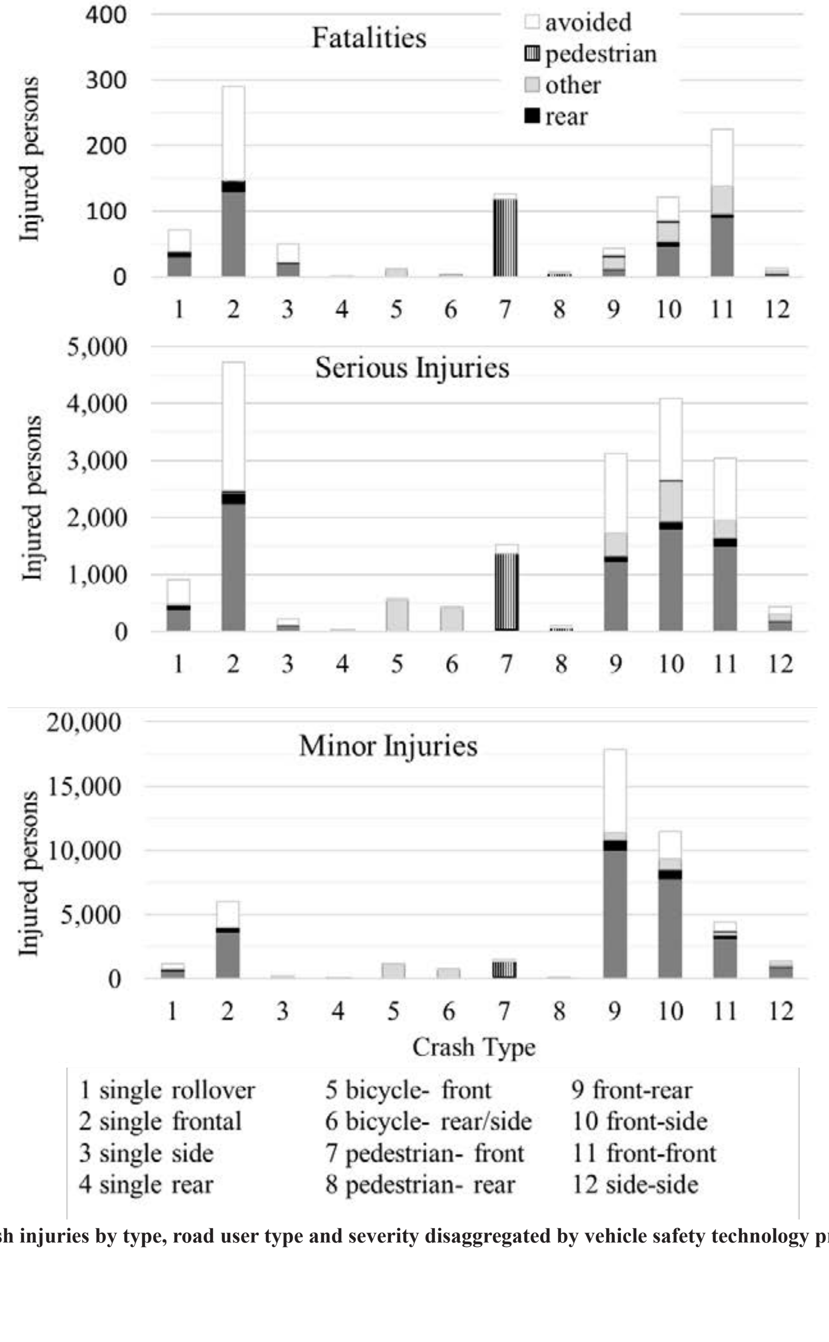

Figure 4. 2016 Crash injuries by type, road user type and severity disaggregated by vehicle safety technology projections in 2030

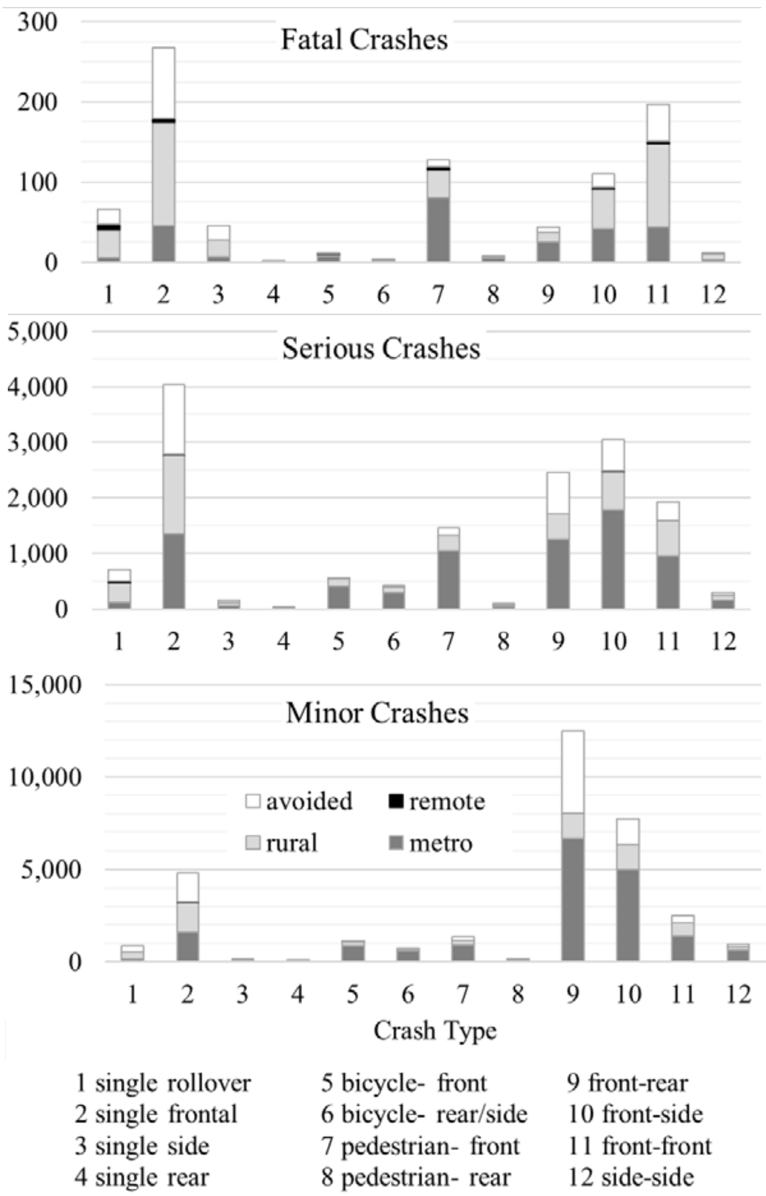

Figure 5. 2016 Injury crashes by location and severity disaggregated by active vehicle safety technology projections in 2030

vehicle telematics so that both drivers and pedestrians are alerted to impending collisions.

- Encourage vehicle design improvements or the uptake of pedestrian technology. Examples to investigate are night vision and active hood / windshield A-frame airbags. Fredriksson, Shin et al. (2011) estimated the latter to decrease AIS 3+ pedestrian injury risk from 85-100% to 20%. This is pertinent for SUVs which demonstrated an increase baseline trend of pedestrian crashes.

Vehicle Safety Priority Area Two: Single vehicle frontal crashes with fixed objects

Single vehicle frontal vehicle-to-object crashes were estimated to be best addressed by active safety technology, however this crash type was projected to make up 17% of all injury crashes in 2030 and more than two thirds of these crashes in 2016 were projected to not be avoided by vehicle safety technologies in 2030.

These were amongst the most serious crash types, particularly for small and light vehicles and remote region, particularly rollovers. They were also amongst the largest contributors to serious road trauma. Single vehicle-to-object crashes were observed to increase over 2006 to 2016, for serious and rural crashes, or when certain market groups were involved.

ESC, LDW and active headlamps were the main active technologies addressing single vehicle fatal frontal crashes modelled in this analysis. In 2030, ESC was estimated to have almost saturated the crashed vehicle fleet, so will have no more to offer in crash avoidance beyond 2030. Both LDW and active headlamps were shown to have potential beyond 2030 due to being less represented in current vehicles that have had crashes of this type than in the fleet overall, and due to poorer crashed vehicle fleet penetration in 2016; especially for light commercial vehicles which lagged severely. Just over half the crashed light vehicle fleet were predicted to be fitted with LDW or active headlights in 2030.

Some suggested countermeasures are:

- Investigate what drives natural penetration to find out why systems which address fatigue, speeding and inattention are not naturally penetrating the light vehicle fleet at rates similar to other vehicle safety technologies. Single forward moving vehicle crashes are often the result of speeding, driver inattention and driver fatigue and the fitment analysis found poor projected uptake of speed, fatigue and inattention systems such as speed zone reminder, speed alert, speed limiter, driver fatigue warning and driver attention detection.
- Investigate what drives natural penetration to find ways to enhance the natural penetration of LDW and active headlights, especially within the light commercial market group.
- Investigate what drives natural penetration to find ways to enhance the natural penetration of relevant passive safety technologies, especially within the light commercial market group which are severely lagging: e.g. front passenger head airbag, all rear airbags and rollover protection (which is also lagging in SUVs).
- Deploy programs targeted at enhancing driver acceptance of lane departure warning systems, especially for professional drivers. Reagan and McCartt (2016) found LDW systems to only be switched on 33% of the time.
- Increase the proportion of roads with edge-lines. Most LDW systems currently rely on edge-lines and do not function where there are no lane-markings. Increasing the proportion of lane-markings on roads where fatigue, speeding and inattention are likely will increase the real- world effectiveness of LDW.
- Investigate ways to improve injury outcomes in small and light vehicle single vehicle crashes. This may involve vehicle design or encouraging uptake of passive safety systems such as rollover protection, active headrests, and the various airbags currently available. Small and light vehicles were found to have poorer outcomes in these crash types.
- Investigate ways to improve injury outcomes in rural and remote locations. Remote single vehicle crashes were found to have poorer outcomes. Such a way could be to encourage uptake of automatic crash notification systems or to educate remote region drivers about them. Automatic crash notification systems are an emerging safety technology designed to notify emergency responders that a crash has occurred and provide its location. This not only speeds up the response, but may be the only way that some crashes are detected before fatalities occur.

Vehicle Safety Priority Area Three: Front-to-front vehicle cashes both at intersections and mid-blocks and front-to-side impacts at intersections including straight crossing path and right turn across path crash types

37% of crashes in 2030 were projected to be front-to-front or front-to-side crashes. In 2016, 57% of front-to-front collisions were at intersections and 35% came from adjacent approaches. In 2016, 80% of front-to-side were at intersections and 43% came from adjacent directions. Furthermore, fatal and serious front-to-side crashes were projected to increase in proportion in rural areas between 2016 and 2030. Both front-to-front and front-to-side are significant contributors to road fatalities and injury crashes generally and more than 80% of these two crash types were not projected to be avoided in 2030.

General AEB systems have had a poorer impact on these crashes because of the lack of sensitivity to the crash type and likely travelling speed. Intersection-AEB systems which target straight crossing path crashes are emerging but have very limited fitment currently.

Targeting front-to-front and front-to-side crashes improves rural and metropolitan crash outcomes, because although most intersection crashes occur in metropolitan regions, most of the remaining fatal front-to-front and front-to-side crashes in 2030 were projected to be rural.

Some suggested countermeasures are:

- Investigate what drives natural penetration to find out why ITS, high speed AEB systems and intersection-AEB technologies are not naturally penetrating the light vehicle fleet at rates similar to other technologies. Intersection AEB systems which target straight crossing path collisions are likely to be able to prevent around 40% of straight crossing path crashes and if AEB systems could improve speed range sensitivity both generally and specifically for right turn/other direction crashes more fatalities could be avoided. Furthermore, an increased speed range in general AEB systems could aid avoidance of high-speed front-to-rear crashes.
- Investigate what drives natural penetration to find ways to enhance the natural penetration of relevant passive safety technologies, especially within the light commercial market group which are severely lagging: e.g. front passenger head airbag and all rear airbags.

- Investigate the possibilities offered by vehicle-to-vehicle and vehicle-to-infrastructure communication technology and deploy what is found to be effective. There is great body of research on intelligent transport systems (ITS). It is possible for intelligent intersection infrastructure to warn drivers of approaching vehicles from cross directions.
- Continue to expand red light speed camera programs. These have proven effectiveness (Budd, Scully et al. 2011) on these crash types (44% casualty crash reduction).

Conclusions

Three future vehicle safety priority areas were identified from the analysis: (i) fatal pedestrian crashes, (ii) single vehicle frontal crashes with objects, (iii) front-to-front vehicle crashes both at intersections and mid-blocks and front-to-side impacts at intersections including straight crossing path and right turn across path crash types. These crash types were projected to be the largest contributors to fatalities by 2030. Although not the most prevalent crash type, crashes involving bicycles and mopeds were forecast to grow proportionately over the study period. Remaining crash types in 2030 will be poorly addressed by current vehicle safety technologies. For example, when considering single vehicle-to-object crashes, ESC will provide no further benefits in reducing single vehicle crashes after 2030 since the fleet will have achieved full fitment in 2030 vehicle fleet. In addition, evaluation evidence to date suggests AEB systems as fitted to vehicles currently has limited impact in addressing high speed crashes with fixed objects although future development of AEB might provide some benefits in reducing this crash type despite real-world effectiveness not having been established yet.

Most crashes were considered to have some potential to be avoided by active safety technologies, so it is still likely that avoidance will further increase beyond 2030 due to increased market penetration and technological developments which increase effectiveness. This analysis highlighted the limitations in fatality and serious injury reductions related to the natural penetration of vehicle safety technology fitment up to 2030. Significant numbers of fatalities resulting from intersection crashes, single vehicle run off road and head on crashes will remain whist pedestrian crashes will grow in their proportionate importance. Additional or enhanced vehicle safety technologies will need to be developed that better address these crash types such as AEB effective for fixed object crashes and at intersections and vehicle-to-vehicle technologies to mitigate intersection crashes. In addition, means to address the key remaining crash types elsewhere in the system need to be considered through measures such as road infrastructure treatments and appropriate speed limit setting for high risk environments where vehicle safety technology proves inadequate.

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Development and application of a vehicle safety rating score for public transport minibuses

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Key Findings

- Minibuses transporting between nine and 15 passengers are widely used for public transport in low- and middle-income countries, yet levels of active and passive safety provided are often poor;
- A safety rating system was devised allowing relatively inexperienced personnel to quickly assess and score vehicles on a scale from zero to 50 points;
- A survey of 566 in-service minibuses in the United Arab Emirates highlighted low levels of compliance with applicable Gulf Cooperation Council (GCC) motor vehicle safety standards, with the vehicle sample scoring an average of 14.4 out of 50 (compared with an estimated score of 20 for compliance with the standard applicable at the time);
- The safety rating system was made available to the Abu Dhabi Department of Transport to set a threshold score below which vehicles could be progressively removed from service with the aim of improving the state of minibus safety within the UAE.

Abstract

Minibuses are widely used for public transport, particularly in developing countries, yet their safety levels are often poor. This study identified a simple set of active and passive safety measures and 566 minibuses in the United Arab Emirates were inspected. Most vehicles were without seat belts or head restraints and had inadequate seat attachment. Low rates of active and passive safety features were recorded. The safety rating system assigned weightings to each of the variables in the survey, based on an assessment of their approximate relative risk. Applied to the benchmarking sample, safety rating scores (out of 50) ranged from below 10 points for the least safe vehicles to around 40 points for the best. Many vehicles inspected scored below 20 points. The safety rating score provided a practical assessment of the safety of the UAE minibus vehicle fleet and could be adapted to other vehicle types. The study outcomes are helping to both justify a new minibus safety standard in the UAE aiming to significantly reduce death and serious injury among the many passengers using this service, as well as to begin the process of removing the least safe vehicles from the fleet.

