Vol 32, Issue 1, 2021

Journal of Road Safety

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

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- Road Traffic Light in New Configuration

INTERSECTION SPEED ZONES

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Intersection Speed Zones help reduce the number of people killed or seriously injured by

35%

Intersection Speed Zones help reduce speeds around intersections, making it easier and safer for people to pull into or out of a side road.

You'll have more time to react to mistakes and avoid collisions, so crashes are less likely and the outcome is less severe, if a crash occurs.

* *Standard Safety Intervention Toolkit*, published February 2019, Waka Kotahi NZ Transport Agency. First edition. NZBN: 9429041910085.

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New Zealand Government

Safety features and technologies for heavy vehicles

Transport for NSW continues to work with the heavy vehicle industry to support smarter safer vehicle design and technologies with lifesaving features, and to encourage more people to choose the safest vehicle.

With the increase in freight task and traffic on our roads, heavy vehicles are facing more challenges. Adopting safety technologies and features in our fleets ensures our heavy vehicle drivers are safer and helps decrease serious injuries and fatalities on NSW roads.

An increased emphasis on improving heavy vehicle safety will reduce the incidence of crashes, injuries and fatalities on NSW roads. This is a positive outcome for both the industry and the community as a whole.

The Centre for Road Safety has published Safety features and technologies for heavy vehicles. This booklet is intended as a handy reference to explain a broad range of technologies and features that benefit heavy vehicle safety. Many of the features are inexpensive and can be retrofitted. It also provides research findings on the reduction of fatal heavy vehicle crashes by the adoption of some of the technologies referenced.

Did you know that if all heavy vehicles were fitted with:

Autonomous Emergency Braking, fatal heavy vehicle crashes would be **reduced by**

25%

Lane Depature Warning, fatal heavy vehicle crashes would be **reduced by**

6%

Electronic Stability Control, fatal heavy vehicle crashes would be **reduced by**

4%

Heavy vehicle operators are encouraged to consider incorporating these safety features into their vehicles.

Copies of this booklet can be downloaded by visiting **roadsafety.transport.nsw.gov.au** or for more information contact **towardszero.nsw.gov.au**

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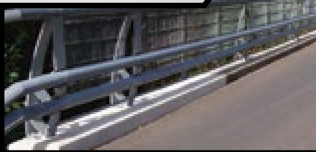

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Cover image

Constructions to improve road infrastructure can impose challenges, and casualties may occur during active construction periods. See a study on construction zones along the New South Wales Pacific Highway in the Original Road Safety Research article: Sarrami, P., Lemin, 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. Photo provided by Pooria Sarrami, MD|PhD

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The *Journal of Road Safety (JRS)* is an international, scholarly, cross-disciplinary, peer-reviewed and open-access journal purely focused on road safety. The JRS accepts papers from any country or region and aims to publish a diverse range of high quality papers on road safety from researchers, policy makers, program implementers and other road safety experts.

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*.

All submissions are assessed on the basis of quality and importance for advancing road safety, and decisions on the publication of the paper are based on the value of the contribution the paper makes in road safety. Once a paper is submitted, the Editor-in-Chief and/or Managing Editor initially review the submission. Authors are notified if their paper is judged to be outside of the JRS' scope or lacks originality or message that is important to the readers of the JRS.

Peer-review submissions that pass the initial screening process will be sent out to a minimum of three peer reviewers selected on the basis of expertise and prior work in the area. Additional peer reviewers may be called on at the discretion of the Editor(s), e.g. in the case of a disagreement between referees' opinions. The names of the reviewers are not disclosed to the authors.

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As a rule of thumb, manuscripts can undergo only one major revision. Any editorial decisions regarding manuscript acceptance by the Editor-in-Chief and Managing Editor are final and further discussions or communications will not be entered into in the case of a submission being rejected. For both peer-review and contributed articles, one or more of the reviewers may require a major revision or reject the paper because of content that may otherwise be of general interest to readers but is not at the level expected of a caliber of a scientific journal paper.

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We welcome questions and suggestions to continue to improve the *Journal of the Australasian College of Road Safety.*
Please contact Managing Editor journaleditor@acrs.org.au

Professor H. Clay Gabler, Ph.D. (1954-2021) †

Samuel Herrick Professor of Engineering and Chair for biomedical engineering graduate studies in the Department of Biomedical Engineering and Mechanics in the College of Engineering at Virginia Polytechnic Institute and Virginia State University (Virginia Tech)

It is with deep sorrow that we inform the road safety community and our Journal readers that we have been informed one of our Journal of Road Safety's prestigious Editorial Board Members, Professor Clay Gabler sadly passed away on Monday 11th January 2021 after suffering a very rapidly-progressing neurodegenerative disorder.

Prof. Gabler was an internationally recognised researcher throughout the crashworthiness, biomechanics and road infrastructure industry. His work in these areas is internationally renowned, with major contributions to road safety and as a result he was much sought after as a project collaborator by road authorities and researchers worldwide. He regularly visited Australia working with a number of University researchers on various Australian Research Council projects. He will be dearly missed by all his friends and colleagues.

As a tribute to Prof Gabler, the May 2021 Edition of the Journal of Road Safety will be dedicated to his memory, work and associations. The Journal Editors are requesting from friends and colleagues '**Perspective/Commentary on Road Safety'** articles that are related to Prof Gabler's career, research work, associations (university or industry) or simply general interest biography style articles, that would be of interest to readers, thus helping us provide a tribute and written legacy to Prof. Gabler. Articles of up to 1000 words are being requested. The deadline for the articles is **15th March 2021**.

Peer-reviewed

Original Road Safety Research

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

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Key Findings

- In 2016 in New Zealand, pedestrians accounted for 7.6% of road fatalities and 6.6% of serious injuries
- In nearly all crashes, a combination of Safe System pillars failed to protect the pedestrian
- Across all levels of New Zealand's transport system there is a stronger focus on vehicle occupant safety, priority, and comfort than for pedestrians
- A proactive, systemic approach is required to achieve a tangible reduction in the burden of pedestrian casualties

Abstract

In 2016 in New Zealand, pedestrians accounted for 7.6% (n=25) of all road fatalities and 6.6% (n=257) of serious injuries (Ministry of Transport, 2017). The aim of this research was to analyse a sample of pedestrian deaths and serious injury (DSI) cases to understand the contribution of Safe System gaps in serious harm outcomes. A sample of 100 pedestrian fatality and 200 serious injury crash reports from 2013-2017 were analysed to identify the contribution of the four Safe System pillars (roads and roadsides, vehicle, speed environment, user) in each crash case. The research identified common crash scenarios and highlighted the need for improvements in speed management, safer vehicles, safety campaigns, and infrastructure design. In addition, the research identified latent high-order sociotechnical system factors that obstruct the mechanisms to effectively address these Safe System issues and which ultimately perpetuate the occurrence of pedestrian DSIs.

Keywords

Pedestrian, road trauma, Safe System, sociotechnical system, death and serious injuries

Introduction

Pedestrian road trauma

Pedestrians are an integral part of New Zealand's transport system. Walking reduces traffic congestion, promotes a sense of community, supports a healthy lifestyle (Kelly, Murphy, & Mutrie, 2017; Lee & Buchner, 2008; Newman, Kosonen, & Kenworthy, 2016), and causes the least harm to other people. However, walking for transport is not always easy or safe (Bakovic, 2012; Stoker et al., 2015). In 2016 in New Zealand, pedestrians accounted for 7.6% (n=25) of the road fatalities and 6.6% (n=257) of serious injuries. Many variables associated with pedestrian deaths and serious injuries (DSI) are reported in the literature and these are summarised below.

The association of vehicle speed on pedestrian DSIs, both in New Zealand and internationally is well understood. For example, there is agreement that higher vehicle speeds at the point of impact result in more severe outcomes for pedestrians (Kröyer, 2015; Zeeger & Bushell, 2010), and that a significant reduction in injuries can be achieved when the impact velocity is less than 30km/h (Jurewicz, Sobhani, Chau, Woolley, & Brodie, 2017).

The literature suggests that males are more likely to be killed or seriously injured as pedestrians than females (Prato, Gitelman, & Bekhor, 2012; Stoker et al., 2015); children aged 5-9 years, and people aged over 80 years are most ‘at-risk’ groups (Ministry of Transport, 2017); and people from marginalised and minority ethnic backgrounds are overrepresented as pedestrian casualties (Baker & White, 2011; Desapriya et al., 2011; Grisé, 2015).

Whilst several demographic factors regarding pedestrian victims are well reported in the literature, there is little demographic information available about the drivers who hit them. Driver information is more available in the form of their behaviour prior to the crash. For example, New Zealand’s Ministry of Transport highlights that common contributing factors associated with these crash types are inattention, failure to give way, and not seeing the other party (Ministry of Transport, 2017). There is some evidence that motorists involved in pedestrian crashes are likely to have more driving violations than the general population (Desapriya et al., 2011). Finally, the use of mobile phones or headphones, or the use of alcohol or drugs by either the pedestrian or the driver can increase crash risk (Harwood et al., 2008; Lichenstein, Smith, Ambrose, & Moody, 2012; Zeeger & Bushell, 2010).

Urban areas are the most common locations for pedestrian DSIs. In 2016 in New Zealand this figure was reported at 84% (Ministry of Transport, 2017). This is likely due to the higher proportion of pedestrian activity and traffic exposure than in rural settings (Prato et al., 2012; Zeeger & Bushell, 2010). Common crash locations reported in the literature include: roundabouts on multi-lane roads; unsignalised crossings; shared signal phasing for pedestrians and vehicles (Gitelman, Balasha, Carmel, Hendel, & Pesahov, 2012); crossing the road within 15m of an intersection (Schneider et al., 2010); and crossing mid-block – a particularly a risky location for children when they dart onto the street (Retting, Ferguson, & McCartt, 2003).

The seriousness of the outcome for pedestrians when struck by a vehicle can be mitigated (or aggravated) by the mass, shape, and other design aspects of the vehicle. For example, metal bull bars increase the risk of severe injury or death to a pedestrian in the event of a collision (Anderson, van den Berg, Ponte, Streeter, & McLean, 2006) whilst the inclusion of energy-absorbing vehicle components can minimise the severity of pedestrians’ injuries (Crandall, Bhalla, & Madeley, 2002). In addition, although all vehicle configurations have blind spots, trucks have noticeably more blind spots than passenger cars (Summerskill & Marshall, 2015).

For the purposes of this paper, pedestrians are defined as “any person on foot or who is using a powered wheelchair or mobility scooter or a wheeled means of conveyance propelled by human power, other than a cycle” (New Zealand Transport Agency, 2009). Furthermore, this paper specifically describes pedestrian DSIs resulting from being struck by a motor vehicle on New Zealand’s roads. This paper does not examine pedestrian DSIs resulting from slips, trips, or falls.

New Zealand’s Safe System

The Safe System approach was adopted by the New Zealand Government in 2010 as part of the Safer Journeys Strategy, a 10-year road safety strategy. The concept of the Safe System acknowledges road user fallibility and vulnerability and argues that a mistake should not cost someone their life, or lead them to be seriously injured. Under this approach, responsibility for the system is shared by everyone, including but not limited to: policy makers; users; planners; vehicle manufacturers; and engineers. Broadly, the Safe System framework can be understood through four ‘pillars’: safer roads and roadsides; safer speeds; safer vehicles; and safer road users (New Zealand Government & National Road Safety Committee, 2016).