Keywords

Vehicle safety, minibus, safety assessment, public transport

Introduction

This study formed one component of a longer-term program to improve the safety of minibuses in the United Arab Emirates. An earlier study by Fildes, Logan and El-Sadig (2014) outlined a proposed new safety standard for the UAE to improve the safety of these vehicles, defined in the Emirates as commercial passenger-carrying vehicles for carrying no more than 14 passengers (nine in Abu Dhabi). With the primary project goal being to undertake a benefit-cost analysis to determine the economic impact of implementing a new safety specification, it was first

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necessary to gain a more detailed understanding of the safety specification and maintenance condition of the existing fleet. To facilitate communication with the stakeholders involved, the decision was made to develop a safety rating score to quantify the outputs of the safety survey.

In the UAE at the time this project was undertaken, all motor vehicles, including minibuses, were required to comply with Gulf Cooperation Council standard, UAE.S/GSO 42:2003 (ESMA, 2003), with similar requirements to European standards of the early 21st century. Anecdotally, however, compliance with the standard often appeared poor among in-service vehicles and there were and still are currently no incentives, such as an NCAP program, to encourage consumers to purchase vehicles of better than the minimum regulatory requirements.

Method

The data collection activity was undertaken in the Emirates by local technicians who had limited vehicle safety expertise. Therefore, a set of variables was devised that satisfied three main criteria:

1. to be indicative of the overall safety level and condition of an in-service minibus;
2. to be obtained from a sample of vehicles by non-expert data collectors; and
3. to be obtained primarily through visual inspection, without the need for performance testing or complex measurements requiring specific expertise.

The parameters were grouped into two main categories (*C*): primary safety (crash avoidance) and secondary safety (crashworthiness). Each of these was assigned a relative weighting, summing to one:

Within each of the main categories, individual parameters (*R*) were chosen based on expert judgement, while satisfying the restrictions listed above. In the same way as the main category weightings summed to unity, the individual parameters selected to represent each main category were also required to total one.

$$SR_{norm} = \sum_{i=1}^{i=n} T_i \sum_{j=1}^{j=p} C_i . R_{i,j} \qquad (2)$$

where:

SR_{norm} is the weighted safety rating;
p is the number of individual parameters in category i;
$R_{i,j}$ is the weighting for parameter j within category i;
T_i is the weighting for category i
C_i is the weighting for the parent category

The weighted safety rating, between zero and one, was scaled up by a nominal factor of 50 to yield the Safety Rating Score for each vehicle.

The values for individual weightings were chosen to reflect their relative importance among their respective category. For practical reasons, this process was achieved by reaching expert consensus among the research team, based on multiple decades of road safety research experience, since amassing sufficient research evidence to objectively compare the relative benefits of different safety features was beyond the scope of the study, even if such evidence was available.

Results

Parameter selection – primary safety

Three safety features were selected for inclusion in the crash avoidance category, as shown in Table 1.

A pseudo-static stability factor was based on static stability factor (SSF), defined by the US National Highway Traffic Safety Administration in NHTSA (2000). SSF, being based on vehicle track width and the height of the centre of gravity (CofG).

$$\mathrm{SSF} = \frac{T}{2H} \qquad (3)$$

where:

SSF is the Static Stability Factor;
T is the track width of the vehicle;
H is the measured height of the centre of gravity;

SSF is the Static Stability Factor;
T is the track width of the vehicle;
H is the measured height of the centre of gravity;

If the entire mass of the vehicle were concentrated into a point, the CofG location represents the height this point. CofG is normally determined using a tilt table test, in which the tethered vehicle is tilted sideways from the horizontal until the wheels on one side begin to leave the ground at which point the tilt angle is measured. SSF thus represents a measure of propensity to rollover. Since it was impossible to determine this experimentally, the height of the CofG was determined for this vehicle type by the engineering approximation of the vertical distance from the ground to the base of the driver seat at the seat back pivot.

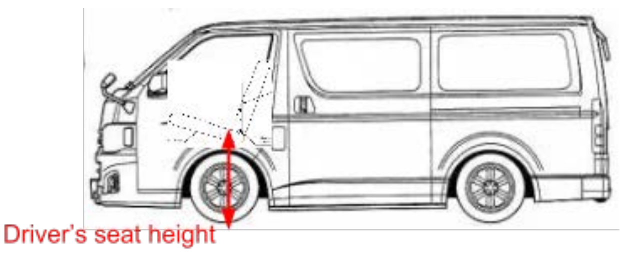

Figure 1. Height measurement for pseudo static stability factor

The parameter values for ESC and ABS were set to one when fitted; zero when not fitted. Pseudo-SSF values ranged between zero for pseudo-SSF of 0.6 or lower to one for 0.9 and higher, with the endpoints chosen to represent the range of vehicles surveyed in the study and the likely rollover risk. In between the endpoints linear interpolation was used to determine the value assigned.

Table 1. Primary safety features assessed, with relative weightings

Safety feature/characteristic	Weighting
Electronic stability control (ESC)	0.60
Pseudo-static stability factor	0.35
Antilock braking system (ABS)	0.05
Total	1.00

Parameter selection – secondary safety

Secondary safety parameters were selected to reflect the prioritisation of minibus passengers in the current UAE environment. Crashworthiness rating (CWR) was derived from Newstead, Watson and Cameron (2013), which statistically evaluates crashworthiness based on real-world secondary safety performance from 24 years of police-reported crash data across Australia and New Zealand. The method by Newstead et al relies on a statistically valid sample being available, therefore in the case of vehicles in the study without crashworthiness ratings, engineering judgement was used on the basis of approximate mechanical equivalence (such as Chinese brands based on previous models of Japanese vehicles) or through comparisons of NCAP ratings where available. The parameter values for CWR were on a scale from a CWR of 2.0 representing a zero score, to a score of one for a CWR of 5.0, linearly interpolated between the two endpoints and assigned values of zero or one for scores lower than 2.0 or higher than 5.0 respectively. This parameter was assigned a third of the overall secondary safety weighting.

Experience with observations of the minibus fleet strongly indicated poor seat belt fitment rates, despite the fact that it is a legal requirement. Furthermore, while many vehicles observed had seat belts fitted in the rear compartment, they were often unavailable to passengers by being tucked under the seat, folded or knotted or otherwise made inaccessible. The scores assigned for rear seat belt fitment by position were: zero for no belt or an inaccessible belt, 0.5 for a two-point belt and 1.0 for a three-point belt. The final score was the average of all rear seating positions, since seat belt availability frequently varied between seats.

Three parameters assessing airbag fitment provided 28% of the secondary safety assessment in total, covering frontal airbags and side or curtain airbags in either or both of the front or rear passenger compartments, with a score of one awarded for fitment of each.

Headrest fitment was evaluated by awarding one point for a seating position with a headrest (either integrated or adjustable) and zero points for a seat without any support above shoulder level. The final value for this parameter was the average of the values for all of the rear seating positions.

The final two parameters were average inter seat spacing and passenger ‘knee room’ (also referred to as ‘foot room’), as shown in Figure 2. Inter seat spacing influences the possibility of passenger to passenger contact during a crash event, particularly when restrained by two-point, lap belts only. The knee room parameter, while correlated with inter-seat spacing, is primarily related to comfort and accessibility but could also influence the risk of lower limb injuries in a frontal impact. Inter seat spacing was scored zero points for 60 cm and below, one point for 90

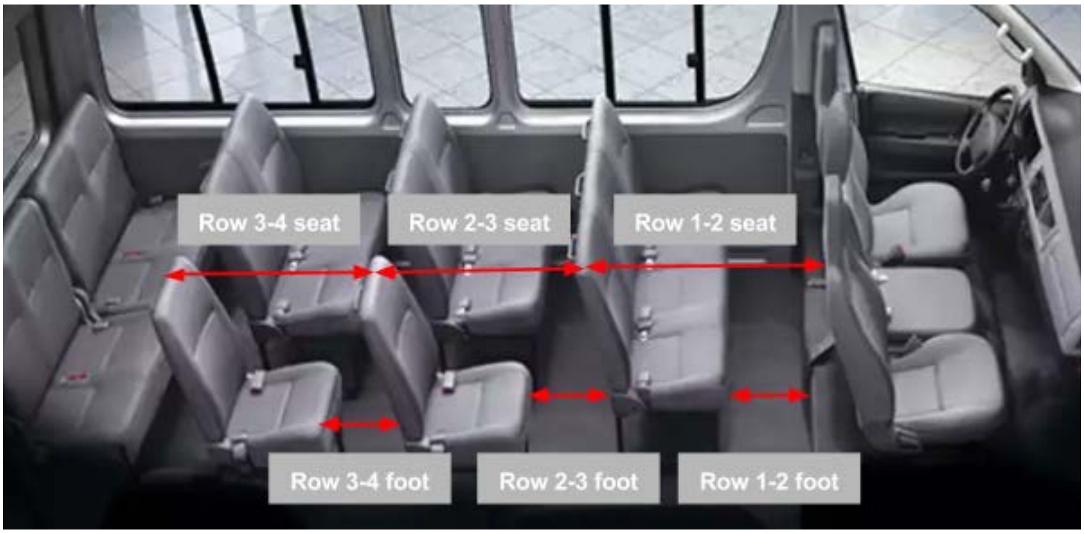

Figure 2. Key for seat-to-seat and knee-room measurements

Table 2. Secondary safety features assessed, with relative weightings

Safety feature/characteristic	Weighting
CWR (Crashworthiness rating)	0.33
Rear seatbelt fitment (average of all seating positions)	0.33
Front airbag fitment	0.10
Side/curtain airbag fitment (front compartment)	0.09
Side/curtain airbag fitment (rear compartment)	0.09
Rear head restraint fitment (average of all seating positions)	0.04
Average seat-seat spacing (cm)	0.015
Average knee room (cm)	0.005
Total	1.00

cm and above and interpolated linearly in between these two end points. The lower limit was derived from the Economic Commission for Europe (ECE) standard R107 Rev 6 Annex 4 (ECE, 2014) and the upper limit based on the torso height of a 50th percentile male (McBride, 2011). The average of the scores for all passenger rows was used to determine the final score. Similarly, knee/foot spacing scores were consistent with ECE (2014), but with allowances made to reflect the current requirements of UAE GSO.S 42 and for consistency with the maximum inter-seat spacing value used. Consequently, the assigned parameter values ranged from 20 cm (zero) to 40 cm (one point), with interpolations in between.

It should be noted that some subtle, more complex effects were neglected: for example, the use of a two-point belt with low seat-to-seat spacings could result in increased neck or spinal trauma compared with non-use of seat belts. On balance, the judgement was made that seatbelt fitment should be encouraged, regardless of the type.

The list of parameters included in the safety rating score was compared qualitatively with the safety-related clauses of UAE.S/GSO 42 and good correlation found between the two, except for the three clauses pertaining to windscreen and windows, speedometer accuracy and tyre specification. Electronic Stability Control was assessed, but is not yet mandatory for minibuses in the Gulf region (ESMA, 2016).

Main criteria weighting and general comments

The two categories (primary safety and secondary safety) were combined by assigning weightings of 0.3 and 0.7 respectively, aligning with the relative priorities of each in the Middle Eastern context.

A star rating score was calculated for a selection of vehicles representing a wide range of safety levels in order to ensure that the scores awarded were commensurate with a subjective assessment of individual vehicles and gave good discrimination between poorer and better performing vehicles.

While the rating system was targeted at discriminating vehicles based on their fundamental specification, in practice the secondary safety component of the score reflected vehicle operating condition to an extent, given that—in particular—a sizeable proportion of vehicles were not fitted with seat belts in accordance with the standard.

Study data collectors rated several vehicles under supervision of the study team to ensure accuracy and consistency before data collection began.

Typical minibus safety rating scores

The study sample was dominated by variants of the Toyota Hiace, which makes up a significant proportion of the minibus fleet in the Emirates. Also present were examples of the Nissan Urvan and its newer replacement, the NV350. The remaining general use minibuses comprised Mitsubishi, Mazda and Chinese-built Foton vehicles. Also included were a sample of Mercedes-Benz Vito vehicles dedicated by the Abu Dhabi government to transporting airline passengers between Abu Dhabi city and the airport. These were commissioned between 2013 and 2014.

Scores for a selection of the vehicles included in the study are provided in Table 3 below. The mean safety score (out of a maximum of 50) for the entire sample was 14.4, with a standard deviation of 8.2.

Mean safety rating scores clearly differentiate between the less safe and more safe vehicles. The spread between the minimum and maximum scores results from variations in rear seat passenger belt fitment, seat spacing and vehicle

Table 3. Benchmarking study safety rating scores.

		Safety score (0-50)		
Vehicle	**No.**	**Min**	**Mean**	**Max**
Toyota Hiace, 1996-2004	79	6.8	7.6	12.9
Toyota Hiace, 2005-2014 (narrower track)	392	9.7	13.6	23.2
Toyota Hiace, 2005-2014 (wider track)	10	13.1	18.3	24.0
Nissan Urvan, 2001-2012	13	6.5	9.1	13.0
Mercedes-Benz Vito, 2013-2014	35	40.9	40.9	40.9

condition. The wider track Toyota Hiace has not only a 200 mm wider track, but is often a higher specification model with three-point seat belts and head rests, unless modified by the owner. The Mercedes-Benz vehicles were all well-maintained and did not appear to have been modified.

Discussion

The safety rating method devised for this study showed good discrimination between vehicle types, reflecting variations in base vehicle design and specification, as well as vehicle fitout and in-service condition. While the inspections of a number of vehicles in this study were undertaken at the government-operated inspection stations in conjunction with their mandatory annual check, the majority were conducted at a central bus station and considerable variation was observed between individual vehicles. Several issues were observed, with the following being of particular note:

- Although two-point seat belts on all rear seating positions are mandatory, a large proportion of vehicles either had no belts fitted, the belts were rolled up or fed between the seat back and squab such that they would be unavailable to passengers;
- In the emirate of Abu Dhabi there is a requirement for minibuses to seat no more than nine occupants in total, compared with the 14-15 seats normally fitted to the most common vehicle, the Toyota Hiace. Consequently, it is necessary for operators to remove one or more of the standard bench seats and refit different seat assemblies to reconfigure the vehicle. It seemed likely that this process is not always carried out with due diligence, since third row seats in many vehicles were inadequately secured or not equipped with seat belts.
- Fitment of frontal airbags for front seat passengers and, in many cases, drivers also was inconsistent, even allowing for vehicle age. This may be an indication of problems with the import approval process.

A safety rating score of around 20 correlated with a vehicle that would be compliant with the current UAE.S/GSO 42:2003. By way of comparison, the study proposed two hypothetical alternative vehicles that would constitute a practical improvement over the existing fleet, using the predominant Toyota Hiace as a case study:

- Improvement #1: a safety retrofit program to existing narrow track Toyota Hiace vehicles, currently averaging 13.0 points. A hypothetical maximum safety rating score of 27.5 points could be achieved by retrofitting existing vehicles of 2005 and newer with high-back seats with headrests, three-point seat belts and relocating the seats to provide a minimum of 870 mm inter-seat spacing. This configuration reflects the seat type and layout of Toyota Hiaces available in many international markets, albeit in a narrower track form.
- Improvement #2: a replacement Toyota Hiace, based on the 2015 Australian market Hiace Commuter minibus with wide track chassis, fitted with high-back seats, head restraints, and 3-point seat belts as standard equipment, along with Electronic Stability Control (ESC), Anti-lock Brakes (ABS), and Electronic Stability Control (ESC). With fitment of driver and passenger frontal impact airbags, in good condition and with all safety features currently available to all passengers, this would give a Safety Rating of 38.

One limitation of this study is the lack of research evidence to support the relative weightings (and therefore relative risk of crash involvement or serious injury outcome given a crash) between individual safety features and characteristics. However, the values selected, while not necessarily objectively measuring relative risk, certainly provide a strong indication of the relative importance of each to minibus passengers in the Emirati minibus fleet as it stands. Similarly, the relative weightings between primary and secondary safety along with maintenance and condition could be varied to suit the priorities and current safety standards of other jurisdictions. In Australia, for example, a higher weight might be assigned to crash avoidance, acknowledging that vehicle crashworthiness is perhaps of a generally better standard and perhaps more uniform between vehicles. Consequently, disparity among the fleet regarding primary safety features would be better quantified with more emphasis on this category. Future work could focus on developing a more objective basis for determining intra- and inter-category weightings.

Additional study limitations included the use of a proxy for static stability factor (SSF) rather than a test-derived value, and the necessity of assuming crashworthiness equivalence for vehicles sold into the Middle Eastern market with those tested in other countries.

Furthermore, in order to apply this method to other jurisdictions, the individual parameters should be selected and weighted to reflect the current fleet standard and desired vehicle safety outcomes, with the goal of encouraging ongoing improvements to vehicle safety policy.

Conclusions

This study set out to develop a safety rating score able to be relatively easily determined from a combination of publicly available information and a visual inspection undertaken by non-expert personnel. The schema has the advantage of being transparent and objective, with the weights of individual safety features and characteristics as well as the overall categories highlighting their individual contributions. Because of this, individual weightings can be adjusted to reflect the priorities in other jurisdictions.

Applied to a real-world sample, vehicles scored from below 10 points out of a maximum of 50 up to almost 41 points for the better equipped and maintained minibuses.

The safety rating score was made available to the Abu Dhabi Department of Transport to set a threshold score below which vehicles will be progressively phased out of service, with a benefit-cost study indicating the societal benefits of this program aimed at significantly improving the state of minibus safety in the United Arab Emirates.

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Road Safety Case Studies

Speed Management in Iran: A Review Process

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This peer-reviewed paper was first submitted as an Extended Abstract and an Oral Presentation was recommended by two reviewers at the 2021 Australasian Road Safety Conference (ARSC2021) to be held in Melbourne, Australia in September. The two Reviewers also recommended that the Extended Abstract be expanded into a 'Full Paper' and undergo further peer-review as a journal submission by three independent experts in the field. The Extended Abstract will be published in the ARSC2021 Proceedings with a link guiding readers to this 'Full Paper' version which is being reproduced here with the kind permission of the authors and will only be available in this edition of the JRS.

Key Findings

- A demonstration project in Iran has provided an ideal environment to implement a Safe System focused on speed management, speed limit setting and infrastructure treatment.
- Public understanding, engagement and support is a critical component for the success of this project to reinforce a culture of safety on Iranian roads.
- A baseline review supports the rationale for reduced speed limits as an interim measure while Safe System infrastructure upgrades are implemented.
- The in- depth crash investigation process can be enhanced through a revised focus on identifying preventative measures in reducing risks.
- The electronic enforcement infrastructure can be enhanced to directly deter speeding.

Abstract

The level of road trauma is high in the Eastern Mediterranean Region with the Islamic Republic of Iran having a particularly high fatality rate at 20.5 per 100,000 population. The Government, assisted by the World Health Organisation (WHO), committed to implementing demonstration projects in three provinces that will form the basis of road safety actions to be advanced by the WHO across the Region. In recognition that speed management is a pivotal factor in achieving a safer road and traffic system, and as a component of the project, a review was carried out in 2019 by a team of international experts in the field in collaboration with national consultants. This review was undertaken in consideration of the Safe System Approach and the Results-Based Management Approach. The findings of this review and their implications for future actions in Iran are discussed in this paper.

Keywords

Speed management, speed limits, traffic calming, traffic policing, offender processing, crash investigation, Road Safety, Safe System, Road Crash

Glossary

AASHTO - American Association of State Highway and Transportation Officials

MRUD- Ministry of Roads and Urban Development

NRSC – National Road Safety Commission

RBMA - Results-Based Management Approach

RMTO – Road Maintenance and Transportation Organization

SOP's – Standard Operating Procedures

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SSA – Safe System Approach
VSL – Variable speed limits
VMS – Variable message signs
WHO – World Health Organisation

Introduction

In Iran, road traffic crashes are one of the leading causes of fatalities and injuries. According to WHO Global Status Report on Road Safety (2018) the annual crash fatality rate in Iran is 20.5 per 100,000 population, which is higher than the global average. The costs of traffic injuries in Iran in 2013 using the willingness to pay method constituted 6.46% of gross national income, much higher than the global average (Ainy, et al. 2014). Consistent with this, the medical costs and economic burden of road traffic injuries were estimated in 2011 to be USD $4.44 billion (Behnood, 2017). Both these estimates do not account for the personal loss, suffering and trauma to Iranian families and the work environment.

In response to these high levels of road trauma, the WHO country office in coordination with the National Road Safety Commission (NRSC), Road Maintenance & Transportation Organization (RMTO), Traffic police, and the National Emergency Medical Organization commissioned a consultancy project titled "*Technical support towards enhancement of Speed Management strategy for road traffic injury prevention*." They appointed international experts in joint collaboration with national partners to conduct an extensive review of speed management practices in Iran. This review was undertaken as an initiative to provide the foundation and justification for identifying and implementing speed management interventions in demonstration sites.

The RMTO is the main government agency responsible for rural road safety, reporting to the Ministry of Roads and Urban Development. The RMTO is guided by the American Association for State Highway and Transport Officials (AASHTO) for geometric design standards and speed limit setting. There are 31 Provinces in Iran with 20,625 kms of arterials (freeways 2,503kms, expressways 18,122 kms), 25,814 kms of main roads and 37,601 kms of minor roads in their interurban road network. Urban roads are the responsibility of local government. The general maximum speed limit on freeways is 120kph and on highways is 110kph. The enforcement tolerance is generous by international standards of good practice.

Purpose of the Project

The purpose of the project was to investigate the ways the country was seeking to address the problem of speed related road trauma and advise on how these practices could be improved. Consistent with the Safe System Approach (SSA) and the WHO Results-Based Management Approach (RBMA), the aim was to align Iran's road safety strategy with these principles and provide guidelines for setting speed limits as well as an educational and enforcement framework.

Complementary to the project, it is noteworthy that two members of the international team presented as keynote speakers and facilitators at the 24th International Conference on Safe Communities in Tabriz, Iran (22-25 August. 2019). Critical themes included road safety governance, speed management, enforcement and public education campaigns.

Description of the Project

This paper presents the perspectives of International and National practitioners to road safety reform with particular focus on the introduction of six demonstration sites in three Iranian provinces. The proposed introduction of international good practice in SSA and RBMA to these sites, traversing over 1300kms provides a rich opportunity to identify challenges across all road safety disciplines and the processes adopted to overcome these challenges. These sites were selected because of crash history, traffic volumes, multiple speed zone changes, the environmental conditions and the potential for beneficial infrastructure upgrades.

In the initial phase, a National Consultant, the ARG Engineering Company (ARG), was engaged by WHO Iran, to conduct a situational analysis through a literature review, a desktop review, meetings with stakeholders and field visits covering the following items:

- A variety of road infrastructure including divided roads, two-way rural roads, village, city and remote locations as well as observations on line markings, edge shoulders, roadside barriers and roadside furniture;
- Traffic crash trends and relevant morbidity and mortality by various road types/settings;
- Speed limit policy in different road settings and standard operating procedures (SOPs);
- The traffic laws and regulations related to speed management;
- Enforcement practices (both manual and automated controls) in various settings/road types;
- Applied methods of speed management and traffic calming such as speed signs; advisory signs, roundabouts, speed bumps, rumble strips;
- Community awareness campaigns and messages;
- Vehicle safety standards (age of the fleet and poor quality domestically built vehicles);
- Drivers' habits and characteristics (i.e. diverging when unsafe and unsafe following distances); and
- Strengths and weaknesses of the data on speeding related crashes.

This review acted as a 'baseline-study', which could be used to monitor, evaluate and build a solid research framework for road safety reform. Within the project scope, the International consultants were responsible to assist by:

- Establishing protocols, policies, training and an education framework for enhancing road user compliance with road rules and regulations;
- Establishing a framework for highly visible and active police enforcement strategies;
- Recommending a speed limit policy for different road types/settings in the country; based on the situational analysis results and Safe System requirements;
- Preparing a speed management framework with practical steps to apply the recommended speed limit policy within the country;
- Facilitating a series of technical workshops with participation of all stakeholder representatives;
- Finalising the recommended policy and framework based on the workshop findings;
- Meeting with high-level authorities to advocate for speed management and presenting a summary of findings and recommendations; and
- Recommending applied speed management and traffic calming approaches and strategy (including the criteria to choose the best method of speed management based on the environmental context).

While the project focus is speed management within SSA, it does not neglect or devalue other contributing factors to crashes and related injuries such as fatigue and non-wearing of seat-belts which are being strictly monitored within crash investigation protocols.

In addition to reviewing the data provided by the National Consultant, the International team undertook two missions to Iran to observe the road environment and driver behaviour throughout a number of provinces and many thousands of kilometres on all road networks. The team consulted with the road authorities at national and provincial levels, traffic police, the Ministry of Health and Medical Education, academics, and NGOs, involved in road safety. They also facilitated workshops covering

Figure 1. Vehicular traffic and road infrastructure in Iran.
Source: Ray Shuey, Strategic Safety Solutions

Figure 2. Police enforcement in Iran

Source: Top row left to right – Ahmed Salari, ARG Engineering, Iran. Bottom row left to right Ray Shuey Strategic Safety Solutions

the SSA, traffic policing, infringement processing, crash investigation, road safety campaigns, community advocacy, SSA speed limit setting and traffic calming. These perspectives are presented below in relation to the project observations, discussion and findings.

Project Team Observations

The Department of State and Ministry of the Interior manage local speed limits but cannot set speed limits higher than the top speeds set by MRUD. MRUD has set maximum speeds of 120kmh for cars, 110kmh for buses, and 100kmh for trucks (on freeways). At the time of the review, speed setting criteria included:

1. Road function and type
2. 85th percentile speeds of free-flowing traffic, plus 8km/h;
3. Geometric design (site distance, etc.); and
4. Prevailing land use.

This approach had been informed by the US AASHTO guidelines. These criteria were identified as being out of step with contemporary principles and practices. Instead of basing maximum speed limits on what 85% of drivers choose, the current international leading practice is based on the safe system principles and places injury related criteria as paramount in setting speed limits.

During observational visits, blackspots were observed on rural road networks including:

- A T-intersection, at grade, where a slow-speed road (60kmh) connected with a high-speed road (110kmh);
- A site where a bus had vaulted the steel guardrail and crashed head-on into another bus, killing 40 people;
- Many locations on 110kmh zoned roads with U-turns and very short run-up lanes (entry from a standing start to merge or exit to slow from a fast-moving lane);
- Many sites where there were local businesses along high-speed roads with no separation, barriers, or on/off ramps;
- A downhill mountain road with a curve sign-posted at 50kmh and traffic being observed driving at 80kmh; and

- Pedestrians observed walking on road-ways with high-speed traffic.

Figure 1 depicts a sample of traffic within the Iranian road network.

In addition, it was identified that setting differing speed limits for different types of vehicles can increase the speed differential and thus contribute to an increase in the overall serious crash risk. This risk was confirmed in observations where cars travelling in excess of the speed limit were confronted with ‘a wall’ of slow-moving trucks being passed on grades resulting in the need for evasive action. Police advised that as a common fatal crash cause where sedans would under-run large transport vehicles (highlighting the need to explore improvements to truck rear under-run and side under-run protection systems).

For practical purposes, the speed differential should be at minimum - whether this be for cars vs heavy vehicles or cars vs cars. The differential creates uncertainty in driver behaviour and is a risk factor which must be minimised. In addition to the concerns raised by police, the risks have been substantiated by research in other countries (Dhahir & Hassan, 2017; Fildes & Lee, 1993; Garber, et al., 2006). As an example, a summary of the evidence entitled “*Differential speed limits make roads less safe*”, produced by a United States trucking association encapsulates the problem observed in Iran. It said, “the more drivers deviate from the average speed, the greater the chance of being involved in an accident” and 80% of rear-end collisions involving a large truck and car resulting in a fatality, [it was] the passenger vehicle [that] rear-ended the truck.” The traffic police have limited powers to stop motorists. There are 1,000 traffic police and 241 road traffic police stations across the country, a ratio of 3 stations per 1,000 square kilometres. They have 1112 modern portable police-operated speed video cameras, introduced in November, 2016. These were observed in operation by the project team during the field studies. Figure 2 depicts a variety of speed measuring equipment used in Iran for speed enforcement.

In this part, it is recommended to point out the SEPHTAN system – a device that was installed on public inter urban bus, while controlling the working hours of driver, transport documents, location of the bus, it controls the speed of the bus online and in speeding, alarm driver and send message to police station.

While these devices are used for speed detection, the operators or mobile police patrols do not actively pull drivers over to issue infringement notices and there is limited active awareness of enforcement. Advice was provided that on some occasions, a roadside interception occurred further down the road in what was described as a potentially dangerous practice especially on high-speed road networks No evidence was observed or advised of any on-road visible police enforcement with vehicle interceptions for traffic offences or any active follow-up for observed offences to compensate for this deficiency. Good practice road-policing must ensure there are visible enforcement presence and activities to act as a deterrent. These activities should be defined in SOP’s for both mobile and static enforcement with a primary focus on safety (Shuey 2013) and will to be addressed in subsequent training and workshop programs.

Fixed cameras on the freeway network appear to be an effective system for measuring speeds – both spot enforcement and point-to-point average speeds. However, while there are 2300 cameras installed on the network, only 1800 are speed detection cameras with approximately 1000 operating at any one time. This is, in part due to vandalism including people shooting the cameras with guns and lack of timely maintenance and repair services. Those cameras additional to speed detection purposes are weigh-in-motion for heavy transport and traffic monitoring systems.

On triggering a speed camera, the computerised number plate recognition system has a priority focus in that a warning is immediately sent via SMS to the vehicle owner, followed thereafter by another SMS when police have processed the offence indicating that an infringement is issued and due for payment. These processes initiate from the central traffic monitoring and police control rooms in Tehran. However, the verification process and regulatory framework to complement the initial speed infringement would benefit from the adoption of strict effectiveness and efficiency criteria. Importantly*, it was reported that ~50% of speeding offences detected by cameras are not fully prosecuted by Police.* This is a critical system failure in the end-to-end processes from speed detection to final resolution of fines collection, clemency or exoneration.