The Sociotechnical System

Sociotechnical Systems Theory emphasises the causal relationships between different hierarchical levels in complex systems. For example, Rasmussen’s (1997) work on risk management in workplace settings describes a system hierarchy made up of six levels: government, regulators/associations, company, management, staff, work. This approach has also been applied to crash analyses, and highlights how the relationships between decisions, actions, and failures at different system levels lead to particular outcomes, rather than individual people or isolated errors (Mackie, Hawley, Scott, & Woodward, 2016).

Aim

The aim of this research was to analyse a sample of pedestrian DSI cases to understand the contribution of Safe System gaps in serious harm outcomes. The following research questions were examined:

1. How do DSI crashes differ in relation to underlying Safe System factors?
2. What common scenarios for pedestrian DSI crashes exist, and how can these be understood through the sociotechnical system?

Methods

The goal of the analysis was to use a Safe System framework to analyse pedestrian DSI crash cases that occurred in New Zealand between 2013-2017. In this section we describe the empirical data used, the analysis framework applied to these data, and the method used to understand the contribution of higher-level sociotechnical system factors to crash scenarios.

Data

Data from New Zealand's Crash Analysis System (CAS) database in the form of Traffic Crash Reports (TCRs) produced by NZ Police were retrieved. TCRs are completed by police officers at the scene of all road crashes. They record the available information about where, when, how, and why the crash happened.

It is recognised that crash data contains potential biases including: the language of the form; the 'at the scene' nature of the data entry; and the accuracy of injury reporting and therefore best practice would be to validate police data against hospitalisation data (Abay, 2015; Cryer et al., 2001; Tarko & Azam, 2011). However, due to financial and data access constraints, that approach was not possible in this study. To complement the TCR data, thee other sources were referred to. They were: the Safer Journeys Risk Assessment Tool, a GIS mapping software hosted by the New Zealand Transport Agency which gave details of the road environment; Google Street View, which gave photographic context of the crash location; and Monash University's Vehicle Safety Ratings report (Newstead, Watson, Keall, & Cameron, 2017) to understand the implicated vehicle's aggressivity rating and safety rating.

Crash analysis framework

Between 2013-2017 there were 1,471 pedestrian DSIs on New Zealand's roads (Ministry of Transport, 2017). Each DSI case is ascribed a unique number by the NZ Police in the CAS database. A list of crash numbers was obtained and each casualty case was assigned a randomly generated number using the MS Excel RAND function. These were sorted from the smallest to largest number and the first 100 fatalities (99 crashes) and the first 200 serious injures (199 crashes) were selected for analysis. Thirteen crash cases were excluded: six occurred in a workplace, not on the public road network; three had insufficient data in the TCR; two involved people falling from inside a moving vehicle; and two were incorrectly coded as pedestrians but were cyclists. To replace those excluded cases, the next random number in the list was used.

The TCR reports and the other crash-associated data sources described above were coded into 64 variables (49 polychotomous, 10 dichotomous, 5 open-ended) by a single analyst following a Safe System coding framework which, in its design, acknowledged that DSI crashes happen when a combination of system failures occur (Larsson & Tingvall, 2013). Each case was examined using variables relating to the four Safe System pillars: Speed; Roads and Roadsides; Vehicles; and Users (Hirsch et al., 2019; Mackie et al., 2017). The 'User' pillar was split into two to more equally represent drivers and pedestrians. Each Safe System pillar could be 'triggered' or implicated in a crash in response to certain factors that lay outside the Safe System being present. While multiple factors could trigger the pillar, the pillar itself could only be triggered once per casualty case. The coding framework, including each variable coded and the factors that triggered the Safe System pillars is presented in Figure 1.

Some explanatory notes from Figure 1 are listed below:

- Speed pillar
    - Safe and Appropriate Speed (SAAS): This is a metric in the Safer Journeys Risk Assessment Tool. It suggests the optimal operating speed for most roads in New Zealand based on that road's function, design, safety, and use.
- Vehicle pillar
    - W/COF: A regular vehicle check in New Zealand to ensure that the vehicle meets specific safety standards. Warrant of Fitness (WoF) or Certificate of Fitness (CoF). This was selected to reflect the maintenance of the vehicle and its ability to perform to the standards of its manufacturer.
    - Aggressivity Rating: This rating provides an estimate of the risk of an unprotected road user or driver of another car being killed or seriously injured when they are involved in a crash with the model vehicle (Newstead et al., 2017).
- Roads and Roadsides pillar
    - ONRC: The 'one network road classification' as described in the Safer Journeys Risk Assessment Tool. The road function and land use were measures used in lieu of 'rural' vs 'urban' as it was deemed they had more sensitivity in their definitions.
- User pillar
    - Occupation: TRCs often give a specific occupation (i.e. accountant). The coder then classified these based on These classifications were determined by the Australian and New Zealand Standard Classification of Occupations (ANZSCO) Version V1.2 "classification of occupation". Additional categories were included for students, retired people, volunteers, beneficiaries, people who were unemployed, and tourists.

A spreadsheet for data entry was designed to eliminate coding error by including drop-down lists rather than allowing open-ended responses. In addition, the pillar trigger cells were automatically populated once the data were entered for each variable. To ensure rigour, ten 'test' cases were initially coded by the analyst, then independently by the first author. The set-up of the spreadsheet meant that coders were forced to assign a certain number of cases to each category and because of this, a fixed-marginal kappa was used (Siegel & Castellan,

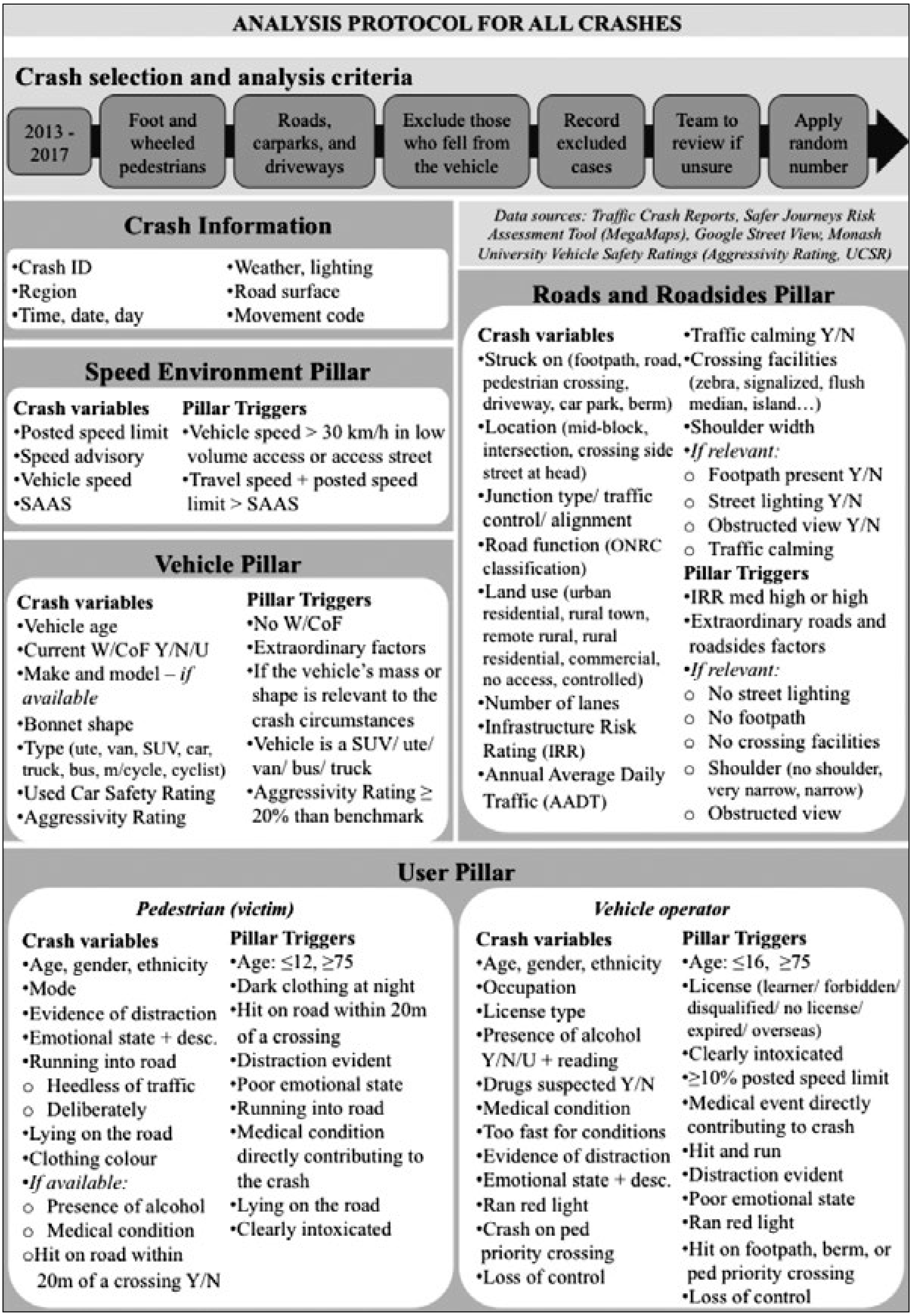

Figure 1. Variables for the Crash Analysis

1988). Across all variables the average score was 0.9. Based on the kappa results, all discrepancies in coding were discussed and solutions agreed. In the majority of cases, simple changes were made to the spreadsheet to minimise the identified discrepancies in future coding.

Understanding higher-level system factors

Common crash scenarios were identified from the output of the empirical analysis. To understand the transport system delivery issues which resulted in the system failures that led to these scenarios, the TCR analysis was supplemented with a workshop of expert industry and community group stakeholders (n=11), a meeting with members of a local government authority's Walking and Cycling Team (n=2), and a review of key policy, guidance, and planning documents. In the workshop and meeting, the scenarios were discussed following Rasmussen's model of risk management (Rasmussen, 1997) and the Cycling Safety System Model (Mackie, Hawley, Scott, & Woodward, 2016). For this research, Rasmussen's model was adapted for a road safety context with five system levels: road users; environmental context; practices and standards; government policy; and societal norms and culture.

Whilst useful for understanding the road user and environmental factors present in pedestrian crashes, TCRs do not provide a rich, contextual understanding of the sociotechnical system factors that come together to result in people being killed or seriously injured. For example, whilst factors relating to the vehicle design or user behaviour could be implicated as contributing to the crash, the TCR analysis cannot extend to demonstrating areas of systems or policy failure such as vehicle import laws, or road rules.

The combination of the crash analysis and system expert review enabled a 'causation pathway analysis' to map out how different levels of the transport system contributed to crash scenarios (Mackie, Hawley, Scott, & Woodward, 2016). The mapping exercise identified how intrinsic high-level system failures can be traced to DSI outcomes for everyday people. In doing so, this method acknowledged that crashes can be defined, not only by the four pillars of the Safe System, but also by various levels of the sociotechnical system – the processes, practises, organisational structures, and policies that ultimately create the context for pedestrian DSIs. This approach fits with the Safe System principle of 'Shared Responsibility', where all actors in the system take responsibility for ensuring safe outcomes.

Results

Crash analysis results

Temporal and geographic patterns

Most DSI crashes occurred during the day, with markedly fewer (25%) between 8pm and 8am. Crashes that did take place at night were more likely to involve pedestrian fatalities. Of all cases analysed, 76% occurred on a weekday.