These observations typify the ‘hole in the bucket’ phenomenon whereby visible police enforcement is diluted through leakages in its deterrent effect particularly when the expected outcome of an exposed offence does not occur, thus confirming the ineffectiveness of the system (Homel, 1988). Further, punishment avoidance critically undermines the intended general deterrence of the camera infrastructure where drivers evade being detected or punished following the committing of illegal behaviours. This has a strong influence on future offending behaviours (Stafford and Warr, 1993, Fleiter et al., 2013). These studies highlight the need to improve the rigour of traffic enforcement processes while maintaining the unpredictability of enforcement operations (Bates et al., 2012).

The conceptual approach espoused by Homel has been modified by the project team to become a funnel model for the offender processing environment, whereby the overall efficiency challenges are identified for actionable reform within this project (Figure 3). The number of offenders detected can be directly compared with those eventually sanctioned. Those who escape a sanction, after

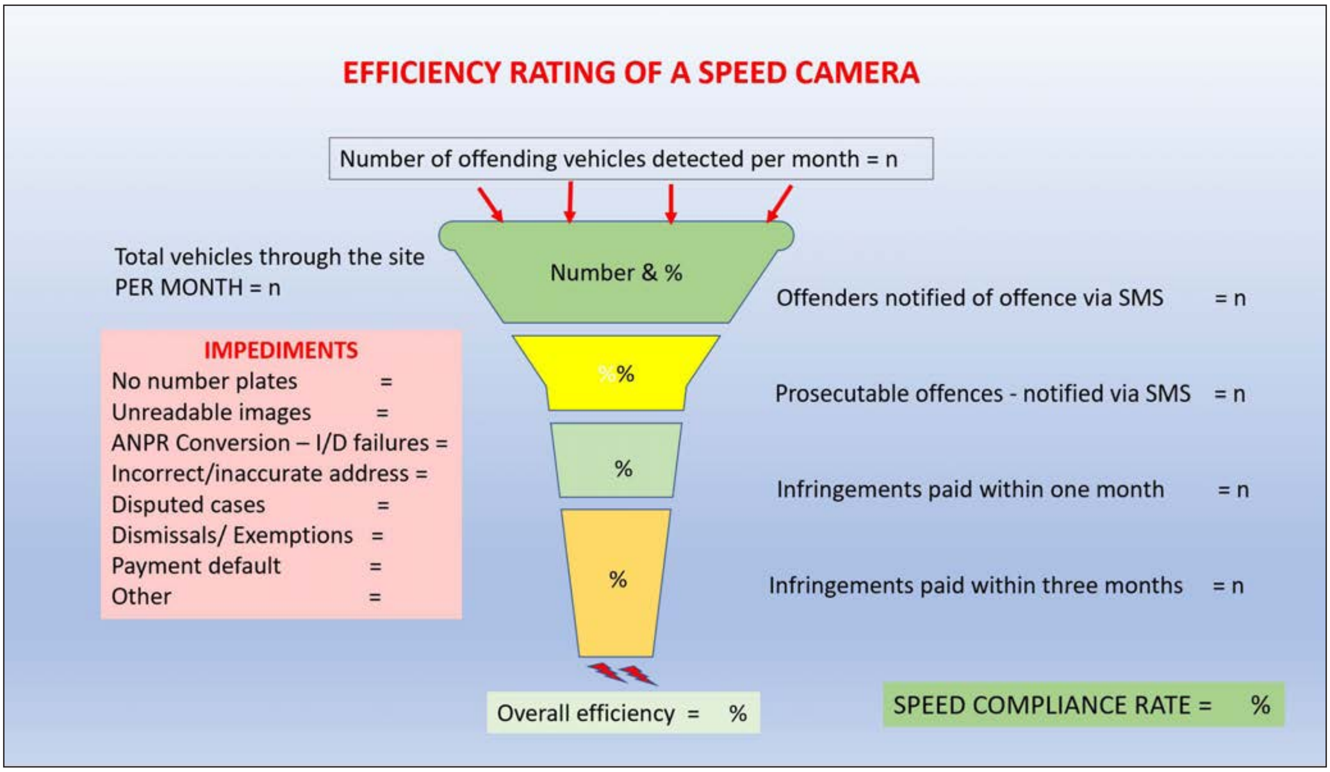

Figure 3. Efficiency rating of a speed camera as the foundation reform for offender processing

Source: Ray Shuey, Strategic Safety Solutions

initially being advised and those never advised through system inefficiency or ineffectiveness will almost certainly continue their errant speed behaviours.

Figure 3 provides a pictorial representation to enable a more comprehensive performance management framework to identify gaps and barriers in the process. Operationalising this framework will enable an in-depth analysis of the data to initiate reform.

These critical observations will be monitored and expanded in the offender processing cycle as negative reinforcement of poor driver behaviours and the relationship within the driving culture. The prevalence and rationale for speeding needs to be addressed within the framework of the demonstration project to determine underlying reasons. This broader perspective will then focus on the psychology of speeding and the deterrence theory to further understand errant driver behaviours (McKenna 2008). In the view of the International Consultants, the Traffic Police in Iran are reasonably well-resourced with speed-detection equipment, however these resources could be used more effectively and strategically with targeted outcomes and accompanied by specific performance measures. These are to be addressed in pending workshops.

The crash investigation and data management process was identified as another component which can be enhanced in this demonstration project. It is well acknowledged that trained police officers have expertise in satisfying the judicial requirements of determining fault within the Qisas (Retaliation/retribution) and Diyat or compensation (blood money) law (Islamic Penal Code 2013). The Diyat or financial compensation is applicable when an accidental or semi intentional act causes bodily harm or death (Electronic Journal of Islamic and Middle Eastern Law, 2014). Additionally, it is of consequence that some religious and cultural factors such as belief in fatalism can be counter-productive to developing interventions and safety countermeasures (Kayani, 2016).

The primary criterion is the apportioning of blame so that the victim(s) or victim's heirs or estate may be compensated for the death, serious injury or disability. This process has limited capacity for creating deterrence as it 'individualises' the offence against the victim rather than the society or the state. An assessment is required to be compared with good practice whereby the goal of the investigation should be to comprehensively identify the crash mechanisms involved, without the necessity to attribute blame.

This consideration of blame is further identified specifically in determining speed as a contributory factor in causality crashes where the statistics range from 8% declared by police to 25% and higher by other road safety bodies. This is attributed to the investigative process, the relative blame and the compensation to be apportioned. It was explained that because police are responsible for the enforcement of speed limits, the cause is often deflected to other reasons such as fatigue due to long distance driving and a poor road network as major contributing factors. Notwithstanding a range of potential contributory factors, the true role of speeding and inappropriate speed in the circumstances needs to be rationally considered in the crash investigative assessment.

The review process will therefore focus on the root cause analysis with primary, secondary and tertiary causes as contributory factors and make a final determination of *how can the risk of a crash of this nature be prevented in the future*? This concept and a 'contributory factor data-base' aligns with the SSA for crash prevention strategies.

The National Road Safety Commission (NRSC) has developed a sophisticated approach to investigating serious crashes within the six demonstration corridors. This is intended to provide on-scene attendance and in-depth analysis of those crashes meeting its pre-determined criteria (any crash with five or more fatalities). The system involves on-line registration of the initial report, protocols, and processing with unified data collection forms. However, these investigations will only address a proportion of actual crashes, albeit the most serious.

To complement this process, it is proposed that a two-tiered approach be adopted to achieve expert investigation and analysis of ***all*** fatality and serious injury crashes in the demonstration corridors. The intention is for local police experts to continue to investigate all crashes within the legislative requirements of the Diyat and follow normal reporting procedures. The investigator will be required to list primary and contributory factors and then make a recommendation for preventative actions. An 'expert review panel' is to be established to mirror the competence and skills of the NRSC to review the crash on a 'no blame' basis with a determination to identify preventative measures to avoid future crashes. This is to become a critical component to expedite the identification of critical risks and provide a strong evidence base for intervention and reform.

Observations of the road infrastructure and environment, road user behaviours, and current policies and governance are summarised below.

Road infrastructure:

- There were higher posted speed limits than acceptable within good practice;
- Insufficient signage, lack of credibility and lack of advisory signs;
- Good audio tactile line marking but most line markings were faded or too light;
- Broken and insufficient barrier systems and a lack of good practice wire rope fencing;
- Lack of transitional speed zones and many speed limit zones too short;
- Lack of good practice in traffic calming treatments (mostly speed humps are used);
- Unsafe pedestrian crossings with limited on-site warnings;
- Unsafe U-turn and T-intersection design; and
- Adequate camera network and VMS/VSL technology.

Road user behaviours:

- Noncompliance with speed limits is prevalent as ingrained behaviour from some drivers;
- Dangerous, aggressive/discourteous driving is evident;
- Tailgating, lack of lane discipline and limited use of indicators, especially of weaving traffic;
- Speed differentials – trucks vs cars and cars vs cars;
- Counter-flow motorcycle practices & helmet non-compliance; and
- Dangerous pedestrian crossing behaviour and practices.

Policy and governance:

- The Traffic Police are the licensing authority;
- No defined strategy for speed management;
- No sustainable budget for road safety/speed management;
- Strategic enforcement practices need to be enhanced;
- Lack of integrity and effectiveness in the penalty system;
- Lack of interagency collaboration and lack of a strong lead road safety agency;
- Lack of robust crash investigation practices, to act as a robust agent for road safety reform;
- Disconnect with local municipalities on road & traffic planning;
- Dangerous and ineffective (active) speed enforcement practices; and
- Inadequate driver training and licensing (discussed further).

Discussion on Potential Opportunities for Improvement

These critical observations provide the catalyst for adopting an holistic framework to address road safety reform across a broad road infrastructure network with varying road user behavioural issues. Specifically, the International Team is advising the National Consultants on the many opportunities for Iran to improve speed management and reduce road trauma within this framework. This process is intended as capacity building for further national initiatives.

Speed Limits, Zoning and Traffic Calming

Many speed limits across the rural road network are too high for assuring safety and do not align with the SSA. Using the guide prepared by the international team, it is suggested that the RMTO review existing speed limits across the country. This will enable better alignment with safe system scientific principles in Iran. On the information thus far gathered from the crash data, the camera data, speed surveys, observations and interviews, there is clear evidence to substantiate reducing the speed limits as an interim measure while Safe System principles are applied to the infrastructure. The evaluation criteria will then assess its potential application throughout Iran and enable the Iranian authorities to confirm or modify the guidelines.

Using a (functional) road classification centred on movement and place (Austroads, 2020), together with crash risk calculations, will assist to determine appropriate road safety treatments consistent with both the function of the road (movement) and the human environment and activities surrounding the road (place). This will best determine how the gap with existing limits can be managed with low-cost infrastructure treatments in many cases. In this way, safe maximum speed limits can be set for assuring better intrinsic safety for all road users, including vulnerable road users such as pedestrians, bicyclists and motorcyclists. The international team has developed guidelines for adopting the Safe System principles and treatments within the Movement and Place Framework to set speed limits.

Traffic calming and infrastructure safety treatments can be adopted as part of the package of measures to provide lower risk speed limits and make the road environment safer for normal travel These include such treatments as roundabouts, lane-narrowing, audio-tactile line-marking and wire rope side and median barriers. Also, the Swedish 2+1 system could be well utilised on appropriate lengths of the rural road network to reduce head on fatalities (Carlsson, 2009).

Licensing, Regulations, Penalties and Enforcement

The project teams' observations of general driving behaviours on major highways and rural roads in conjunction with the concerns of the local authorities highlight the need to improve driver training and licensing system in Iran. Testing, including a hazard perception test should be stricter and a graduated licensing system is recommended. Also, as a deterrent against recidivism, each driver should be assigned a unique licence number for life. This would assure the integrity of the licensing system such that drivers would not be able to rid themselves of demerit points or loss of licence by obtaining another licence with a different number.

It is noted that the penalty system is not graded sufficiently to reflect the seriousness of speed in the fatality and injury hierarchy. i.e. apart from degrees of speed (above the posted speed limit). Good practice jurisdictions have dedicated offences of (a) speed or manner dangerous, (b) reckless driving, and (c) culpable driving causing death(s). The introduction of these culpability offences makes it even more imperative for the 'expert investigators' to have the best possible equipment, investigative knowledge and team support. Equipment such as 3D laser scanners, Event Data Recorders and Crash Reconstruction Software are common for police investigators to identify the 'real' causes of crashes.

A most serious concern is the infringement processing system. This is founded on a solid technological infrastructure of nation-wide speed and point-to-point (time over distance) speed cameras, identifying and recording infringements in real-time and passing to police for validation and ticket issue. An SMS is sent to the vehicle owner at the time of the offence but full prosecution of the offences is not completed in all cases. Some drivers do not pay fines until they sell their car. This undermines the effect of the penalties as deterrents. In addition, when penalty points are awarded to licence holders, there are ways for drivers/riders to obtain another licence when the maximum points result in licence cancellation.

Processing system integrity is in question directly with the certainty of penalty (if an offence is committed) and the immediacy of sanction/penalty. While the available evidence confirms that the perceived certainty of penalty is a more important consideration in achieving deterrence than the penalty regime, it appears that the penalties need to be sufficiently salient to be seen as consequential and prevent recurrent offences. Information provided to the project team failed to confirm that (a) infringements are currently issued in a timely manner (2 days for high level offences and 7 days for routine infringements), (b) the identified infringements are always processed to a prosecution (percentage prosecute-ability), and (c) the fines are paid or collected. Any weakness or delay in this process is critical in the penalty regime and counter-productive to behavioural reform.

A similar issue, where huge advantages can be realised, is the use of available data. The "Intelligent speed enforcement system" founded on the speed camera infrastructure, wireless technology and real-time recording of infringements provides routine and standard reports. This system should be totally integrated to provide meaningful data for "intelligence-led" enforcement capability. These cameras can provide information such as highest speed, mean speed, average speed, recidivist offence vehicles, vehicle profiling etc. - all of which can be integrated into a real intelligence system including speed survey analysis, crash data analysis and offender profiling providing the stimulus for real road safety reform.

To complement these initiatives, strategic traffic law enforcement must be *Intelligence-led, outcome-focused and dynamically driven*. The foundation for strategic enforcement is in following the four principles of effective enforcement, namely:

1. Highly visible and active enforcement;
2. Repeated often;
3. Fair and consistent in operation (aligned with procedural justice); and
4. Well-publicised (with strong media messages, partnership and community support) (Shuey, 2009).

This integrated and holistic approach with strong partnership support will enhance the effectiveness, efficiency and safety of all operations resulting in a community perception of ANYWHERE/ANYTIME/ ANYBODY if you speed, you will be caught and punished. This perception is integral to road safety reform particularly in changing/modifying driver behaviour (Shuey, 2013). These four critical aspects of enforcement are an adaptation of the requirement to maintain the unpredictability of operations as a primary strategy (Homel, 1993).

Public Education and Community Participation

Based on the observations of the project team and discussions with key stakeholders, there appears to be little regard for speed limits and other road rules among the driving public in Iran. The level of non-compliance with speed limits is perceived to be akin to mass civil disobedience. This may be as a direct result of the lack of highly visible and active road policing interceptions for speeding combined with the ineffectiveness of the offender processing of electronic enforcement, both of which have been discussed above.

The general public in Iran needs to be more informed about road injury risk of speeding, in order to achieve a higher degree of acceptance of speed enforcement. This is a pivotal requirement in road safety recognised from 1937 as a guiding component in "a balanced program of official activities by the states and organised public support for the official program" (Damon, 1958). Varying research to the present time has reinforced the importance of communication as a parallel road safety requirement (Raftery, et al., 2014).