Figure 2 compares pedestrians' personal risk (per million hours walked) and collective risk (percentage of all crash cases) by region. Personal risk was high in regions

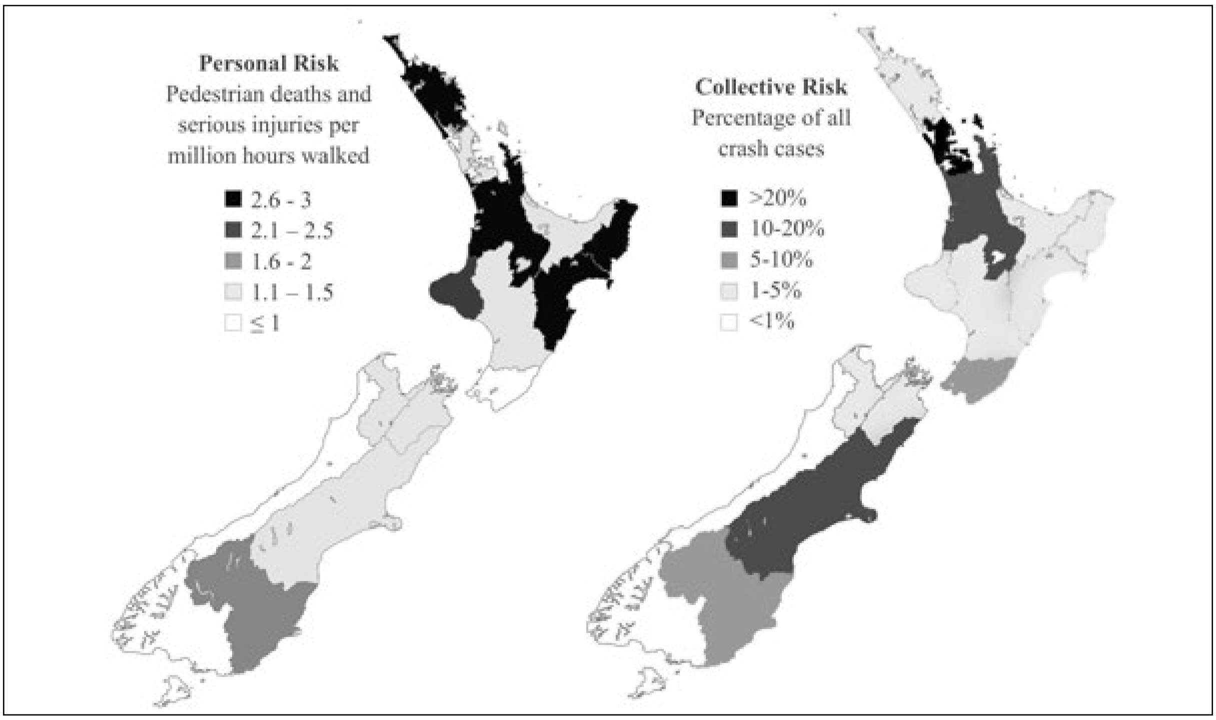

Figure 2. Personal Risk (Ministry of Transport 2015) and Collective Risk (crash cases from this study)

featuring large rural populations with limited pedestrian-focused infrastructure. Collective risk was highest in Auckland where crashes were centralised in the CBD, West Auckland, and South Auckland.

Speed Environment factors

The speed environment was activated in 39% of serious injury cases and in 63% of fatal cases. Crashes where vehicle operating speeds were 50 km/h or under were more survivable (71% of serious injury cases, 59% fatal cases). This finding mirrors the literature which shows that the higher the vehicle speed on impact, the more severe the outcome for the pedestrian due to their vulnerable, unprotected nature (Desapriya et al., 2011; Jurewicz et al., 2017; Kröyer, 2015; Zeeger & Bushell, 2010). Nevertheless, pedestrian casualty still occurred at slow speeds, typically in road environments where there was limited visibility or where complex decision-making was required, such as in driveways or car parks. Dominant injuries at these speeds involved crushing, and falling and hitting the head. Victims were typically young children and older adults. In this sample, 18% of fatal cases and 6.5% serious injury cases occurred when a vehicle was travelling at 30km/h or less.

Vehicle factors

This pillar was activated in 53% of the serious injury cases and in 68% of the fatal cases. The location on the vehicle where the pedestrian was struck was strongly associated with injury severity and different crash contexts. Pedestrians struck on the side of the vehicle (20% serious injury cases, 2% fatal cases) tended to be in lower speed environments (50 km/h or under). Rather than suffering from the full force of the vehicle, these crashes typically involved a pedestrian receiving a blow off a wing mirror, or having a lower limb run over. For this reason, the severity tended to favour serious injury outcomes.

Crashes where pedestrians were struck by the rear of the vehicle (11% serious injury cases, 6% fatal cases) were associated with low-speed reversing. Fatal reversing crashes typically involved larger vehicles such as trucks or SUVs, and/ or fragile or small stature pedestrians such as children or elderly adults. Reversing crashes mostly occurred in driveways or car parks where the driver's vision was obscured by the vehicle's blind spot, or environmental factors such as fences or shrubs.

The majority of pedestrians were struck on the front of the vehicle (68% serious injury cases, 92% fatal cases). Of these front-strike crashes, the bonnet shape had consequences for the outcome severity. Pedestrians hit by vans, trucks, utes, and SUVs had a higher proportion of fatal outcomes (55% of fatal cases) in comparison to those hit by medium sized sedans and mini cars (40% fatal cases). In 5% of cases the vehicle was a motorcycle.

The vehicle's aggressivity was identified in 183 of all crash cases. Within these, the vehicle's aggressivity was implicated in two thirds of fatal cases and one half of serious injury cases. These vehicles were overrepresented by SUVs, utes, and vans.

Roads and Roadsides factors

This pillar was activated in 65% of serious injury cases and 65% fatal cases. The most commonly occurring location – 80% of cases – was urban environments where, in comparison to rural areas, there are higher numbers of vehicles, pedestrians, and journeys.

Fatal cases were commonly associated with a lack of street lighting at night (24% fatal, 2% serious injury) and the absence of a substantial roadside shoulder (12% fatal, 2% serious injury). These cases were mostly located in rural, high-speed environments which are predominantly designed for the passageway of cars, with little consideration for pedestrian travel. Often, people walking rurally have no other option than to walk on, or close to the edge of the road. The risk is amplified at night time due to the lack of street lighting.

Serious injury cases were more commonly associated with urban street environment issues. For example, a lack of crossing facilities was identified as a contributing factor in 33.5% of serious injury cases and 21% of fatal cases. This was particularly of note on four-lane urban roads where serious injury crashes occurred four times more frequently than fatal crashes. These crash cases were predominantly associated with no pedestrian crossing amenities resulting in pedestrians stepping out from between parked vehicles or stepping off a refuge and filtering through slow moving traffic on congested urban roads (often striking the side of the vehicle).

In 13% serious injury and 12% fatal cases, drivers failed to stop at a pedestrian priority crossing such as a signalised crossing or a zebra crossing. Only flat zebra crossings, and no raised zebra crossings were implicated in these crashes. This reinforces Safe System principles whereby vertical deflection is provided to slow speeds by appealing to instinct as a priority, not relying only on cognitive aspects like signs or symbolic markings.

User factors

Overall, of the four Safe System pillars, the user pillar (drivers and pedestrians) was triggered most frequently – in 97% of all cases. Drivers were activated in 59% of serious injury cases and 63% of fatal cases whilst pedestrians were activated in 70% of serious injury cases and 84% of fatal cases. Although the pedestrian pillar was the most frequent pillar to be triggered, this does not mean that the pedestrian had primary responsibility in each of these crash cases. Rather, certain factors about the pedestrian were deemed to contribute to the cause or outcome of the crash.

The most common factor associated with drivers was distraction or inattention (43% all cases). It was associated

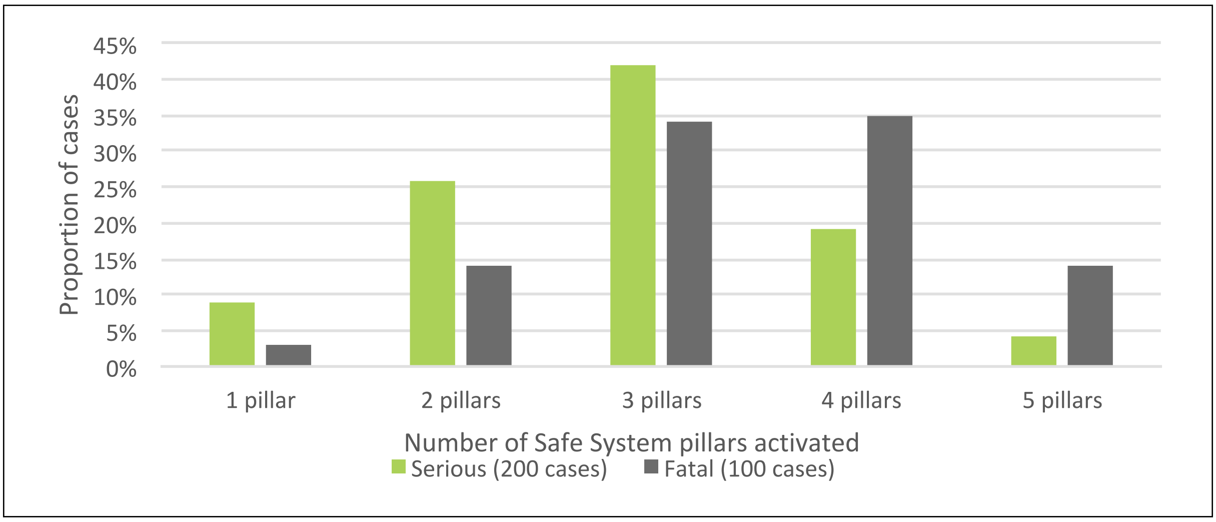

Figure 3. Proportion of fatal and serious cases involving multiple Safe System pillars

with half of the fatalities and one third of serious injuries and involved: looking for a gap in traffic but not checking for pedestrians (20 cases); general inattention (18 cases); driver failing to see the pedestrian (18 cases); and insufficient checking when reversing (15 cases). Distraction or inattention was also the most common pedestrian-implicated factor (37% all cases) and was evenly distributed between DSI crashes. The most common types of pedestrian distraction or inattention were: inadequate checking when entering the road space (55 cases); unsupervised children entering the road space or playing (17 cases); general inattention (10 cases); and using a phone or headphones (8 cases).

Although only 5% of all cases involved drivers travelling greater than or equal to 10% over the posted speed limit, a greater proportion (11% cases) were classified in the TCR as 'travelling too fast for the conditions'.

Overall, males were more crash-involved than females. Males were drivers in 75% of fatal crashes, compared to 57% of serious injury crashes. Likewise, male pedestrians were victims in 65% fatal cases and 52% serious injury cases.