Messages must be clear, concise and targeted - Who? What? How? When? and Why? It is a good idea to use focus group research of mediums and messages to ensure the education is clear and credible (Wundersitz, et al, 2010). Social marketing to create a demand for speed management must be a long-term component of regular speed management campaigns (Fleiter, et al., 2014). This should assist the community support for enforcement and penalties that are needed to influence speed behaviour.

Importantly, sending out messages is not sufficient to optimise desired behavioural change (Elliot, 1998, Elliot, 2011 Fleiter, et al, 2014). Regular general deterrence operations using high profile police traffic enforcement boosted by high profile media and community campaigns to convince motorists that they are likely to be caught if they speed should be planned and carried out in tandem with the public messaging about the likelihood of getting caught and penalised for exceeding the speed limit. Sociological and psychological research should be used to inform behavioural campaigns. "The more that is known about the target audience – its characteristics, needs, wants, knowledge, beliefs behaviours, perceived risks, social environment and stage in the behaviour-change process – the greater the chances of developing a successful and cost-effective campaign." (Delhomme, et al.)

Campaigns work best as a collaborative effort. The non-government organisation (NGO) sector and government agencies should collaborate in concerted messages to the general public on risks related with speeding and the need for road safety to be adopted as a cultural norm. Perhaps the business sector could also participate by sponsoring campaigns or conducting internal speed management programs for their employees. Strategies to raise the profile and content of road safety messages are being advised by the international team.

Institutional Strengthening and Interagency Collaboration

It is suggested that Traffic Police and RMTO and other government agencies maximise the use of available data. Improvements to data collection and analysis would assist to understand the dimensions of the speed road safety issues that need to be addressed. Social and behavioural scientists could be engaged to prepare speed related problem definition documents. The use of research and analysis should inform all road safety actions, including research carried out in other jurisdictions (WHO, 2010). Also, pre- and post-intervention surveys can be used to identify the successful and less successful actions.

The role and influence of the lead agency in speed management is very important with the existing NRSC required to be strengthened. There may need to be some kind of formal review body at the political level to ensure that agencies support each other in their speed management roles. To strengthen the Commission's outcome-focus, each representative must have documented accountable performance measures (Bliss and Breen, 2009) and attend progress meetings every 6 weeks. This requirement alone will sharpen the focus of all contributing agencies, through top-down accountability.

Interagency consultations and joint strategic planning for speed management requires respectful and positive communications. These may be formal or informal, but need to focus on common road safety goals (i.e. a single over-arching goal applicable to **all** contributing agencies as to how their agency goals contribute to saving lives). For example, a joint speed enforcement plan could be devised by RMTO, Traffic Police and other partner agencies. There is a need to ensure a better understanding and commitment by agencies and politicians of safe system philosophy and approach. A mindset change to safe system thinking must be integral to speed management programs across all agencies.

A speed management committee should be established and convened regularly within the demonstration zones (at least once per month). This Committee should then develop a speed management strategy through a broad community consultative process and as with the national committee, each member having accountability and transparent performance targets. Further, it may be useful to negotiate memoranda of understandings (MoUs) with key partners specific to speed management. As a component of the road safety community education program, a plan must be developed for a public information campaigns on speed management measures, to keep people informed about the actions being taken and reasons for these actions (WHO, 2008).

Preliminary Findings

The baseline study, field observations and review of good practice undertaken to date have provided a solid foundation upon which to develop the demonstration project using Safe System principles guided by national and international knowledge transfer. This is to be supported by NRSC and government commitment with interagency collaboration to design, develop and deliver a safer road environment. It provides a rich source of research to monitor and evaluate progress, holistically and within the various disciplines to monitor and evaluate progress over the life of the project and beyond.

Among the preliminary findings that provide the strongest opportunities for road safety returns on the investment are:

- A demonstration project in Iran has provided an ideal environment to implement a Safe System focused on speed management, speed limit setting and infrastructure treatment
- Public understanding, engagement and support is a critical component for the success of this project to reinforce a culture of safety on Iranian roads.
- A baseline review supports the rationale for reduced speed limits as an interim measure while Safe System infrastructure upgrades are implemented
- The crash investigation process can be enhanced through a revised focus on identifying preventative measures in reducing risks
- The electronic enforcement infrastructure can be enhanced to directly deter speeding

Implications and Next Steps

The consultants recommended sixteen specific practical improvements for Iran, listed in Appendix A, all of which have been endorsed by the NRSC. These recommendations endorse the establishment and continuance of the demonstration project to be supported by interagency collaboration and enhanced data sources. It is critical to acknowledge the importance of an integrated approach using multi-discipline skills and partnerships to achieve common objectives. Upgraded training is recommended across all road safety sectors as well as an internal and external communication strategy. The project should maximise current and emerging technologies, maximise research opportunities and strive to achieve benchmark status for Iranian road safety.

The consultants advocated three priority actions:

1. Use the new speed limit guidelines to trial changes in demonstration sites – enhanced safety model corridor(s);
2. Improve data quality and accessibility; and
3. Plan and carry out public education and general deterrence programs of action.

The demonstration project has commenced in the three provinces, officially launched by senior government ministers on 27 April, 2021, with oversighting, monitoring and evaluation over the next three years. The initiation of this project provides a practical example and impetus for other low- and middle-income countries to commit to a structured process of reform within the framework of SSA. Using the coordinated skills of a national team supported by international professionals ensures knowledge transfer and capacity building aligns with good practice with the ultimate aim of saving lives.

Acknowledgement

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Appendix A – Recommendations presented and endorsed by the National Road Safety Commission

Recommendation 1 – Implement a demonstration project on Enhanced Safety Model Corridors.

Recommendation 2 – Improve the collection and analysis of crash data and share the data with all interested stakeholder organisations.

Recommendation 3 – Plan and carry out a general deterrence campaign, involving high profile speed enforcement and complementary public media campaign.

Recommendation 4 – Review and improve interagency collaboration and the role of the National Road Safety Commission.

Recommendation 5 – Improve the integrity and timeliness of the administration of speed offence penalties.

Recommendation 6 – Arrange for intensive road safety traffic enforcement and crash investigation training by international experts for Traffic Police

Recommendation 7 – Arrange for intensive training by an international expert for the development of public education campaign expertise within the RMTO, Ministry of Health and Medical Education, Traffic Police and NGOs.

Recommendation 8 – Arrange for intensive training by an international expert on speed limit setting with the use of the new guidelines.

Recommendation 9 – Develop and implement a program of speed blackspot identification and remediation.

Recommendation 10 – Develop and resource an annual program of public education and social marketing on speed risk and enforcement.

Recommendation 11 – Implement a graduated licensing/education system modelled on a competency-based framework.

Recommendation 12 – Review speed management regulations and penalties and improve the deterrent value of these penalties.

Recommendation 13 – Promote the use of emerging technologies and telematics, such as those developed by the Tehran University of Medical Science, to employers, universities and others.

Recommendation 14 – Develop and commission a program of speed management research and evaluation to expert research bodies.

Recommendation 15 – Conduct and report on speed surveys at all high-speed-risk locations the rural road network at least once per year.

Recommendation 16 – Implement a benchmarking program of Iran traffic enforcement against International standards in a star-rating assessment using the International Road Policing Assessment tool.

Contributed articles

Road Safety Case Studies

Safety Effectiveness Evaluation of Raised Pedestrian Crossings in Ho Chi Minh City

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Key Findings

- The raised pedestrian crossing is only effective at the value of the 85th percentile of measured speed (V85) for vehicle groups (motorcycles, cars, trucks, buses) is equal to or greater than 35.5km/h;
- The raised pedestrian crossings within 10.5 metre width have shown more effectiveness of the intervention;
- The invention showed positive impact on speed management, with the highest decrease in speed for cars (-13.93%) and lowest for trucks (-6.54%), on 10.5m of raise pedestrian crossings width;
- This measure reduces the speed of the vehicle around 8% approximately at 7.5m of raise pedestrian crossings width.

Abstract

Traffic crashes are one of the immediate and long-term serious problems all over the world including Vietnam. Speed is one of the direct causes of a crash. In recent years, Ho Chi Minh City has synchronously implemented many measures to manage speed, in particular, a pilot implementation of raised pedestrian crossing measures at many locations in the city. Technical efficiency assessment of this measure is necessary to help the city build more scientific evidence for scaling up successful measures. This study was conducted at four locations on Ton Duc Thang Street, District 1, with four vehicle groups including motorbikes, cars, trucks, and buses. The results indicate that this measure had a positive effect on V85 speed with four group of vehicles at 35.5km/h or more. The effectiveness was stronger for greater widths of raised pedestrian crossing i.e., more effective at 10.5m of raised pedestrian crossings width than 7.5m. This measure reduces V85 speed of vehicles by nearly 14% on 10.5m of raised pedestrian crossings width, and positive impacts are highest for cars (13.93%), and lowest for trucks (6.54%). While traffic volume and the surrounding context may impact on the result, they are not considered in this study. These results provide important scientific evidence for scaling up this measure city wide in the future.

Keywords

Traffic safety, Technical efficiency, Raised Pedestrian Crossing, Speed Management

Introduction

Traffic crashes cause great damage to people, property, and socio-economy, particularly in low-incomes and middle-incomes countries. It is estimated that annual traffic crashes cost the world between 1% and 3% of the gross national product (GNP) (WHO, Global Status Report on Road Safety, 2020).

Vietnam is classified as a middle-income country by the World Health Organization (1740 USD/capita), with the proportion of deaths due to traffic crashes per 100,000 people being 24.5 and traffic crashes cause annual losses accounting for 2.9% of GDP (WHO, Global Status Report on Road Safety, 2015). Thus, traffic crashes clearly affect

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not only individuals but also the whole society. Nearly 54% of deaths due to traffic crashes are related to pedestrians (23%), bicycles (3%) and motorbikes (28%) (WHO, Global Status Report on Road Safety, 2018).

Speed is the direct cause affecting the severity of crashes, injury levels and deaths of traffic crashes (Vadeby, Anna & Forsman, Åsa, 2017). Many studies around the world also show that, along with improving the quality of vehicles and road infrastructure, the reduction in speed will improve the efficiency of ensuring and improving the safety of traffic, including a number of cases and severity (Bachani, A. M., Zia, N., Hung, Y. W., Adetunji, R., Cuong, P. V., Faried, A., Jiwattanakulpaisarn, P. & Hyder, A. A., 2017; WHO, Managing Speed, 2017). Specifically, every 1% increase in speed will lead to an additional 4% increase in deaths and 3% of injuries when crashes occur (Finch, D.J., Kompfner, P., Lockwood, C.R., Maycock, G, 1994). When the average speed decreases by 5%, it will reduce 30% of deaths in traffic crashes (WHO, Managing Speed, 2017).

The study also showed that the risk to pedestrians when colliding with cars will increase greatly (4.5 times) when the speed of cars increases from 50 km/h to 65 km/h (Martin, J. and Wu, D., 2017). The risk of death in traffic crashes between cars and cars is up by 85% when the collision speed of cars is 65 km/h (Jurewicz, Sobhani, Woolley, et al, 2016). In another study of speed-related crashes in New Zealand, the study showed that if the average speed on New Zealand's rural roads decreased by 4 km/h, the total number of people killed by road crashes would decrease by about 15% and the total number of injured people will be about 8% less (Frieth, 2005).

Traffic crashes in Ho Chi Minh City (HCMC) in recent years have seen positive changes including the number of accidents and the number of deaths and injuries. In 2020 in HCMC, traffic crashes decreased under all three indicators (641 accidents, 560 deaths, 141 injuries) when compared to 2019, all of these indicators tend to decrease with the corresponding 5.74%, 11.67%, 13.5%. (HCMC TSC, 2019; HCMC TSC, 2020)

Analysis of data related to causes of traffic crashes in the city for 5 years (2016-2020), indicates speed is always one of 6 leading causes of traffic crashes in the city and tends to increase in recent years, 2019 (ranked 6th) and 2020 (ranked 5th). Hence, the city government has prioritised the synchronous implementation of multiple measures for speed management from policy measures, (speed reduction on some roads) to technical interventions, (installation of signs, speed humps, yellow flashing lights…), and especially the raised pedestrian crossings.

However, until now, there has been no research to evaluate the effectiveness of these measures in terms of their technical effectiveness. Therefore, this implementation of technical efficiency assessment at some raising the pedestrian crossings on Ton Duc Thang Street is considered as the initial research result for this assessment and is essential in the current situation. The framework of this article, will focus on collecting actual speed data at the site of 4 main vehicle groups (motorcycles, cars, trucks, and buses) at 4 locations, which have constructed raised pedestrian crossing measure on Ton Duc Thang Street, District 1, HCMC.

The results of this analysis will be the initial assessment of the technical efficiency of the measure to improve the pedestrian crossing and be the basis for implementing future studies, as well as scaling up this measure city wide.

Methods of Data Collection & Analysis

This analysis was carried out at 4 locations, which have built raised pedestrian crossings on Ton Duc Thang Street as shown in Figure 1.

- Location 1: intersection of Ton Duc Thang - Ham Nghi (30m from Ham Nghi Street);
- Location 2: in front of Majestic Hotel;
- Location 3: in front of the Statue of Tran Hung Dao;
- Location 4: in front of Ton Duc Thang Museum.

All inventions at 4 locations have the same height of 0.07m, while the locations 1 and 3 have the raised pedestrian crossing width of 10.5m, the locations 2 and 4 have

Table 1. Summary of traffic crashes data in HCMC for 5 years (2016-2020)

Year	Number of cases/ percentage change in comparsion with previous year	Number of deaths/ percentage change in comparsion with previous year	Number of injuries/ percentage change in comparsion with previous year
2016	887	797	238
2017	788/ –11.16%	714/ –10.41%	216/ –9.24%
2018	743/ –6.19%	691/ –3.89%	197/ –7.51%
2019	680/ –11.46%	634/ –10.96%	163/ –18.91%
2020	641/ –5.74%	560/ –11.67%	141/ –13.5%

(HCMC TSC, 2016; HCMC TSC, 2017; HCMC TSC, 2018; HCMC TSC, 2019; HCMC TSC, 2020)

Figure 1. Survey - data collection on Ton Duc Thang Street

their widths of 7.5m. The team used speed gun software developed by Aamir Ullah to measure the actual speed of the vehicle. Speed Gun software compatible with iPhone, iPad, and iPod requires iOS version 8.0 or higher. This is a smart software used to measure the movement speed of objects in space with a smart camera of the device, as shown in Figure 2, and Figure 3.

As the software is a non- commercially available version, the developer doesn't confirm its reliability. Therefore, to assess the reliability of this software, the research team organized an experimental assessment. We drew two lines on a straight road, with 30 meters distance from first line to the second line. Four motorbikes (Grande, Exciter, Winner, and Honda blade), which have electronic odometers, ran at 40km/h at the first line and 35km/h at the second line. Eight inspectors had been arranged for this task, and divided into two groups, one group to get data at the first line and other one at second line to measure 50 data for each inspector using iPhone 6s. The results show that the reliability of the software is around 83% (82.6%).