For drivers, the most common gender and age groups were males aged between 41 and 50 years (14.6% of all crashes) and females between 21 and 30 years of age (7.3% all crashes). Using The New Zealand Household Travel Survey's breakdown of minutes spent walking each week per person by age group (Ministry of Tansport, 2015), pedestrian age exposure was determined. Pedestrians aged over 74 years had the highest rate of DSIs per minute of walking exposure. This was followed by people aged 25-34, despite being represented by the second lowest rate of walking per person per week. People aged between 45-74 had the lowest rates of death and serious injury per minute of walking exposure. Of note were male pedestrians aged 13-20 who represented the highest number of cases (n=30). Just over a third of these cases

Table 1. Common crash scenarios identified in this research

Crash scenario	Number of cases		% all DSI cases
	Serious	Fatal	
Attempting to cross an urban road mid-block with no nearby crossing facilities.	57	19	25.3%
Struck on pedestrian priority crossing (either a flat zebra or a signalised crossing).	28	10	12.6%
Children under 12 years of age struck on the road. Associated with playing, escaped supervision, sudden change of speed and/ or direction.	27	5	10.6%
Lack of street lighting at night in rural residential or remote rural environments. Often associated with pedestrian emotion, distraction, or intoxication.	4	24	9.3%

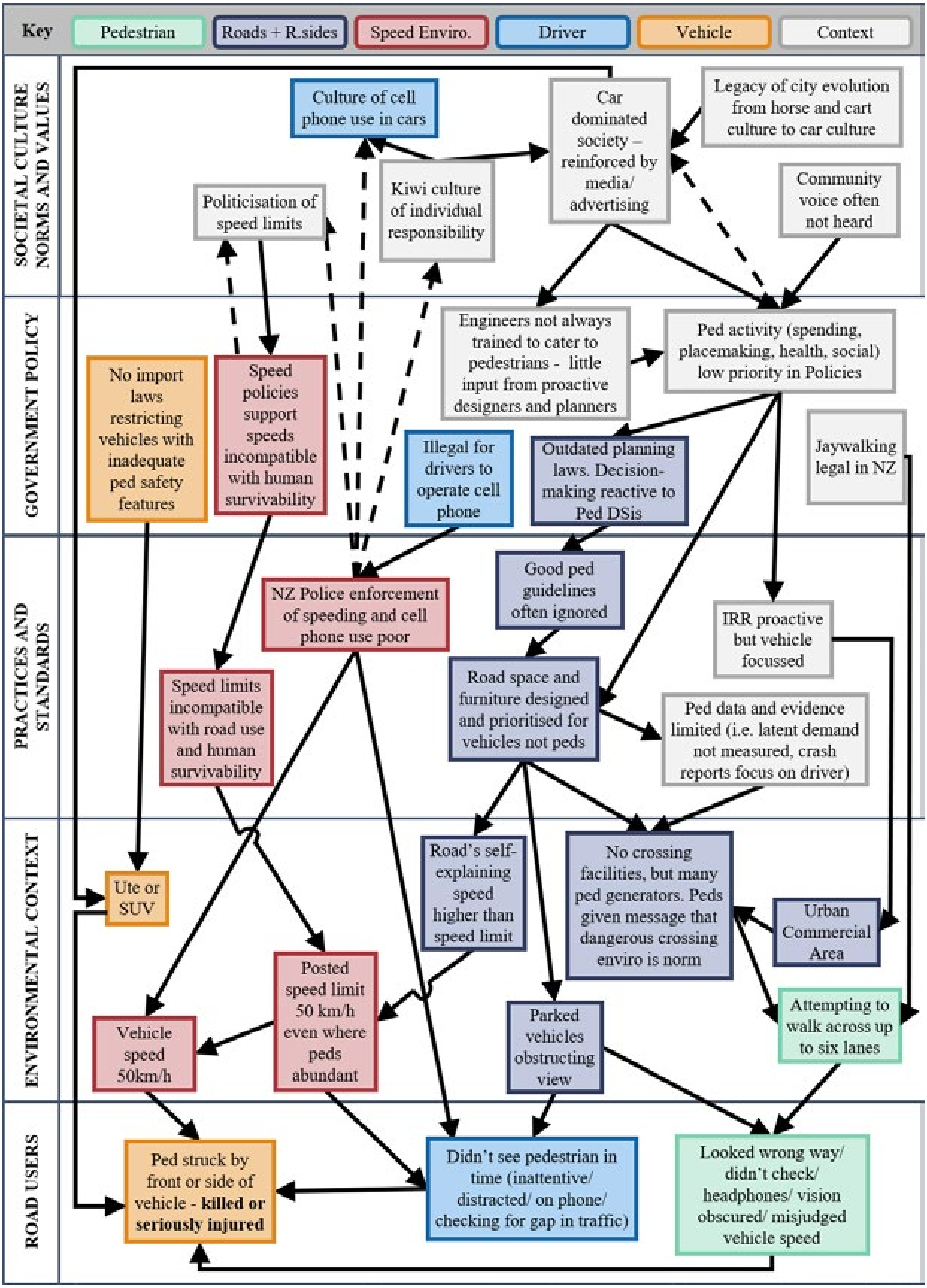

Figure 4. Mapping system failures for 'mid-block crossing with no facilities' (25.3% cases)

involved antisocial behaviours such as playing ’chicken’ with the traffic and being involved in fights on the street.

Driver and pedestrian ethnicity was available in 79% of cases. Although Pākehā (New Zealanders of European descent) were involved in the highest number of all cases (55% drivers, 46% pedestrians), they were underrepresented as a proportion of New Zealand’s population (74%) (Statistics New Zealand, 2013). Māori, who comprise 15% of New Zealand’s population (Statistics New Zealand, 2013) were represented in 13% driver cases and 17% pedestrian cases. Pasifika were represented in 7% driver and 6% pedestrian cases and comprise 7% of New Zealand’s population (Statistics New Zealand, 2013). Within these ethnicity bands, Pākehā are more likely to be drivers and Māori are more likely to be pedestrians. In addition, there is a discrepancy in the number of Pākehā cases to their proportion of the population. For Māori, this is an equity issue and is linked to factors such as vehicle access, education, and other social biases of colonisation.

Pedestrians wearing dark clothing at night time were identified in 13.6% of all cases. This was determined by pairing the TCR code for dark clothing with the time of day. Dark coloured clothing in low light conditions is understood to reduce pedestrian conspicuity (Tyrrell, Wood, Owens, Whetsel-Borzendowski, & Stafford-Sewall, 2016). In these cases, a fatal pedestrian outcome was 2.5 times more likely than a serious injury outcome. In half of those cases, the roads and roadsides pillar was also activated for a lack of street lighting and the absence of a substantial roadside shoulder or footpath, demonstrating the effect of multiple system failures on outcome severity.

This study was concerned with the contribution of system pillars to crash outcomes, and the research design did not incorporate ‘reckless behaviour’ into the analysis protocol (Mackie et al., 2017). However, data were filtered to understand the relative contribution of people who were inebriated or emotionally unstable. Whilst being intoxicated by alcohol as a pedestrian is not illegal in New Zealand, alcohol intoxication is associated with unpredictable behaviours and was therefore included if the pedestrian was present in the live lane. Examples of emotionally unstable driver behaviours included: hit and run, using a vehicle as a weapon, and road rage. For pedestrians, these behaviours included: being suicidal or being involved in a fight. The relative involvement of drunk or/and emotionally unstable drivers was 13.5% serious injuries and 12% fatalities. For pedestrians this figure was 12.5% serious injury cases and 26% fatalities.

Overall, multiple Safe System pillar failures were often implicated in pedestrian DSIs - more so in fatal crashes than in serious injury crashes (Figure 3). This reflects contemporary accident theory (Reason, 1990), which states that adverse events occur when multiple system failures allow it.

Higher-level sociotechnical system results

The pattern of multiple Safe System pillar failure being associated with a higher proportion of fatalities as presented in Figure 3 reinforces the importance of critically examining the connections between individual pillar failures. By mitigating each pillar’s contribution to crashes, the overall crash burden may be reduced. Four common crash scenarios emerged from the analysis (Table 1), representing 58% of the DSI cases. Crash data from the TCRs was valuable in providing this understanding of the road user and environmental context and how factors combined to form scenarios.

System failures – through all levels of the sociotechnical system – behind the common crash scenarios were examined during the system expert review. Through this process, causation pathways were mapped to identify how different levels of the transport system contributed to crash scenarios (Mackie, Hawley, Scott, & Woodward, 2016). The mapping exercise identified how intrinsic high-level system failures can be traced to DSI outcomes for everyday people. A simplified flow-chart of the output from the mapping exercise for the ‘mid-block crossing’ scenario is provided in Figure 4.

Discussion

This research revealed that the majority of DSIs occurred when the pedestrian was simply going about their daily business and a lapse in attention or error occurred on the part of the pedestrian, driver, or both. Invariably, in nearly all of these crashes, other factors within the Safe System failed to protect the pedestrian. These included road environments that did not provide a safe location for pedestrians to cross, speed environments that were not appropriate for human fragility, and vehicle designs that were not forgiving. Within each of the common crash scenarios there was also evidence of sociotechnical system failure from across all levels. These include: social attitudes and norms; political structures such as government policies; and local council design standards and practices. Below we discuss practical recommendations for each Safe System pillar and within this discussion outline some higher-level sociotechnical system changes that could be made to minimise pedestrian DSIs.

Various models of human behaviour, public health, and road safety suggest that the built environment is the greatest determinant of health or safety outcomes (Newman et al., 2016; Sobhani, Jurewicz, Makwasha, Alavi, & Nieuwesteeg, 2016). Yet, in many examples where the roads and roadsides pillar failed, it was evident that the design of the road environment was focussed on perpetuating the landscape of automobility through promoting the priority, efficiency, and safety of vehicles, often in contravention to safe pedestrian outcomes.

Providing a road and roadside environment that is both enabling and forgiving to pedestrians is vital to ensure safe outcomes as well as positive perceptions and associated behaviours for people pursuing active transport modes such as walking and wheeling. At some point, all drivers are also pedestrians, so this is a universal need. Redeveloping metrics to acknowledge the social and economic value of pedestrians (i.e. carbon savings, purchasing power) – and valuing these outcomes above vehicle metrics (i.e. vehicle kilometers travelled, travel time savings) – would be a useful way to influence a change in the political language around pedestrians and vehicles, and, ultimately decisions around funding and design of spaces that prioritise people.

This study identified the roads and roadsides pillar as having the potential to provide a safety net or buffer when other pillars fail. Improvements could include: raised pedestrian-priority crossings along desire lines to key destinations; wider footpaths with good visibility; addressing shared signal phasing; and improving shoulder width and street lighting on rural roads (Desapriya et al., 2011; Griswold, Fishbain, Washington, & Ragland, 2011; Jurewicz et al., 2017; Makwasha & Turner, 2017; Retting et al., 2003). In particular, future efforts to mandate the incorporation of the understanding of play, placemaking, desire lines, and accessibility issues into street design may be beneficial to make streets places that are healthier and safer (Desapriya et al., 2011; Grisé, 2015; Grisé, Buliung, Rothman, & Howard, 2018).

The analysis reinforced the long-held understanding that crash risk and pedestrian injury outcomes are strongly associated with vehicle speed (Kröyer, 2015; Zeeger & Bushell, 2010). Collectively, these findings reinforced that pedestrians are less likely to survive impacts over 30km/h and therefore the speed zoning of some urban environments, such as in Town Centres, some secondary collector roads, and at school bus stops may need to be reviewed. Government initiatives, such as New Zealand's Speed Management Programme, need to better reflect evidence on speed management measures so that pedestrian safety is continually prioritised and improved. Despite this, the findings showed that pedestrian casualty also occurs at slow speeds. This reinforces the need for a system that not only advocates for slower operating speeds, but also provides a further safety-net through other Safe System pillars, such as mandating reversing cameras in new vehicles, planning for person-centered car park designs, and promoting education around driveway risks.

The fragility of pedestrians was also demonstrated through an examination of the vehicle pillar, with more fatal cases associated with a large mass vehicles, or those with aggressive bonnet shapes. The vehicle contribution to safety should continue to reduce as the presence of more forgiving vehicle fronts, object detection, autonomous emergency braking, reversing cameras, intelligent speed assistance, and other pedestrian-specific safety features become more prevalent over time as technology improves and the fleet is upgraded. However, the 14-year average age of the New Zealand fleet coupled with current vehicle imports laws mean that these emerging technologies will not be widespread in the New Zealand fleet for several years. This can be combated to some degree by proactive vehicle import policies by the New Zealand Government. Safe vehicle systems could be encouraged through changes to import policy, motor vehicle safety standards, and vehicle regulations (Schmitt & Muser, 2016). These could favour vehicles which, in addition to occupant protection, include systems designed to protect vulnerable road users. Some vehicle safety systems could include: pedestrian friendly frontal shape, good direct vision (windscreen and side windows); good indirect vision (mirrors, rear windscreen, reversing cameras) (Cook et al., 2011); and the use of force-absorbing materials on lights, windscreens, and bonnets (Schmitt & Muser, 2016).

Limitations

There are limitations in analysing crash data from police reports alone. Firstly, it is understood that inbuilt system bias exists in police reporting of crashes (Tarko & Azam, 2011). This is partly due to the 'on the spot' nature of the reports, which must be filled out at the scene of the crash. In addition, the language of the CAS forms are inherently biased against the pedestrian (e.g. a pedestrian can only enter the road 'heedless of traffic' or 'deliberately'). This bias can be addressed to a degree by linking police data with hospitalisation data, which contains more detail about the crash from the perspective of the pedestrian's injury outcomes (Cryer et al., 2001). In New Zealand, a national dataset linking road crash data and hospital admissions which could be used by practitioners, researchers, and policymakers is needed. Secondly, non-injury collisions are often under-reported and near-miss events are unlikely to be reported. In comparison, injury crashes occur relatively irregularly. Therefore, focus on these exceptional events only does not provide a thorough understanding of everyday pedestrian risk. Given the low rate and nature of road crashes, it is often difficult to draw statistically significant inferences from these rare and sometimes unique events (Hydén, 1987). While patterns within DSI crashes are useful to some extent, an additional analysis of minor injury and non-injury crashes may yield benefit for developing solutions.

Conclusions

This study gives a better understanding of the context behind pedestrian and traffic conflict and therefore has the potential to contribute to Safe System thinking – to help extend thinking beyond the traditional focus of susceptibility to crash forces and to focus more on developing systems that are robust, forgiving, and anticipate and therefore mitigate problems. Through the sociotechnical system mapping, and the Safe

System review, the research highlights how, across all sociotechnical system levels of transport in New Zealand, the safety, priority, and comfort of people driving vehicles is prioritised over that of pedestrians.

These in-built biases affect the latent system conditions that increase the likelihood of pedestrian DSIs. Ultimately, the values and policies of the high-level transport system require a paradigm shift away from a focus on individual behaviour and towards an ingrained and comprehensive Safe System ethos. These intrinsic system issues could be addressed through higher-level system reforms that prioritise pedestrian safety. These include: giving pedestrian safety and access higher priority in road safety planning, design and investment; managing vehicle speeds down to survivable levels; reducing the aggressivity of the vehicle fleet; promoting pedestrian safety through advertising campaigns; and taking a whole-of-system approach to pedestrian safety. A proactive and systemic approach is required before meaningful street changes and a tangible reduction in the burden of pedestrian casualties in New Zealand can be achieved.

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

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Key Findings

- We identified 35 traffic incidents within the location of construction zones;
- The incident rate in the construction periods was significantly higher than in non-construction periods;
- There was no difference between the age, injury severity and mortality rate of casualties.

Abstract

Transport incidents are among the major causes of trauma and injury in Australia and worldwide. While improving infrastructure can decrease the rate of incidents, the required construction imposes challenges regarding simultaneous public use of the relevant road sections. This study focused on construction zones along the New South Wales (NSW) Pacific Highway. We aimed to investigate if the rate of people who had major trauma as a result of a transport incident in a construction zone was higher than the rate of people with similar incidents at other times. This was a retrospective study, conducted by screening the data of patients admitted to the trauma services, or who died due to traffic incidents on the NSW Pacific Highway 2011-2016. We identified 35 causalities who experienced a traffic incident within a construction zone, 19 of these incidents occurred during the construction dates and 16 before or after those dates. The rate of casualty in construction periods was 2.21 per 1000 days, which is significantly higher than the rate in non-construction periods (1.2 per 1000 days, p-value: 0.037). There was no significant difference between the age, injury severity score and mortality rate of casualties who had an incident during the construction dates and those who had an incident in non-construction periods. This study indicated that the rate of incidents increased at NSW Pacific Highway construction zones during construction periods. More investigation is needed to improve the safety of road users during highway road constructions.

Keywords

Injury, trauma, construction sites, highway construction, safety, transport incidents

Introduction

Road traffic incidents are among the major causes of trauma and injury in Australia, and worldwide. In New South Wales (NSW) annually, around 1,400 patients are admitted to the NSW trauma services for major trauma due to transport incidents (NSW Agency for Clinical Innovation, 2018). With 389 lives lost in 2017 on NSW roads, the NSW Government has adopted the target of 'Towards Zero', aiming to reduce the rate of road traffic fatalities by 30% from 2008-2010 levels by 2021, and ultimately have zero fatalities and serious injuries by 2056 (Transport for NSW, 2018). To achieve these targets, the NSW Safer Roads Program, has been undertaken to improve road conditions, which includes improving infrastructure by construction projects (Transport for NSW, 2018). The Pacific Highway upgrade was commenced in 1996 (Road and Maritime Services, 2020). At July 2020, 657km of the highway has been upgraded to four lanes of divided road, while still, 129km are under construction (Road and Maritime Services, 2020).

Undertaking construction works are not without their challenges. Several studies in the United States of America (USA) have reported that construction zones are associated with increased rates of transport incidents (Garber & Woo, 1990; Graham, Paulsen, & Glennon, 1978; Khattak, Khattak, & Council, 2002). There are also conflicting results, where earlier studies indicated rates such as 6.8% increase in the incident rates in USA highway construction roads (Graham et al., 1978), a more recent study reported reduced incidence rates (Jin, Saito, & Eggett, 2008).

Traffic incidents pose hazards for both road users and the people who work in construction zones. The majority of crashes within construction zones have been found to occur in activity area locations (Garber & Zhao, 2002), with rear-end incidents identified as the main types of crashes (Garber & Zhao, 2002; Pigman & Agent, 1990).

Different factors are suggested to be associated with transport incidents in construction zones, such as length and duration of the construction zone (Theofilatos, Ziakopoulos, Papadimitriou, Yannis, & Diamandouros, 2017), poor light condition (Li & Bai, 2009) and drivers' misjudgement on stopping distance or driving too close to other cars (Chambless, Ghadiali, Lindly, & McFadden, 2002; Pigman & Agent, 1990).

In general, contributing factors are human, vehicular, and environmental (Pigman & Agent, 1990). From these, the human factors (driver inattention, following too close, speeding, and failing to yield way) constitute a high proportion of work zone transport incidents (Pigman & Agent, 1990).

An Australian qualitative study found that people who work in road construction activities believe police presence and driver education are the most effective safety measures (Debnath, Blackman, & Haworth, 2015), however, there is limited data in Australia on the effects of highway construction zones on the rate of transport incidents. Access to data related to such incidents can be challenging as not all incidents are reported to police (Blackman, Debnath, & Haworth, 2020). Still, a recent unpublished review of trauma admissions to two NSW regional trauma services, Port Macquarie Base Hospital and Coffs Harbour Health Campus, indicated an unprecedented increase in major trauma admission rates in particular periods. Based on the knowledge of the local healthcare practitioners, it was speculated that these peaks in admission rates might have occurred during the construction times of the NSW Pacific Highway upgrades. However, as there was no evidence to support the observed increase in the rate of injuries being associated with highway construction zones, this study was designed to explore this speculation.

We aimed to investigate if the rate of people who had major trauma as a result of transport incidents in construction zones was higher than the rate of people with similar incidents in other situations. The study aimed to address two research questions: 1. Was the rate of people who had a transport incident in a highway construction zone higher than when there was no highway construction being conducted? 2. Was there any difference in the mortality rate and level of injuries sustained by people who had a transport incident in a highway construction zone, and those who had a transport incident when there was no highway construction being conducted?

Methods

Data sources

This study was a retrospective data collection of injuries and deaths due to transport incidents on Pacific Highway construction zones. We focused on the construction zones along the NSW Pacific Highway between Herons Creek and Port Macquarie, Port Macquarie and Coffs Harbour, and on the Woolgoolga to Maclean upgrade. More information on the Pacific Highway upgrades can be accessed here: https://www.pacifichighway.nsw.gov.au/. Data was collected from the NSW Trauma Registry and the Gold Coast University Hospital. The NSW Trauma Registry is governed by the NSW Institute of Trauma and Injury Management (ITIM), and contains data on major trauma patients from all designated trauma services in NSW (ITIM, 2019). Trauma patient data is entered into this registry if their injury is moderate to severe, as defined by them having an Injury Severity Score (ISS) of greater than 12, an admission to an Intensive Care Unit, or having died during their admission. In the northern areas of NSW, owing to proximity, patients can be transferred to Queensland, therefore we collected data on these patients from the Gold Coast University Hospital.

Patients were included, if the mechanism of injury was 'transport incident', location of injury (incident) was relevant to the study, and the time of injury was between 01/01/2011 and 31/12/2016. Since some road incident casualties might have died on the scene, and this data would not be included in the trauma services data, we accessed coronal files via the National Coronial Information System (NCIS). NCIS is a data system for Australian and New Zealand coronial cases, including all the deaths that are reported to the Coroner (NCIS, 2019). NCIS is managed by the Victorian Department of Justice and Community Safety. We screened NCIS records for reports of death due to transport incidents in the time and location, as earlier indicated.

After identifying the study cohort, records of the included patients were accessed from hospitals to retrieve the exact location of injury that was documented on the ambulance or retrieval case sheets. For those records that had the required location of the incident information, we obtained the case sheets from the retrieval data (the NSW Ambulance and NSW Ambulance Retrieval). Additionally, one of the authors (PL) used local residential knowledge as well as archived media reports to check the exact location of some incidents. Finally, if the precise location of the incident could not be ascertained after all the attempts, the cases were excluded.

In addition to incident and injury data gathered in this study, external information regarding construction zone locations and periods was obtained from the NSW Roads and Maritime Services (RMS) Pacific Highway project office (Road and Maritime Services, 2020).

Data analysis

For each record included in the study, we collected data to identify whether the patient/or deceased persons were involved in a transport incident, location of the incident, basic demographic data, injury severity and outcomes.

Information obtained from the ambulance notes on the address of incidents was turned into latitude and longitude using the Google maps geocoder (Google, 2019). Hence we identified the exact location of traffic incidents, as well as where construction zones were started and ended. The combination of these data was entered into a geospatial mapping program for a visual demonstration. In the resulted map, we could identify transport incidents that occurred on the construction zones. Then we divided the identified incidents into two groups: those which occurred during the time period of construction and those which occurred at other periods. We then calculated the rate of the transport incidents during construction dates versus non-construction periods to see if the incident rate was higher during the construction dates (research question 1). Finally, the severity of injuries sustained and outcomes (mortality), was compared between people who were involved in transport incidents during construction periods versus those who incurred an injury in non-construction periods (research question 2). We used binomial and Poisson mid-p exact tests and corresponding conditional maximum likelihood estimates where appropriate.

Ethics approval

All the collected data was taken from the data already collected as part of the care of patients or for other routine administrative purposes. Therefore, the research did not cause any risk or inconvenience to participants and patients' privacy and confidentiality was protected by the research team. We obtained approvals from the Hunter New England Research Ethics and Governance Office (HREC/17/HNE/475, 7 December 2017), Queensland Department of Justice and Regulation HRE (CF/18/5261, 28 March 2018), and Queensland Public Health Act (RD007265, 20 February 2018). NCIS approval was also received from the Victorian Department of Justice Human Research Ethics Committee (CF/18/5261, 20 March 2018). Also, we obtained three site-specific approvals.