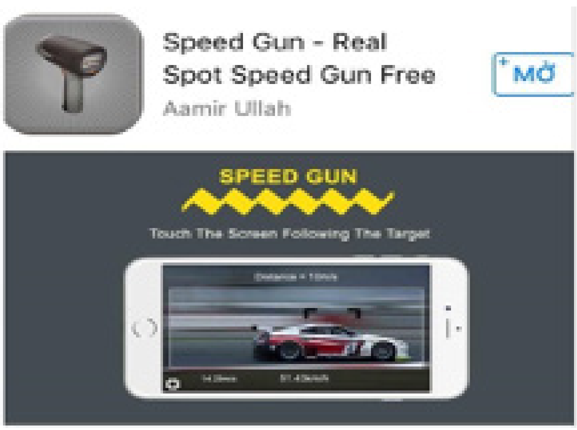

Figure 2. Speed Gun software

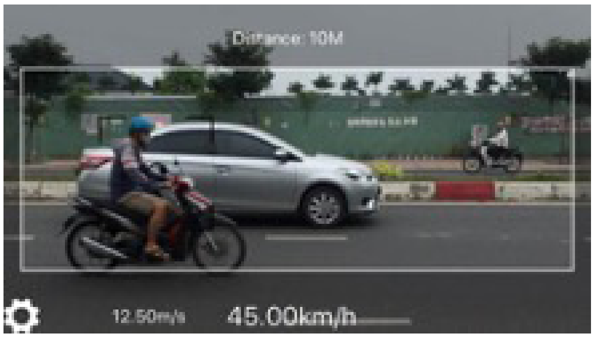

Figure 3. Speed Gun software interface when collecting data

To collect data at the site, the team arranged 8 surveyors, (trained students), divided into two groups, each group of 4 people, standing at 30m distance before the interventions apart, one group standing at the actual position measure following the direction of the vehicle. Each surveyor was equipped with walkie talkies to confirm which vehicles will be detected for speed. Each surveyor at the site measured a vehicle belonging to the required group of vehicles. Due to the limited functionality of the software, (non-commercial version), to ensure accuracy, the team focused on data collection at three period times per location per day (off-peak hours): 9:00-10:30'; 14h00'-15h30'; 21h30-23:00'. Each location collected 200 data samples for each vehicle group.

Users of speed gun software first need only enter the distance from the position to the vehicle to measure its speed, then move ttransfer speed on the screen according to the target to measure speed. The results on the screen will indicate the speed of the measured object in m/s and km/h.

The analytical results show that there are differences in efficiency in speed reduction for the four groups of vehicles (motorcycles, cars, trucks, buses) at raised pedestrian crossings within 10.5, and 7.5m width, as follows:

The Raised Pedestrian Crossings within 10.5m Width (position 1 and 3 according to Figure 1)

The analytical results indicate that raising pedestrian crossings had only positively affects (reduced vehicle speed) to the behavior of road users for four groups of vehicles when the value of the 85th percentile of measured speed (V85) of vehicles is equal to or greater than 35.5km/h. When the operation speed was less than 35.5km/h, the vehicle speed did not decrease and even it increased because the road users tried to remain at the operation speed at interventions as shown in Figure 4, 5, 6, 7, 8. This effect was also different for each group of vehicles, the highest efficiency was for cars (decreased 13.93%) and the lowest was trucks (decreased 6.54%) (Table 2). This is not really hard to understand because if the speed of vehicles is less than 35.5km/h, the interventions have very weak negative impact on vehi-

Table 2. V85 Speed group of vehicles before and after passing the measures (10.5m)

10.5m raised pedestrian crossings width	Motorcycles	Cars	Trucks	Buses
V85 Initial(km/h) (Vb)	48.2	51.7	42.8	38.7
V85 Final (km/h) (Va)	43.8	44.5	40.0	35.2
Va - Vb (km / h)	-4.4	-5.2	-2.8	-3.5
%	-9.13	-13.93	-6.54	-9.04

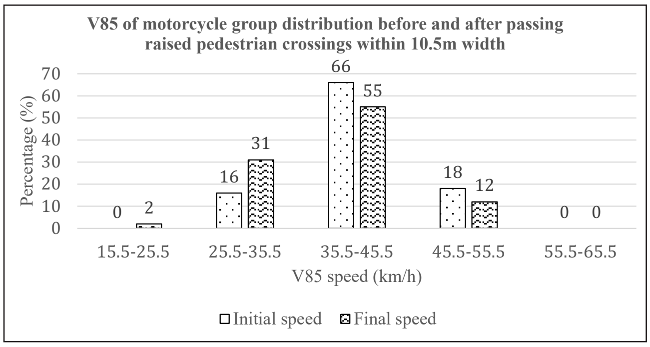

Figure 4. V85 speed of motorcycle group distribution before and after passing raised pedestrian crossings within 10.5m width

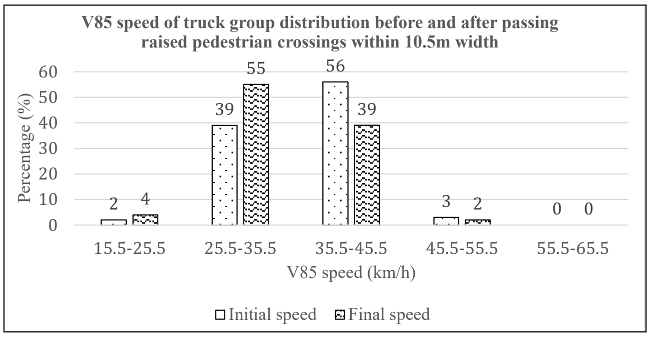

Figure 6. V85speed of truck group distribution before and after passing raised pedestrian crossings within 10.5m width

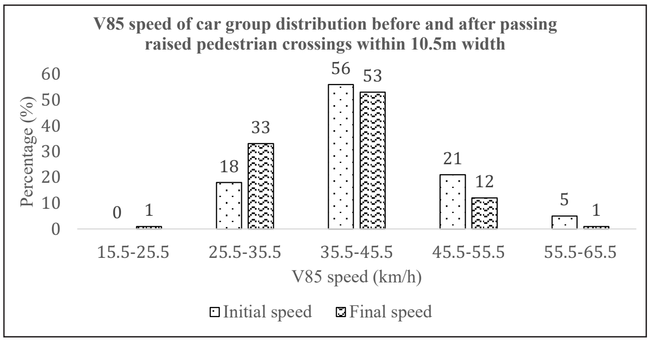

Figure 5. V85 speed of car group distribution before and after passing raised pedestrian crossings within 10.5m width

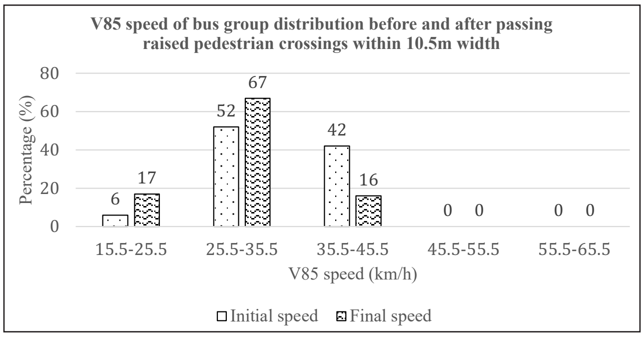

Figure 7. V85 speed of bus group distribution before and after passing raised pedestrian crossings within 10.5m width

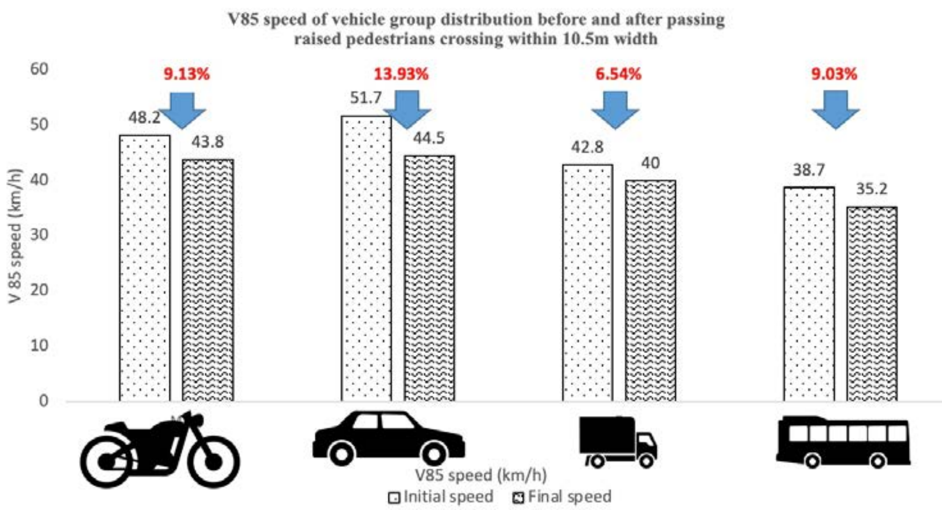

Figure 8. V85 speed of vehicle group distribution before and after passing raised pedestrian crossings within 10.5m width

Table 3. V85 Speed group of vehicles before and after passing the measures (7.5m)

7.5m raised pedestrian crossings width	Motorcycles	Cars	Trucks	Buses
V85 Initial(km/h) (Vb)	43.5	44.5	42.5	37.5
V85 Final (km/h) (Va)	41.0	41.8	39.5	34.5
Va - Vb (km / h)	-2.5	-2.7	-3.0	-3.0
%	-5.75	-6.07	-7.06	-8.00%

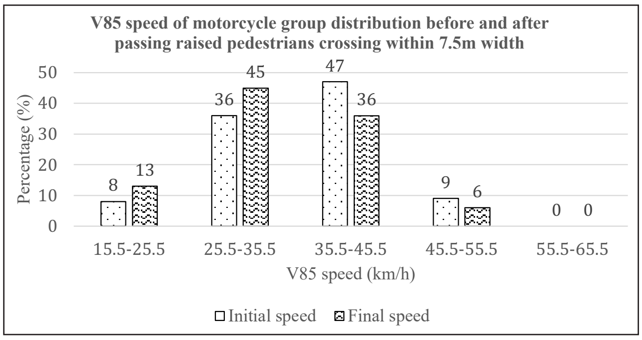

Figure 9. V85 speed of motorcycle group distribution before and after passing raised pedestrian crossings within 7.5m width

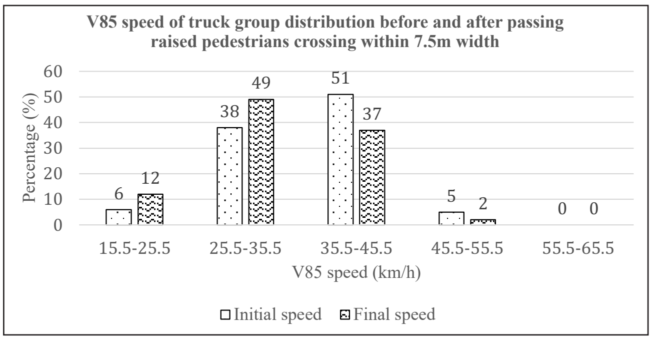

Figure 11. V85 speed of truck group distribution before and after passing raised pedestrians crossing within 7.5m width

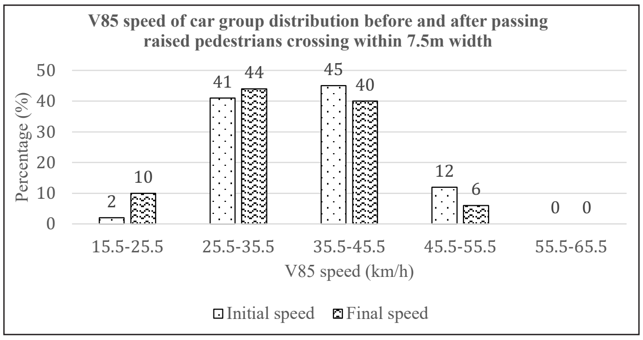

Figure 10. V85 speed of car group distribution before and after passing raised pedestrians crossing within 7.5m width

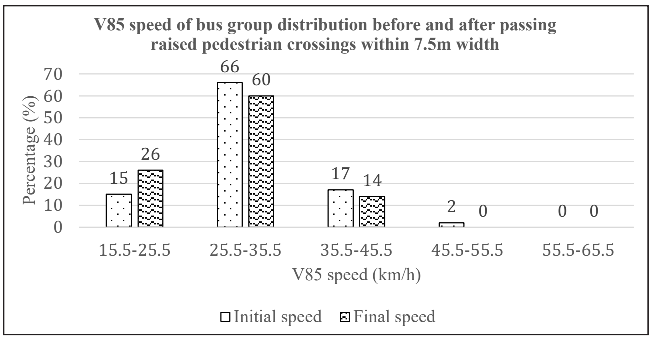

Figure 12. V85 speed of bus group distribution before and after passing raised pedestrian crossings within 7.5m width

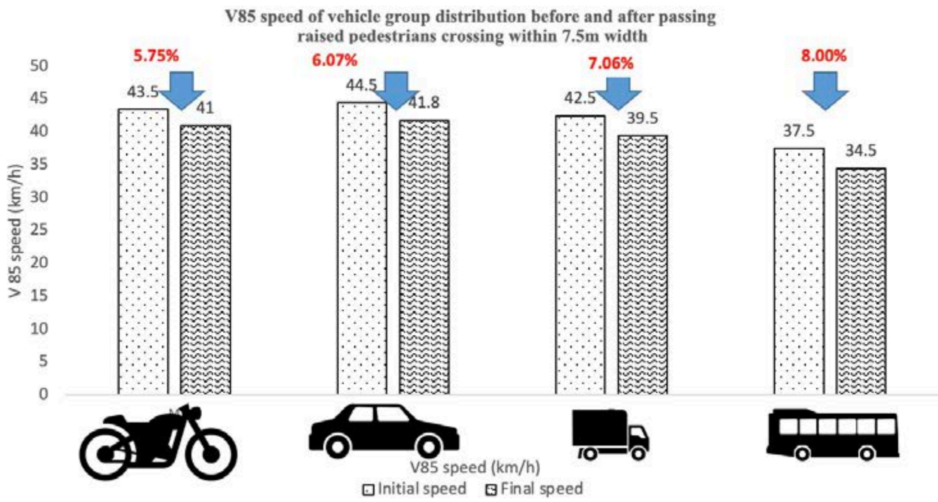

Figure 13. V85 of vehicle group distribution before and after passing raised pedestrian crossings within 7.5m width

cles, as most of drivers keep operating at the same velocity when they pass over this treatment.

The Raised Pedestrian Crossings within 7.5m Width (position 2 and 4 according to Figure 1)

Similarity findings above, the analytical results also show that the raised pedestrians crossing had only positive effects (reducing vehicle speed) to behavior of road users for four groups of vehicles when the value of the 85th percentile of measured speed (V85) of vehicles is equal to or greater than 35.5km/h. When the operation speed was less than 35.5km/h, the vehicle speed did not decrease and even it increased because the road users tried to remain at the operation speed at interventions as shown in Figure 9, 10, 11, 12, 13. This is not really hard to understand because if the speed of vehicles is less than 35.5km/h, the interventions have very weak negative impact on vehicles, as most of drivers keep operating at the same velocity when they pass over this treatment. However, the effect of this measure was also different between the raised pedestrian crossings width (7.5m and 10.5m), the highest efficiency was buses (decreasing 8.0%), and the lowest was motorcycles (decreasing 5.75%) (Table 3

Conclusions

Research analysis shows the raised pedestrian crossing is only effective at operation speeds for vehicle groups (motorcycles, cars, trucks, buses), when the V85 speed of the vehicles is equal to or greater than 35.5km/h.

It was observed that higher the raised pedestrian crossings width higher was the effectiveness of the intervention.