Results

The process of data acquisition is summarised by Figure 1. We initially identified 441 cases with major trauma or death as a result of a transport incident in the postcodes attributable to the NSW Pacific Highway. Based on the NSW Trauma Registry and Gold Coast University Hospital

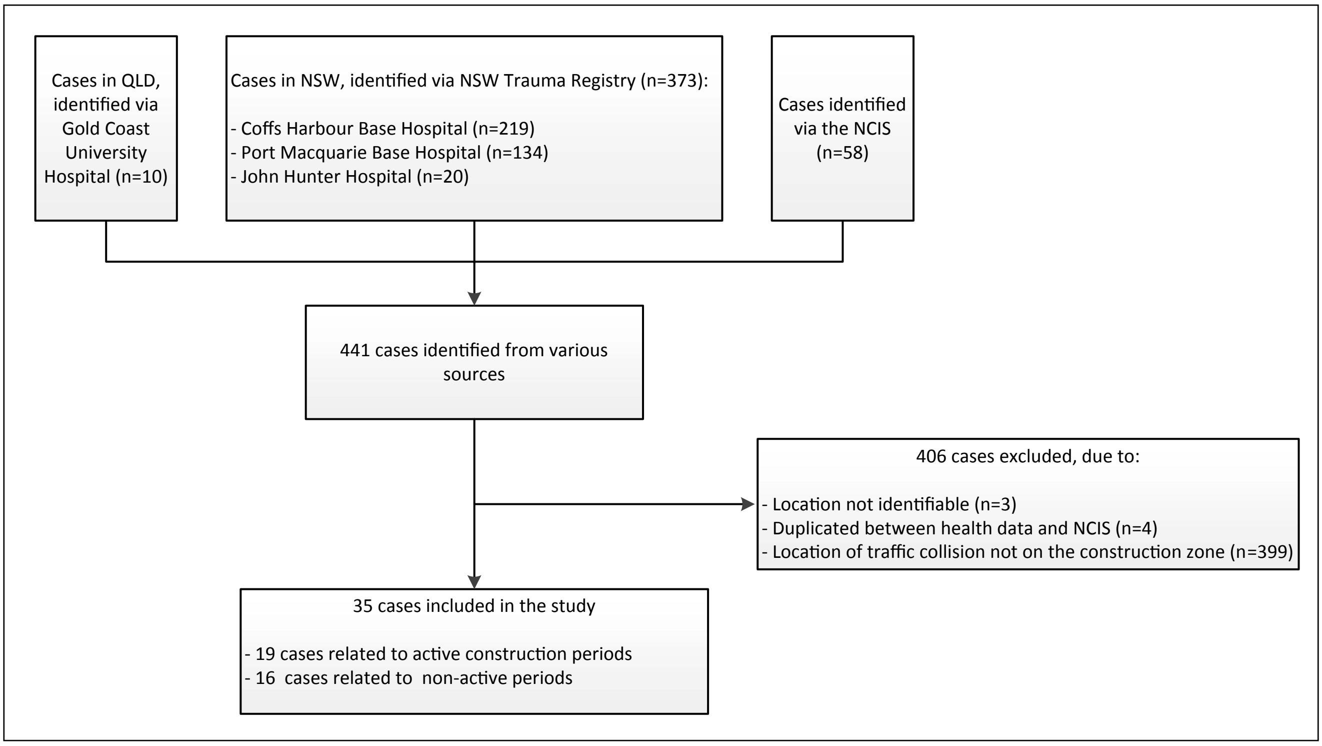

Figure 1: Summary of the data acquisition process

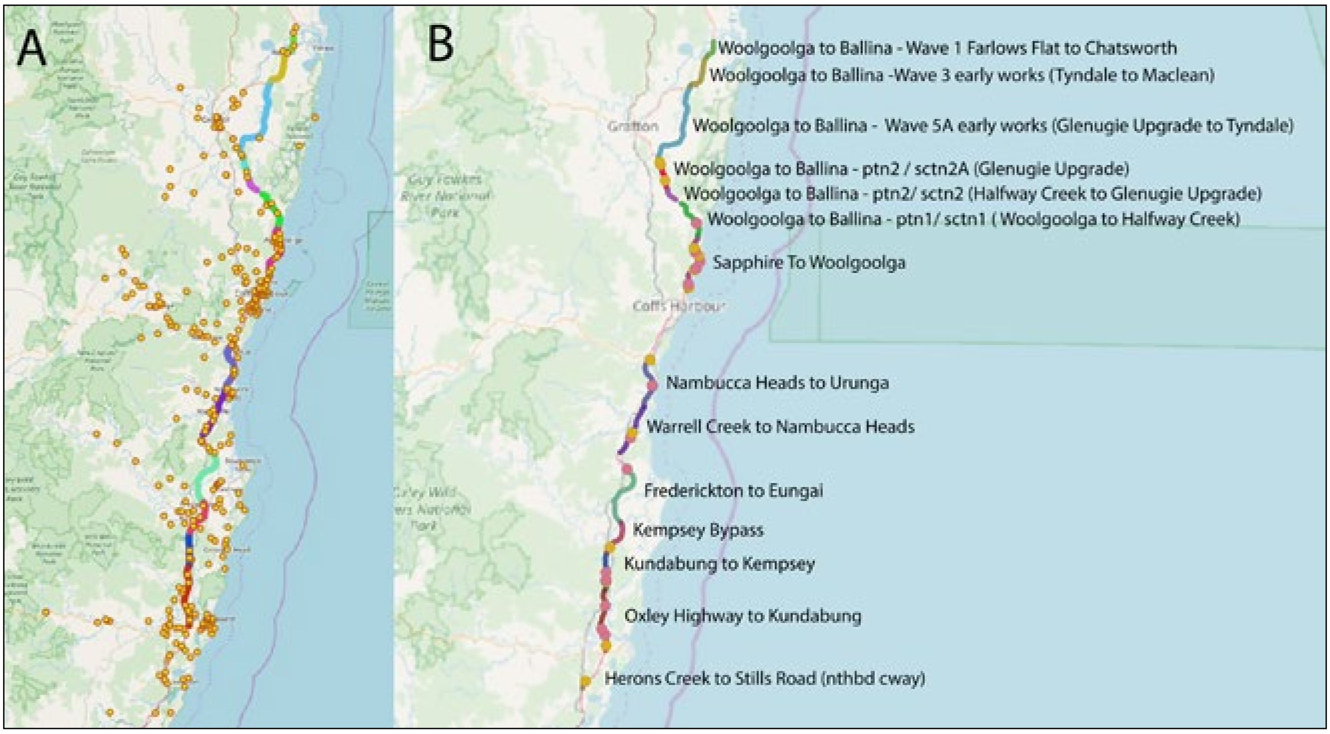

Figure 2: A) Using a Geographic Information System tool, we identified the location of identified cases with moderate to severe injury or death as a result of road traffic incidents during 2011-2016 in the postcodes attributable to the targeted sections of the Pacific Highway. B) After excluding cases that were not on the construction zones, we identified 35 cases who were involved in a transport incident in the construction zones (during construction periods or before or after that).

database, we identified 383 patients. Besides screening NCIS data, we identified 58 cases who died at the scene of a transport incident. Then to access further data on the transport incident location, we checked the hospital records (Coffs Harbour Base Hospital (n=219), Port Macquarie Base Hospital (n=134), John Hunter Hospital (n=20) and Gold Coast University Hospital (n=10)). From the cases identified via NCIS, we could not ascertain the exact location of 3 cases. Also, there were 4 duplicated cases, who died at the Emergency Departments of hospitals, and their data were already included in the hospital data.

Utilising QGIS (Quantum Geographic Information System), a Geographic Information System tool, we located the identified cases geographically (QGIS, 2019) (Figure 2- part A). After excluding those cases that were not on the construction zones, we identified 35 cases involved in a transport incident in the construction zones. From these cases, 19 were related to transport incidents during the construction periods, and 16 were related to transport incidents during non-construction periods (Figure 2- part B).

We calculated the rate of casualties to the time during construction and non-construction periods in each construction zone. Non-construction periods were calculated based on the subtraction of the construction period from the total time of the study. Then we calculated the casualty rate per 1000 days (table 1). Total time of the study was 2,192 days (between 1/1/2011 till 31/12/2016).

The earliest time considered for construction zones was 1/1/2011, even if the construction zones started earlier, and the latest end date for the study was 31/12/2016, even if the construction zones continued afterwards. In the following construction zones, there were no transport incidents, nor at the construction, neither the non-construction periods.

- Woolgoolga to Ballina - ptn2/ sctn2 (Halfway Creek to Glenugie Upgrade)
- Woolgoolga to Ballina - Wave 5A early works (Glenugie Upgrade to Tyndale)
- Woolgoolga to Ballina -Wave 3 early works (Tyndale to Maclean)
- Woolgoolga to Ballina - Wave 1 Farlows Flat to Chatsworth

Addressing research question 1, we identified that the rate of casualty per 1000 days in the construction dates was 2.21, while on the same locations at non-construction times, this rate was 1.2 (table 1). The corresponding rate ratio, 1.84 (95% confidence interval based on the mid-p exact test: 0.94-3.63), was significantly higher than one based on one-tailed mid-p exact test (p-value: 0.037).

The average age of those included in the study (n=35) was 44.7 years old, and there was no statistically significant difference between the average age of casualties of incidents during non-construction and construction periods (47 years old, n=16 versus 43 years old, n=19, T-test,

Table 1: Calculation of casualty rates in construction and non-construction periods

Construction zones	Number of casualties during construction periods	Duration of construction periods (days)	Rate of casualties per 1000 days during construction periods	Number of casualties during non-construction periods	Duration of non-construction periods (days)	Rate of casualties per 1000 days during non-construction periods
Oxley Highway to Kundabung	4	822	4.87	1	1370	0.73
Kundabung to Kempsey	2	791	2.53	3	1401	2.14
Frederickton to Eungai	1	1004	1.00	0	1188	0.00
Warrell Creek to Nambucca Heads	1	761	1.31	1	1431	0.70
Nambucca Heads to Urunga	3	994	3.02	2	1198	1.67
Sapphire To Woolgoolga	6	1306	4.59	5	886	5.65
Woolgoolga to Ballina - ptn1/ sctn1 (Woolgoolga to Halfway Creek)	1	579	1.73	1	1613	0.62
Kempsey Bypass	0	1010	0.00	1	1182	0.85
Herons Creek to Stills Road (nthbd cway)	0	920	0.00	1	1272	0.79
Woolgoolga to Ballina - ptn2 / sctn2A (Glenugie Upgrade)	1	404	2.48	1	1788	0.56
Total	**19**	**8591**	**2.21**	**16**	**13320**	1.20

p value=0.53). All the 16 casualties in non-construction periods survived, while out of 19 cases of casualties who were involved in a transport incident during construction periods, 3 cases were deceased. Nevertheless, the difference in the mortality rate of construction and non-construction groups was not statistically significant (odds ratio: 0, 95% CI: 0-2.29; mid-p exact test, p value=0.18). Moreover, the difference between the average Injury Severity Score of non-construction (ISS: 24.2) and construction periods (ISS: 21.4) was not statistically significant (T-test, p-value: 0.51). Therefore, addressing research question 2, we did not identify any statistically significant differences between the outcomes of the two groups.

Discussion

This study aimed to identify if the rate of people who had major trauma as a result of transport incidents in construction zones was higher than the rate of people with similar incidents in non-construction periods, providing landmark research on the effects of highway construction zones on the rate of road transport incidents in NSW. To achieve that aim, we used routinely collected data to explore the rate of casualties in Highway Pacific construction zones and compared casualties during construction periods versus dates before or after constructions. Our results indicated that the rate of transport incidents had increased during the construction periods. We did not identify any differences between the average age of casualties or their injury severity score and mortality rate. Our finding supports the concept that construction zones could have contributed to the increase in the major trauma admissions to local trauma services. It also aligns with studies undertaken in the United States of America (Graham et al., 1978; Khattak et al., 2002; Pigman & Agent, 1990), despite the differences between the countries transport rules and conditions. However, reduced transport incident rates are reported in a more recent study, which attributes the reduction to improved safety procedures (Jin et al., 2008).

While due to the small sample size in this study, we could not compare construction zones, differences among various construction zones have been reported (Graham et al., 1978). Studying seven different states of USA, Graham et al. (1978) observed that the incident rate decreased in 31% of construction projects and increased in other 24% of these projects, however the overall transport incident rate increased when considering the whole data.

This study has shed light on the potential risk that highway construction zones have for road traffic safety; it is crucial to understand the reason for the increase in incident rates. While the international evidence is not necessarily transferable to the Australian context, it is notable that human, vehicular and environmental factors have been identified to be associated with transport incidents in the construction zones, such as poor light condition (Li & Bai, 2009; Pigman & Agent, 1990) and drivers' misjudgement (Chambless, Ghadiali, Lindly, & McFadden, 2002; Pigman & Agent, 1990). In addition, based on an Australian study, police presence and driver education were perceived as effective safety measures (Debnath et al., 2015). It is crucial to investigate these factors in the current Australian roads.

Construction related incidents are preventable, and observance of standard work procedures are suggested as being instrumental in improving the safety level of the construction zones (Jin et al., 2008). While previous works reported higher crash rates in construction zones, Jin et al. (2008) reported lower rates, most likely due to the observance of standard procedures by contractors. Technological tools might also help, for example, augmented speed warnings are reported to effectively improve drivers' compliance in construction zones (Whitmire II, Morgan, Oron-Gilad, & Hancock, 2011). Since transport incidents on construction sites are preventable, it is important to follow-up the findings of this study by further research studies and projects that explore the bigger picture including minor injuries and also the causation of such transport incidents.

Limitations

While it is imperative to analyse the underlying factors for such association further, we did not have access to detailed information such as the exact time of the incidents. Also, our sample size did not permit further statistical analyses. Otherwise, it could be useful to identify the difference between fatal and non-fatal collisions (Li & Bai, 2008), between collisions occurring in night versus day time (Arditi, Lee, & Polat, 2007), or to explore the effects of seasons on incident rates (Graham et al., 1978). Also, it would also be essential to compare the accident rate before construction time and after to explore the efficiency of construction zones in improving the safety of the roads. With access to data related to vehicular crashes, it would be possible to undertake case studies and to determine the characteristics of transport incidents. For example, previous studies identified 'activity area' as the primary location of crashes in highway construction zones, rear-end type as the main type of crashes and following other cars too closely as the leading cause of crashes (Garber & Zhao, 2002; Pigman & Agent, 1990).

Other limitations of this study were that we explored major injuries and fatalities only and we did not have access to data of transport incidents that were not leading to casualties or were the cause of minor injuries (ISS<12). Therefore, we were not able to capture a potentially more substantial number of cases with minor injuries or incidents with no injuries. Having access to different sources of data would be ideal. In the USA, a discrepancy is reported between different sources of data on the number of incidents in highway construction zones (Graham & Migletz, 1983).

Future studies

Considering the importance of these incidents and injuries for people's lives and health care system, further studies should aim to explore the association between highway constructions and road traffic injuries and understand what factors contribute to such collisions. Having access to detailed data will support such investigations. This knowledge will enable related authorities to work further on prevention and enhancing road safety surrounding construction zones and times. Also, trauma and emergency health services can have a better opportunity for planning and preparation for similar occasions.

Conclusions

Results of this study suggest that construction zones were associated with a higher rate of transport incidents. Further studies are required to explore the association, including underlying causes and solutions.

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Road Safety Policy & Practice

Why do we make safe behaviour so hard for drivers?

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Key Findings

- Stalled progress on improving road safety calls for new strategies.
- The Safe System approach tolerates road-user error so misses chances for prevention. .
- Many errors are caused by poor road system design as illustrated in this paper.
- More human-user centred road system design is needed to reduce errors and crashes.
- Poor design makes it hard for road-users to behave safely.

Abstract

Despite significant improvements in road safety in Australia and developed countries over some decades, the downward trend in fatalities and serious injuries has slowed markedly, and even stalled. New strategies are needed to turn this trend around. Current road safety philosophy, the Safe System, has been effective, but needs broadening to increase the scope of solutions. The Safe System accepts that road users make errors and that the road system should be forgiving of those errors. This leads to countermeasures that emphasise limiting consequences of crashes like lowered speeds, crashworthy vehicles and roads. The problem is that conceptualising road-user error as inevitable ignores the fact that many road-user errors are caused by poor design of the road system including roads, vehicles and road rules. It means road safety overlooks productive avenues for prevention of road-user error and crashes. This paper discusses this issue with Safe System and provides examples of poor road system design that make it difficult for road users to behave safely. This includes poor road rules like inappropriate speed limits, inadequate road design such as poor signage and confusing lane-marking, inadequate vehicle design that limits vision or provides false visual information, as well as problems with driver-assistive technologies: cruise control, automated driving and warning systems. In each case the paper discusses how poor design fails to account for human capacities making it hard for road-users to behave safely. Importantly the paper looks at solutions to these problems and provides some new principles for Safe System.

Keywords

Road-user error, Safe System, human factors and ergonomics, road safety strategy

Introduction

After decades of declining road fatality rates, we have become accustomed to expecting this to continue. In the last decade in Australia, and many similar developed countries, however, there has been a much slower rate of reduction in road-related deaths and almost none for serious injuries (Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2020). The WHO Global status report on road safety (2018), shows that this trend is occurring even in high-income countries which had previously shown years of improving road safety. In fact, in some years, these rates have increased. The lack of improvement means that the national road safety targets set for the 2011 to 2020 period in Australia for example, will not be met (Australian Automobile Association (AAA), 2019). These may have been ambitious targets, but currently road safety is making too little progress towards improvement. This has led to calls for new strategies to address road safety issues in Australia (AAA, 2019) and internationally (WHO, 2009; ITF, 2016). The problem is, what strategies and what issues?

The objective of this paper is to highlight a missing element in current road safety strategy: to design the road system to account for the capacities and limitations of road users. The current approach assumes that errors while driving are many, too difficult to change or cannot be avoided. This is based on an incorrect premise and a simplistic interpretation of the causes of crashes. Unfortunately, this also means that many of our current road safety practices are inadequate and the road system is unnecessarily difficult for road users. This paper puts forward evidence that driver error is not inevitable or irredeemable and in many cases is caused by inadequate design of aspects of the road system. This paper also shows how the current Safe System approach must be expanded to include strategies to reduce circumstances which make safe behaviour difficult for drivers. Failure to acknowledge these problems makes the road system less safe and worse means that we miss opportunities to improve safety.

Problems with the Safe System approach

In countries like Sweden, Netherlands and Australia, road safety strategy over the past decade or two has been based on the Safe System approach (OECD, 2008; ITF, 2016). Largely built on the concepts of Vision Zero (Tingvall and Haworth, 1999) and Sustainable Safety (Wegman et al., 2005), Safe System has become the basis for decision-making by road authorities and its influence can be seen in the sorts of strategies adopted (OECD, 2008; Australian Transport Council, 2011; ITF, 2016). The main principles of the Safe System are that humans will inevitably make errors and that there are known biological limits to the amount of force that can be tolerated before injury occurs. Under the Safe System approach the primary aim is to ensure a more forgiving road system such that forces in collisions do not exceed these limits and that mistakes by road-users do not result in harmful consequences like serious crashes and fatalities. This leads to the current approach which is to tolerate road user error but manage the consequences. This necessarily emphasises solutions that minimise damage to road users when a crash occurs such as seat belts, crashworthy vehicles, separated roads, crash barriers and limiting speeds. There is evidence of some degree of effectiveness in reducing road trauma for these strategies (Mooren, Grzebieta and Job, 2011; Weijermars & Wegman, 2011). But as seen in the crash statistics, there is clearly more work to do.

Safe System models of the road system include humans, but as disruptive influences due to inevitable errors and as a vulnerability due to the potential for injury due to biomechanical forces in crashes. They do not include an active role for the human-user in a safe road system. They largely overlook the strengths, capacities and limitations of humans and hardly consider how to design the system to be most usable for road-users. Most notably, both Safe System and Vision Zero assume that error is inevitable and do not consider the possibility of error prevention. The Dutch Sustainable Safety description of safe system incorporates prevention of human errors, especially through better design of roads that signal functionality and ensure homogeneity and predictability for users, but the inevitable fallibility of users is still recognised as a primary characteristic of this version of safe system. Where Safe System treats error as inevitable, the potentially important strategy of reducing road-user error is ignored or at least discounted. Worse, these approaches fail to recognise that some road safety practices actually create road user error. This means that our current Safe System approach is almost certainly missing out on opportunities to implement some potentially effective strategies to reduce driver error and is even advocating others that have negative effects on road safety.

Recently some have argued that road Safe System approaches should be expanded to encompass all components of the road system, including the impact of road safety legislation and policies, not just individual components, and also to broaden the focus to manage performance variability in the road system, rather than the narrower concept of human failure (Larsson, Dekker and Tingvall, 2010). Multiple studies by Salmon and colleagues have shown how Systems theory, borrowed from workplace safety, can reveal the complex network of interacting factors spanning multiple levels of the road transport system that precede crashes (eg., Salmon, Read, Stanton and Lenne, 2013; Salmon, Hulme, Walker, Waterson, Berber and Stanton, 2020). It is not yet entirely clear how this information can be used to predict accidents or prevent them (Grant, Salmon, Stevens et al, 2018). Further, while Systems theory acknowledges that road user error can be created by the road system, it has not taken it to the next step of encouraging solutions to prevent these errors.

The recent ITF/OECD 2016 report on a Safe System has taken a broader view of the role of the road-user in the road system than in the original 2008 report also by drawing on safe system ideas from sectors other than road safety (eg., Reason, 1997). This view acknowledges the role of multiple components in the road system and that many road-user errors arise from the interaction between the user and the complex components of the road system. It also recognises that the design and operation of a safe road transport system must consider the capacities and limitations of the human user. In spite of this, the first principle in this iteration of Safe System remains: that road users will inevitably make mistakes that lead to crashes. Unfortunately, this principle is not compatible with broader ideas of the Safe System approach. The recommended actions for road safety in this report still retain the focus on tolerating or accommodating for error and still point to human failure rather than designing for human capabilities, expectations and natural ways of behaving. It continues to emphasise the need to mitigate the consequences of error rather than prevent it.

This is most obvious in the advice provided on the design and operation of a safe system: ‘to guide and encourage safe behaviour by users when using the road transport network’ (ITF, 2016, pg 88). This approach assumes that the road system is perfect, and users need help to use it. This is in contrast to the approach from outside road safety which aims to design the system so that it is usable by users. The two approaches lead to different solutions. The ITF approach mainly calls for forgiving or crash mitigation solutions whereas solutions emphasising usability aim to minimise likelihood of error due to problems of use like perception difficulties, misunderstandings and confusions.

This paper puts a case for broadening the Safe System approach to recognise opportunities to prevent or reduce road-user error through improved design. It describes examples of failures of design in the road system that make road-user error more likely and that would not occur if usability was a primary focus in their design.

Is driver error the major cause of road crashes?