For 10.5m of raised pedestrian crossings width, this intervention is positive impact on speed management with the highest decreasing speed for cars (-13.93%) and lowest decreasing speed for trucks (-6.54%).

When the raised pedestrian crossings width are 7.5m, there is no significant difference observed in speed management among vehicle groups. However the intervention reduces the speed all the vehicle groups by 8% approximately.

The traffic volume, and the surrounding context may impact on the result, but they are not considered in this research.s

Finally, the findings of this research will be an important scientific evidence for the first step in this approach study for the scaling up this intervention on city wide in the near future.

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Road Safety Policy & Practice

Economic impact of 30km/h - Benefits and Costs of Speeds in an urban environment

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Key Findings

- Reducing urban speed limits will provide substantial cost savings and health benefits.
- Speed management is an inclusive solution for all road users globally.
- NGOs and advocacy groups play a significant role to facilitate these evolutions.

Introduction

Speed has fundamental economic costs which are hidden for many stakeholders. On the other hand, the economic benefits of speed are highly visible and strongly promoted by benefiting stakeholders and indeed carefully considered in cost-benefit assessments by road operating agencies. Thus, the main purpose of this paper is to explore and present the benefits and costs of low speed roads in urban environments.

Neglected Economic Costs of Speed

Most economic analyses of higher speeds consider only the reduction in travel time, omitting critical economic impacts through crash costs, emissions, fuel costs, and vehicle maintenance. The total costs of speed are often overlooked because lobbying by transport companies and other road users is focused on their travel time, while the main costs of crashes, Greenhouse Gases (GHGs), and health hazzards from emissions are born by the society and government. Thus, those who speed reap the economic benefits and everyone (usually unknowingly) pays the costs.

Cost-benefit analyses employed by many government agencies that build and operate roads show the effectiveness of trucking, transport and logistics companies and motorised road users as advocates for the economic benefits of speed. However, most government agencies do not fully consider pedestrians as road users (Job, 2020). Direct evidence of biased economic analysis comes from the inclusion of driver waiting time in economic modelling for road policies combined with the absence of consideration of waiting time for pedestrians (Job, 2020). These biased analyses influence specific decisions such as signal phasing at intersections (strongly favoring vehicles over pedestrians) and innumerable other decisions. Through such economic analyses, road policy in many countries is determined with the disturbing irrationality that the time of a person waiting in a car has economic value, but no economic value for the time of the very same person waiting to cross the road. Such analyses facilitate the maintenance of inappropriately high speeds where pedestrians are present, by ignoring the economic value of the latter.

One of the fundamentals of road traffic operations is that speed greatly influences not only traffic safety and operations but also climate impacts and air and noise pollution (Sakashita & Job, 2016). These climate change generating impacts of transport remain paramount as transport remains the weakest sector in delivering reductions in GHG emissions, with transport related emissions still growing while other sectors are achieving reductions (Gota, Huizenga, Peet, Medimorec, & Bakker, 2019). Generally, costs of higher speeds can include worsening of all the following:

- Loss of lives and debilitating injuries. Speed is the toxin in crashes (Job & Sakashita, 2016);
- Increases in GHG emissions and thus burdens the battle against climate change, as vehicles travel above optimal speeds or accelerate rapidly in stop-start traffic;
- Increases other air pollutants and noise which harm health (WHO Regional Office for Europe, 2013; Job, 1996);
- Higher transport costs, through vehicle maintenance costs and increasing fuel costs (Thomas, Hwang, West, & Huff, 2013);

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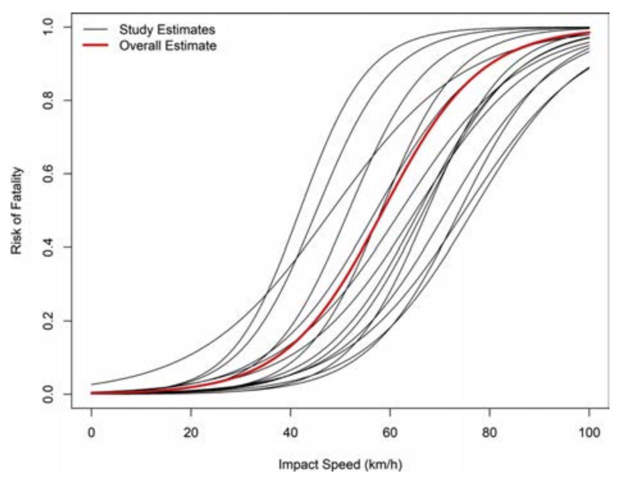

Figure 1. Risk of pedestrian crash fatality by speed of impact changes (Hussain, H., Feng, H., Grzebieta, R., Brijs, T., & Olivier, J., 2019)

- Reduction of equity of access by increasing the risk to pedestrians who must cross high speed roads in their commutes or journeys to school and other vulnerable road users such as cyclists and motorcyclists mixing with high speed traffic. This contributes to inequality and poverty; and
- Reduces opportunities for active transport which exacerbates many inactivity-related health problems such as obesity and cardio-vascular disease.

Pedestrian fatalities are the highest proportion of deaths from crashes in many low- and middle- income countries and globally the most severe type of crash. The graph below shows the risk of fatalities for each speed for a pedestrian crash (Hussain, H., Feng, H., Grzebieta, R., Brijs, T., & Olivier, J., 2019).

Figure 1 shows that speed has a large impact on the road safety. Speed is a risk factor for all crashes ranging from fender-bender to fatal injuries. A more recent systematic review study by Hussain et al. (2019) has identified the relationship between impact speed and the probability of a pedestrian fatality during a vehicle-pedestrian crash, where it is shown that an impact speed of 30km/h has on average a risk of a fatality of around 5%. The results strongly mandate a system of safe-speed limits for different road environments.

The Value of 30km/h in Pedestrianised Areas

With compliance of speeds at or below 30 km/h where pedestrians are present, the reduction in serious injuries to pedestrians can be powerful (in excess of 70 percent (Woolley, Stokes, Turner & Jurewicz, 2018; FHWA, 2020) as well as delivering substantial safety benefits for all other road users in these environments. For example, two TRL (Webster & Layfield, 1996; Webster & Mackie, 2013) studies in the UK compared before and after implementation of 30 km/h (20 mph for the study) zones with physical traffic crash calming measures. The result from the first study for a total of 72 schemes showed that average annual crashes fell by 60 percent, while child pedestrian and cyclist crashes fell by 70 percent and 48 percent, respectively.

The World Bank's recently published Guide for Road Safety Opportunities and Challenges shows that no low-income countries, and only 3 percent of middle-income countries, have 30 km/h or less speed limit policies for urban roads (World Bank, 2020). Research on the full economic impacts of speed are rare, in itself reflecting neglect of the breadth of impacts of travel speed and leading to travel time becoming the dominant factor in current analysis which then (mis)guide vital transport policy decisions. Research on economically ideal speeds are only available for non-urban roads. However, studies show that economically optimal travel speeds are from 76 km/h to 85 km/h on high speed roads, highlighting that economically ideal speeds are significantly lower than the often higher posted speed limits (Hosseinlou, Kheyrabadi, & Zolfaghari, 2015; Cameron, 2003, 2012). In addition, these studies did not consider GHG emissions, the inclusion of which would drive the economically optimum speeds even lower. With the other broad costs of speed (saving lives, GHGs, efficiency, health benefits from reduction in obesity, etc.) noted above considered, the economically optimal speed is significantly lower that the speed limits based on travel time costs, and misinformed or self-interested promotion of higher speeds. With stop-start traffic, more vulnerable road users creating higher risks of serious injuries, costs, and health hazards from emissions, economically optimal speeds in urban environments are much lower, though not well researched.

Conclusions

The recommended reduction of speed limits to 30 km/h has a potential to save lives and debilitating injuries. The strong relationship between speed and the risk of injury and of death applies to all road users involved in crashes. Legislative, enforcement, and road engineering actions to reduce urban speed limits will not only reduce crash injuries and deaths, but will also provide significant cost savings and health benefits delivered by transport noise and air pollution reduction, and increased pedestrian and cyclist active mobility. Finally, lower urban speeds combined with sound urban street policies also facilitate public transport, reduced space for motorised vehicles in favour of non-motorised active transport, freeing up more space for urban recreation and commerce, delivering more liveable vibrant cities (Global Designing Cities Initiative, 2016). Speed management is thus an inclusive solution for all road users globally. These evolutions should be and are being facilitated by advocacy by a wide range of NGOs and advocacy groups along with provision of information from researchers, with promotion from organisations such as the World Bank and Global Road Safety Facility (GRSF).

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ACRS updates

From the President

I have been reflecting on the breadth and depth of our membership, on how you strengthen each element of our community of practice, and on how we renew ourselves into the future.

The first thing I want to say is a massive thank you to each and every member we have. Over the year of the pandemic to 1 March 2021, with the uncertainty that abounds, there are more personal members and more corporate members. As the peak body for road safety in Australia and New Zealand, the membership increasingly reflects the diversity of our potential impact:

- Research institutions which continue to drive the boundaries of road safety science forward which will be so critical to our elimination goal
- Large government agencies which are supporting meaningful dialogue and delivering effective programs, whatever the political stripe of the day
- Local government organisations which are increasingly connecting the safety agenda with the lived community experiences they are responding to
- Private sector organisations comprising manufacturers and suppliers of a whole range of goods and services which will become increasingly important
- Not-for-profit organisations which are providing essential safety glue within the community and are making their own safety voices heard
- Personal members who come from all of the above groups, here and overseas, and interested members of the public, who are each champions in their own right.

This safety ecosystem is Australasia's critical professional platform for road safety as we collectively strive to meet our goal of eliminating fatal and serious injury on the road. The purpose of the College is to support all its members (both personal and corporate) in their efforts to eliminate serious road trauma through knowledge sharing, professional development, networking and advocacy. We must continue to grow and improve our offerings in all these aspects.

In relation to advocacy, which is highly valued by our members, I have been pleased to see a recent increase in the number of issues that members want to see addressed. Members will have noticed a process initiated by our new Chief Executive Ingrid Johnston to establish some policy principles which will facilitate this, and our new Vice President Narelle Haworth will be focusing on our policy area.

The strength of our membership allows us to take strong and principled stands in advocating for road safety policies, speaking as a collective voice to achieve significant improvements in community health and wellbeing. In doing so, we are unapologetically seeking to expand investment in safety, which is suffering from gross under-investment, given the scale of the health losses and the availability of cost-effective treatment.

As an organisation, we seek a virtuous circle – as our membership grows and strengthens, our contribution to society grows and strengthens. Whatever future we make for ourselves, I have no doubt that the College has a vital role to play, and our activity needs to continually reinforce our member focused purpose. This Journal is a defining feature of our College and I encourage you all to take the time to assimilate the learnings and progress reflected in each issue. The Chapters provide an essential means of bringing all elements of our purpose together. However, membership also needs to provide some intrinsic value for the College itself.

If you are engaged in road safety, you are an agent of change. You have a vital safety role to play within society, and you also have a vital role to play within the Australasian College of Road Safety. Please take the time to consider how you may strengthen your College role. You could identify other potential members within your own circle, you could participate more regularly in College activities, you could assume one of the many important voluntary roles within a Chapter, or the Executive Committee. As in road safety as a whole, there is almost no end of opportunity.

Our College has passed the 30 year mark, and we've never been stronger, yet we have a lot more to do. Whether you are early in your road safety activity, or have some kilometres on the clock, whatever your background or perspective, your membership and participation now is a vital part of our renewal for the future. This year, at the Executive Committee, we have said thank you to a lot of collective years served for the College by Raphael Grzebieta, Julie Hatfield, Dreena Lawrence Gray and Eric Chalmers. I have really enjoyed the opportunity to make a contribution to the College over the last 15 years or so, and am proud to serve as President, yet part of our renewal will be the end of my Presidency in May 2022.

For now, I look forward to our conference in September, which itself reflects the renewal task with both in-person and virtual participation, and to spending some time with you all either in Melbourne or online. An exciting future awaits!

Martin Small
President, ACRS

From the CEO

It is with great pleasure and pride that I write my first CEO report. Since I started in this position at the beginning of May, the many conversations I have had with members and stakeholders have reinforced time and again that the College is a highly respected and influential organisation in the road safety sector, with immense and diverse expertise within our membership. It's a privilege to be in this role, and a responsibility that I do not take lightly.

Some highlights of the past few months have been:

UN Global Road Safety Week 17-23 May 2021

The 6th UN Global Road Safety Week 2021 saw the Streets for Life #Love30 campaign gain widespread attention around the world, with the messages seen by over 100 million people. This campaign highlighted the benefits of low-speed streets in urban areas and called on policy-makers to limit speeds to 30km/hr on streets where pedestrians, cyclists and others who are most at risk mix with motorised traffic. ACRS joined the more than 2500 others in signing onto the open letter asking for commitment to safer streets as part of the new Decade for Action for Road Safety 2021-2030, to achieve the Global Goals for Sustainable Development.

ACRS contribution to the development of Australia's National Road Safety Strategy (NRSS) 2021-2030

Following from our engagement with the Office of Road Safety and other stakeholders during the development of the NRSS, ACRS was invited to be part of a targeted consultation on the NRSS Action Plan 2021-2025, as one of just 10 key stakeholders involved. In June 2021 we provided a submission on the draft Action Plan, which emphasised:

- the importance of accountability through an external oversight body with a review of the first 18-24 months of implementation reporting publicly;
- timeframes, funding and responsibilities in the Action Plan;
- linkages between the Strategy, Priority Actions and proposed Safety Performance Indicators; and
- the need for a Commonwealth Road Safety Action plan arising from the NRSS

With the missed targets from the previous National Strategy, there is a strong awareness within the sector of the importance of the new NRSS, and the vital role played in the translation of that into action through the Action Plans. ACRS looks forward to the release of the NRSS and Action Plan in the coming months.

Australasian Road Safety Conference (ARSC) 2021

The final preparations for the ARSC are progressing, with the program including key note speakers now available. There is an exciting line up of Australian, New Zealand and international speakers on topics ranging from older road users to achieving speed management in the Eastern Mediterranean Region; crash data analysis to roadside testing for fatigue; mobile phones to connected and automated vehicles. There truly is something for everyone interested in road safety, including the ACRS Awards, and Conference Awards, with both sets of winners announced during the program.

While we continue to monitor COVID carefully, the hybrid format of this year's conference allows us to be flexible and ensure that after having to postpone in 2020, the conference will be able to proceed this year regardless. We look forward to seeing you in Melbourne or online, on 28-30 September 2021.

International Outreach

The ACRS International Outreach Chapter continues to grow, with almost 60 members from more than 20 countries around the world. The Chapter has now held 3 meetings, with a 4th planned as a pre-conference event on 27th September 2021. The meetings provide an opportunity for road safety experts to share and learn from each other, for example discussing experiences and successes during the UN Global Road Safety Week 17-23 May, and with presentations so far including:

- InaRAP (Indonesia) & Australia-India initiatives,
- effective road safety capacity building in action in Thailand,
- winning political support for speed management in Iran,
- safe journeys for school children in the Philippines, and
- strengthening legislation and enforcement in the Philippines.

As the funding for the initial project to establish the IOC comes to an end, we are now investigating ways of ensuring the sustainability of this initiative into the future.

Ministerial Roundtables

On 24 May 2021, ACRS hosted the third in a series of Ministerial Roundtable discussions, with the last one focused on regional and remote road users. Ten key stakeholders joined representatives from the Department of Infrastructure, Transport, Regional Development and Communications, as well as ACRS staff and facilitator Professor Teresa Senserrick from the QUT Centre for Accident Research and Road Safety, for a meeting Chaired by the Assistant Minister for Road Safety and Freight Transport, the Hon Scott Buchholz MP. The meeting covered many issues including relationships between different levels of government, accountability in how road safety funds are invested, star ratings for roads, improved injury and hospitalisations data, technology, and education, as well as reasons why road safety issues particular to regional and remote areas.

I would like to thank the ACRS President, Executive Committee, staff and members for the warm welcome I have received, and your continued support. I strongly believe that in member-based organisations such as ours, the members are the College. I will strive to ensure that the incredible work you do is valued and respected, as we journey together towards eliminating fatal and serious injury on the roads.

Dr Ingrid Johnston

Chief Executive Officer, ACRS

ACRS Chapter reports

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

Australian Capital Territory (ACT) and Region

The Chapter AGM held on 28 April 2021 elected its office bearers and agreed on its work program for the coming year.

Office Bearers

Chairperson	Eric Chalmers
Vice Chairperson & National Representative	Joanne Wilson-Ridley
Treasurer	Stephen Lake
Secretary	Keith Wheatley

2021-22 Program

- Wildlife Project (continuing)
- Older Drivers (continuing)
  - providing assistance to ACOSS ACT on redevelopment of ACT Older Driver Handbook
  - Support for COTA ACT grant request to explore means of providing active assistance to maintain their active driving skills.
- ACT Road Safety Forum
  - to consider possible changes to the graduated licensing provisions for motor cyclists.
- Reducing speed and fatigue risks for trades people in rural areas
- Promotion of new National Road Safety Strategy & Action Plan
- Motorcycling safety in the ACT & Region.

A Chapter meeting held on 19 May set the following priorities for the year:

- Call Wildlife Working Party meeting shortly to assess responsibilities for the future of the project and to explore options for funding research required to quantify the full extent and costs of wildlife crashes in ACT & Region.

- Finalise the draft of the Older Drivers Handbook with COTA ACT and plan for future coordinating meetings with stakeholders (draft has been forwarded to ACT remainder during Q3 & Q4 2021)
- ACT Road Safety Forum – liaise with Road Safety ACT on timing (possibly Q4 2021)
- Reducing speed & fatigue risks for tradespersons. Assess the programs recently produced by SafeWorkNSW and how the Chapter might assist in promoting them and other relevant programs available. (Q4 2021)
- National Road Safety Strategy & Action Plan. Work with members to decide on focus. (second half 2021 or early 2022) and
- Motorcycling to be discussed with appropriate organisations and timing to be decided).

ACT Chapter Chair & Secretary

Mr Eric Chalmers & Mr Keith Wheatley

South Australia (SA)

Latest CASR Road Safety Research - Speed, brakes, COVID traffic, older pedestrians and safe system training – Friday 7 May 2021

Over 40 people attended on-line to hear a full program of speakers presenting on the latest research by the Centre for Automotive Safety Research (CASR, University of Adelaide).

After Matthew Baldock provided a brief overview and update on CASR, Sam Doecke, presented very interesting new research on using pre-crash speed data from event data recorders to update speed-risk curves. This research adds to the knowledge behind the Wramborg Curves and may potentially update them. Research on light vehicle brake testing methods and the effects of various vehicle brake faults on stopping distances was then presented by Jamie Mackenzie.

Chris Stokes followed with an overview of a short course on The Safe System for road engineers and managers developed by CASR and now being delivered. The course incorporates learning materials developed with the Transport Accident Commission, includes engaging case studies and assessment quizzes. The effects of the COVID-19 restrictions on Traffic flows in South Australia was then explored by Martin Elsegood and the webinar concluded with James Thompson presenting on crashes involving older pedestrians in South Australia. Martin used SCATS traffic count and AddInsight Bluetooth-based speed data along with crash data and found interesting variation from the impacts from COVID between metropolitan and rural areas traffic volumes, speeds and crashes. James highlighted some lesser known aspects of older pedestrian crashes compared to younger pedestrians, including alcohol, responsibility and inattention.

The webinar is available on the ACRS Youtube Channel at https://www.youtube.com/watch?v=-8tMJLF4pSc.

RAA Community Road Safety Education

Originally scheduled as an in-person lunchtime seminar on Thursday 1 July 2021, this event was postponed to a later date due to the uncertainty surrounding the COVID-19 outbreaks occurring at the time.

SA Chapter Chair & Secretary

Jamie MacKenzie and Phil Blake

New South Wales (NSW)

NSW Chapter AGM – 19 May 2021

The NSW Chapter held their Annual General Meeting (AGM) on 19 May, in the week following the ACRS National AGM. The 2021-22 Committee was elected at the AGM and positions determined at the Committee meeting on 25 May 2021.

The NSW Chapter Committee for 2021-22

Mr Duncan McRae (Chair)

Dr Prasannah Prabhahran (Deputy Chair)

Dr Cassandra Gauld (Secretary)

Mr Mick Timms (Treasurer)

Dr Anna Chevalier (Seminar Coordinator)

Mr David McTiernan (Stakeholder Liaison)

Dr Liz de Rome (Committee Member)

Emeritus Professor Mike Regan (Fellow and Committee Member)

Michael Rogers (Committee Member)

Dr Ralston Fernandes (Committee Member)

The Chapter would expressly like to than the outgoing committee members, Ms Justina Diaconu and Mr Peter Frazer for their efforts and commitments during the year. Justina and Peter continue to support road safety through their ongoing work at the NSW Centre for Road Safety (Justina) and the SARAH Foundation (Peter).

Collaboration, consultation, and communication

Members of the NSW Chapter attended several major forums during the quarter, including the Launch of Road Safety Week and the Local Roads Congress. At the Local Roads Congress, Duncan McRae presented on *Road Safety Statistics for Local Roads.*

Seminar series

Since the commencement of the COVID-19 restrictions the NSW Chapter has been limited to delivering online webinars in lieu of face-to-face seminars. The most recent webinar was held on Wednesday 19 May 2021.

The topic of the May webinar was - *Young, novice drivers and telematics feedback to improve safety-related driving performance*. Presented by Professor Teresa Senserrick – Centre for Accident Research and Road Safety, Queensland (CARRS-Q), Queensland University of Technology (QUT), and Dr Amanda Rawlinson – Manager CTP Scheme Policy, State Insurance Regulatory Authority (SIRA).

Details of this and previous seminars are available on the ACRS Website: https://acrs.org.au/chapters/nsw/

Road Safety Submissions

The NSW Chapter has been active in providing submissions to public road safety enquiries. The most recent being, the *NSW Tolling Review* and giving evidence at the NSW *Review of the Compulsory Third Party Insurance Scheme.*

Details of these and previous submissions are available on the ACRS Website:

https://acrs.org.au/publications/submissions/

NSW Chapter Chair & Vice Chair

Mr. Duncan McRae & Dr. Prasannah Prabhakharan

ACRS News

ACRS Submission on National Road Safety Strategy Action Plan 2021-25

In March 2021 the Australasian College of Road Safety (ACRS) provided a submission to the Office of Road Safety on the Draft National Road Safety Strategy 2021-30 (NRSS). The submission was drafted in the interest of creating a NRSS which clearly sets out how road trauma will be reduced over the next decade and beyond.

ACRS was subsequently invited by the Office of Road Safety to participate in targeted consultation on the National Road Safety Action Plan. ACRS welcomed this opportunity to comment on the draft National Road Safety Action Plan 2021-2025 and are grateful to be part of the targeted consultation process. With the missed targets from the previous National Strategy, there is a strong awareness within the sector of the importance of the new National Strategy, and the vital role played in the translation of that into action, through the Action Plan. The 2021 ACRS Submission on National Road Safety Strategy Action Plan 2021-25 can be found here: https://acrs.org.au/wp-content/uploads/2021/07/ACRS-submission-on-draft-NRSS-Action-Plan.pdf. ACRS looks forward to the release of the finalised Action Plan and NRSS in the coming months.

ACRS Submission on New Zealand Land Transport Rule: Setting of Speed Limits 2021

Waka Kotahi NZ Transport Agency recently opened consultation on a proposed new rule enabling an improved approach to speed management planning on New Zealand roads, called the Land Transport Rule: Setting of Speed Limits 2021. The proposed Land Transport Rule: Setting of Speed Limits 2021 (the Rule) has been developed as an action arising from the *Tackling Unsafe Speeds Programme*, which itself is an action of *Road to Zero*, New Zealand's Road Safety Strategy 2020 – 2030. The *Tackling Unsafe Speed Programme* includes three components:

- Introducing a new regulatory framework for speed management to improve how RCAs plan for, consult on and implement speed management changes.
- Transitioning to lower speed limits around schools to improve safety and encourage more children to use active modes of transport.
- Adopting a new approach to road safety cameras to reduce excessive speeds on our highest risk roads

In preparing the submission, the ACRS sought the views of its members in the NZ Chapter. Whilst no member has expressed opposition to the Rule, queries about some aspects of the Rule were raised. Read the ACRS submission on the Land Transport Rule: Setting of Speed Limits 2021 here: https://acrs.org.au/wp-content/uploads/2021/07/ACRS-Submission-Setting-of-Speed-Limits-Rule.pdf

Joint Select Committee on Road Safety Inquiry - Submissions Now Open

The Joint Select Committee on Road Safety, the second of the 46th Parliament, was established by a resolution of appointment that was passed by the House of Representatives on 25 February 2021 and the Senate on 15 March 2021. It follows the previous Joint Select Committee on Road Safety, which tabled its final report on 30 October 2020.

The Joint Select Committee on Road Safety will inquire into and report on measures that can be taken to reduce trauma and deaths on Australian roads. It will investigate and identify opportunities to improve road safety programs and relevant policy in the health, education, industry, transport and other sectors; embed road trauma prevention across agencies; and reduce road trauma in the workplace, including a focus on heavy vehicles and the gig economy.

The Committee is due to present a final report on or before 1 July 2022. Submissions will close on 24 August 2021.

ACRS members are encouraged to participate in this process. If you would like to like to contribute to the ACRS submission, please contact ingrid.johnston@acrs.org.au

In case you missed the papers in the last two Issues of the Journal of Road Safety in 2021

We encourage you to make use of these excellent papers where suitable in your work.

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Peer-Reviewed Papers

Original Road Safety Research

- **Modelling New Zealand Road Deaths**

  Suggested Citation: Morrison, C. and Albequerque, E. (2021). Modelling New Zealand Road Deaths. *Journal of Road Safety,* 32(2), 4-15. https://doi.org/10.33492/JRS-D-19-00246

- **Increasing the effectiveness of mobile speed cameras on rural roads in Victoria based on crash reductions from operations in Queensland**

  Suggested Citation: Cameron, M. and Newstead, S. (2021). Increasing the effectiveness of mobile speed cameras on rural roads in Victoria based on crash reductions from operations in Queensland. *Journal of Road Safety,* 32(2), 16-21. https://doi.org/10.33492/JRS-D-20-00273

- **An Evaluation of Retro-Reflective Screens to Aid Conspicuity of Freight Trains at Passive-Control Level Crossings**

  Suggested Citation: Thompson, J., Baldock, M. and Stokes, C. (2021). An Evaluation of Retro-Reflective Screens to Aid Conspicuity of Freight Trains at Passive-Control Level Crossings. *Journal of Road Safety,* 32(2), 22-29. https://doi.org/10.33492/JRS-D-21-00007

Road Safety Data, Research & Evaluation Methods

- **Investigation of Injury patterns in Heavy-duty Single Vehicle crashes based on real-world accident data in Tamilnadu, India**

  Suggested Citation: Rangam, H., Sivasankaran, S.K. and Balasubramanian, V. (2021). Investigation of Injury patterns in Heavy-duty Single Vehicle crashes based on real-world accident data in Tamilnadu, India. *Journal of Road Safety*, 32(2), 30-40. https://doi.org/10.33492/JRS-D-20-00127

Road Safety Policy & Practice

- **Developing a Scaffolded, Structured Approach to Road Safety Education in Schools**

  Suggested Citation: Horsnell, G., Senserrick, T. and Twisk, D. (2021). Developing a Scaffolded, Structured Approach to Road Safety Education in Schools. *Journal of Road Safety,* 32(2), 41-48. https://doi.org/10.33492/JRS-D-20-00260

Contributed Articles

Commentary on Road Safety

- **Death and Injury in Motorcycle Accidents: The Utilisation of Technology to Reduce Risk**

  Suggested Citation: Evans, V. (2021) Death and Injury in Motorcycle Accidents: The Utilisation of Technology to Reduce Risk. *Journal of Road Safety,* 32(2), 49-56. https://doi.org/10.33492/JRS-D-21-00004

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Peer-Reviewed Papers

Original Road Safety Research

- **Fatal footsteps: Understanding the Safe System context behind New Zealand's pedestrian road trauma**

  Suggested Citation: Hirsch, L., Mackie, H. and McAuley, I. (2021) Fatal footsteps: Understanding the Safe System context behind New Zealand›s pedestrian road trauma. *Journal of Road Safety,* 32(1), 5-16. https://doi.org/10.33492/JRS-D-20-00013

- **Are highway constructions associated with increased transport incidents? A case study of NSW Pacific Highway Construction zones 2011-16**

  Suggested Citation: Sarrami, P., Lemin, P., Balogh, Z.J., Singh, H., Assareh, H., Hall, B., Lassen, C., McDougall, D., Dale, K., Wullschleger, M. and Dinh, M. (2021) Are highway constructions associated with increased transport incidents? A case study of NSW Pacific Highway construction zones 2011-16. *Journal of Road Safety*, 32(1), 17-23. https://doi.org/10.33492/JRS-D-20-00230

Road Safety Policy & Practice

- **Why do we make safe behaviour so hard for drivers?**

  Suggested Citation: Williamson, A. (2021). «Why do we make safe behaviour so hard for drivers?». *Journal of Road Safety*, 32(1), 24-36. https://doi.org/10.33492/JRS-D-20-00255

- **Use of the Safe System Assessment Framework as a Safety Key Performance Indicator**

  Suggested Citation: McHeim, B., Matters, B., Steinmetz, L. and Turner, B. (2021). Use of the Safe System Assessment Framework as a Safety Key Performance Indicator. *Journal of Road Safety,* 32(1), 37-44. https://doi.org/10.33492/JRS-D-19-00260

- **School Road Safety Education in Uganda: Progress and Lessons Learned**

  Suggested Citation: Nkuruho, T.F., Isingoma, C. and Senserrick, T. (2021). School Road Safety Education in Uganda: Progress and Lessons Learned. *Journal of Road Safety*, 32(1), 45-51. https://doi.org/10.33492/JRS-D-20-00266

Contributed Articles

Commentary on Road Safety

- **Road Traffic Light in New Configuration**

  Suggested Citation: Kozin, Y. (2021) Road Traffic Light in New Configuration. *Journal of Road Safety*, 32(1), 52-54. https://doi.org/10.33492/JRS-D-20-00253

Catch up on the Journal of Road Safety back issues here: https://acrs.org.au/journals/

Diary

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

Australasian Road Safety Conference 2021
28-30 September, Melbourne, Australia
https://australasianroadsafetyconference.com.au/

World Day of Remembrance for Road Traffic Victims 2021
21 November
https://worlddayofremembrance.org/


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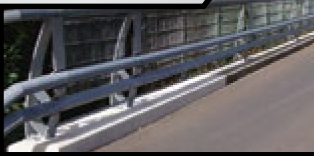

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