Road safety strategy is traditionally built on statistical evidence about road traffic crashes, particularly fatalities. This evidence highlights driver error as the predominant cause of crashes, with studies reporting that around 94% of crashes are caused by driver error (Treat, et al., 1979; Singh, 2015). Causes of crashes are mostly attributed to behaviours like inattention and distraction, speeding, perceptual errors and falling asleep (eg., Austroads, 2015). Unfortunately, most analyses of the causes of crashes are quite crude with emphasis on identifying and categorising a single cause of a crash and hardly ever at the interaction between factors contributing to the crash. Accident analysis in areas other than road safety have long recognised that accidents occur due to a combination of factors and events and almost never have a single cause (Feyer, Williamson and Cairns, 1997; Leveson, 2004). If only a single cause is identified, it is not surprising that it is the last event before the crash and, given the nature of driving, that it involves a failure in road-user behaviour. We almost never ask: Why did the road-user behave that way at that time? What other factors might have influenced the behaviour? This argument is supported in a recent paper by Hauer (2020). He critiqued the history of identifying road-users as the sole cause in crash causation studies on the basis that this impedes identification of targets for prevention that are broad enough to contribute to the Safe Systems approach.

The ITF (2016) report also called for more in-depth studies. It argued that these studies are needed to cover the different aspects of the road transport system in a search for root causes in the chain of events leading to crashes. This analysis should highlight avenues for prevention or mitigate similar crashes. Yet even recent in-depth crash studies (Wundersitz, Baldock and Raftery, 2014; Doecke, Thompson and Stokes, 2020) tend to report single causes along with a list of contributing factors to crashes rather than reflecting a network of causal elements. Even though very extensive, systems theory-based analyses of crashes (Salmon, et al., 2019) also miss out on linking specific types of behavioural failures to specific contributing factors. If only looking for a single causal factor, road safety is missing the opportunity to gain a deeper understanding of how crashes occur and to identify prevention opportunities through looking for common contributing factors across multiple crashes.

Building a better Safe System approach for road safety

Putting all this together, the current Safe System approach to road safety such as put forward in Australia and in the ITF report (2016) acknowledges road user error as the prime cause of crashes, supported by a narrow analysis of crash causes, but most of the solutions it advocates highlight minimising the *impact* of error-related crashes rather than preventing error occurring. In tolerating error, these interpretations of Safe System miss the fact that in a well-designed road system, most error need not occur. It ignores the fact that we often make the road system hard to negotiate for road users and that, as demonstrated by examples in this paper, many practices currently in place increase the risk of error rather than reduce it. The approach also ignores the capabilities of humans and the wealth of knowledge of the interaction between humans and the elements of the road system available from Ergonomics and Psychology (Oppenheim and Shinar, 2011; Woods, Dekker et al, 2012). We almost never acknowledge that road users often avoid crashes in poorly designed sections of the road system.

Of course, not all errors result directly from interactions with the immediate elements of the road system; for example, crashes involving drivers impaired by alcohol and drugs or fatigue. However, drivers affected by alcohol, drugs or fatigue are also less likely to cope with poorly designed elements of vehicles, roads and road rules. Good human-user centred design should mitigate crash risk for these factors as well by making the system easier to use even for impaired drivers.

Examples of problems in the road system for road users

There is a multitude of examples of poor design in the road system that make safe behaviour hard for drivers and road users and so increase the likelihood of error. Generally, these examples relate most directly to the problem for drivers, but they also have negative consequences for other road users such as pedestrians and cyclists as they are often involved in the crashes that result. This is important as around 50 percent of fatalities worldwide are vulnerable road users (WHO, 2019). This section describes some examples of road rules, road design and vehicle design that do not account for human capacities and so make it hard for drivers to behave safely and often increase crash risk for other road users as well. Why this is the case is explained and solutions to prevent errors occurring are suggested.

Road rules and enforcement

Speed management

Speed management is a primary component of both Safe System and Vision Zero approaches based on the relationship between speed and the forces generated in a crash where lowered speeds produce lower energy in a crash so reducing the physical trauma in crash outcomes (Elvik, 2012). Limiting speeds is a major feature of practices based on the Safe System (eg., OECD, 2008; ATC, 2011; ITF, 2016). Mostly the emphasis is on setting limits on speeds that are survivable if a crash occurs, obtaining compliance with speed limits through enforcement using monetary or point-based penalties and encouraging community acceptance of set speeds.

Unfortunately, there is considerable evidence that simply setting lower speed limits is a poor approach to safety as compliance often presents problems for drivers. Compliance is especially difficult when roads communicate conflicting information about appropriate speeds to drivers. To be effective, speed limits need to be creditable to drivers. Studies of rural roads in New Zealand (Charlton and Starkey, 2016), urban roads in Canada (Gargoum, El-Basyouny and Kim, 2016) and both road types in the UK (Yao, Carsten and Hibberd, 2020) show that road characteristics play a large role in compliance with speed limits. Road conditions that signal the potential to do higher speeds than posted such as wide or multilane roads or where the limit is higher than drivers prefer such as roads containing hazards like parked cars, pedestrians or cyclists both create problems for drivers and reduce compliance. A US study also showed that discrepancies between recommended speed limits based on engineering review and the posted speed limit also reduce compliance with the posted limits (Gayah, Donnell, Yu and Li, 2018). As posted speed and engineering recommended speed become more consistent, so does the level of compliance with speed limits. Drivers respond to plausible or creditable factors when choosing their speed, not necessarily the posted speed.

Compliance is also affected when drivers fail to notice speed limit changes. Placement and style of speed signs is obviously important (Wallis and Bulthoff, 2000). Yet Harms and Brookhuis (2016) showed that despite driving a familiar route, drivers did not notice even prominently placed and repeated presentations of altered speed limits. The authors concluded that this failure was related to habituation to aspects of the driving task and not deliberate ignoring of speed signs, as drivers showed no evidence of attention loss in two other imposed tasks during the drive.

Approaches to encourage compliance are mostly linked to enforcement by police through financial or point-based penalties. Evidence shows that police enforcement produces lower and compliant speeds (Gayah et al, 2018) and even presence of police cars lowers speeds (Charlton and Starkey, 2016). Nevertheless, enforcement of speed limits is not entirely supported by the driving community. Surveys consistently show that a significant percentage of drivers view speed enforcement as revenue raising rather than making roads safer (eg., TAC, 2018; Mooren et al., 2013).

A focus mainly on reducing speed limits will always struggle to achieve compliance without significant effort to enforce vigorously although some newer approaches to speed management such as point-to-point speed cameras show promise in increasing compliance and reducing speeding and crashes (Soole et al., 2013). On the other hand, there is considerable research showing that lowered speeds can be produced with little or no enforcement if the speed limits are credible. The concept of self-explaining roads aims to provide this credibility though road layout and environment design (Theeuwes and Godthelp, 1995). This is a central element in the Dutch Sustainable Safety approach (Wegman, Dijkstra, Schermers, and van Vliet, 2005) which emphasises that speed limits must be consistent with road design and the environment to be functional, predictable for drivers and forgiving when crashes occur. This approach has been shown to be effective in reducing crashes in the Netherlands (Weijermars and Wegman, 2011) and reducing speeds in New Zealand (Charlton et al., 2010).

The credibility concept has been included in the road safety strategies of other countries like Australia, although in practice, the primary focus is strongly on setting lower speed limits. For example, the Australian government 2018 inquiry into road safety (Woolley and Crozier, 2018) recommended lowering urban speed limits to 30km/h and included using speed moderating installations where appropriate. A recent joint proposal to the Australian Government by peak road and public safety organisations argues for implementation of temporary speed limit reductions to 30km/h during the COVID-19 pandemic (Lea, Fogarty et al., 2020) with no mention of associated traffic calming treatments.

In summary, the problems for drivers in managing speed suggests that speed limits must be compatible with the characteristics of the road system and be credible. Road safety problems should not be solved by only reducing speed limits but must be accompanied by modifications to the road system such as traffic calming and self-explaining roads. These signal to drivers that a slower speed is needed and, even better, encourages them to do so as they naturally drive at lower speeds and do not require constant checking of speedometer. Slower speeds also have significant benefits for reducing crashes for vulnerable road users (Hussain et al., 2019).

Figure 1: Example of poor and confusing signage

Poor or inadequate road design

Confusing road signs

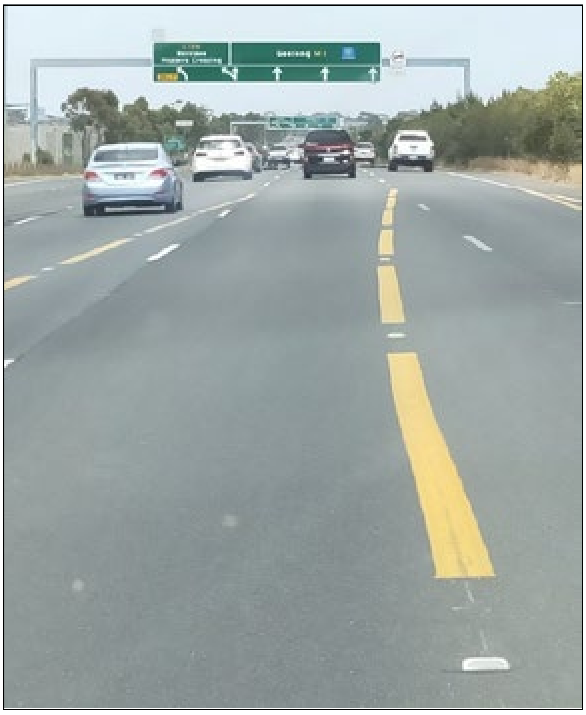
Signage that is too complex for a driver to understand in the short period available to process and react to its content will make safe behaviour very difficult for drivers (Ben-Bassat & Shinar, 2006). The problem is worse if the signage contains information about recent changes to the road system. Figure 1 shows an example of the problem of inadequate signage on a multilane arterial road in Sydney which failed to provide adequate direction to drivers about a change to a major interchange. Since late 1992, access to the M4 motorway westbound from Homebush Bay Drive was via a right-hand turn at traffic lights. In early 2017, after the widening of the M4, a new interchange introduced a G loop lead-on to the M4, but was now accessed from the left-hand lane of Homebush Bay Drive, almost opposite the previous right hand turn. The change was publicised through the media, but the only on-road warning of this change was the very complex sign shown in Figure 1 which was also placed very close to the exit. This sign also contains information about the new access, also by left-hand exit to the same M4 motorway, but eastbound. With the speed limit of 80kph in this section, there is little time for drivers to process this information as they pass the sign at around 22 metres per second. Even worse, drivers who, for more than 20 years, had accessed the M4 westbound using the right-lane, suddenly had to make three, very rapid and unsafe lane changes to access the correct left-lane, or overshoot the turn and then work out how to correct the problem. Drivers who attempt to correct course rather than miss the turnoff would be judged to be unsafe, negligent or even reckless rather than responding to a poorly designed section of road.

Within months of the opening of the M4 access, temporary bollards, then concrete barriers were erected to prevent drivers from making these risky lane-changes. The need to retrofit bollards and barriers is evidence of poor design and management of this change to the road system. A simple, low-cost solution would have informed drivers of the need to prepare for this change by providing more signage along the three to four kilometres of largely uncluttered road leading to the new M4 turnoff.

Guidance on road signage is very well-advanced and regularly updated. For example, the Australian Guide on traffic management devices (Austroads, 2020) calls for signs to be an adequate size and properly located so that drivers can read and act on the message, not be too complex in design and provide adequate warning of hazards or decision points. It also states that 'Signs or markings can seldom be used to solve problems caused by poor and confusing road geometry'. Given this acknowledgment by road safety authorities of the need for good design of road signage and markings, it is puzzling that such poor design is tolerated on our roadways. Even worse, that drivers' attempts to overcome poor signage are judged as driver risk-taking or error if these attempts have adverse safety consequences.

Confusing lane markings

There are multiple other examples of poor road design that confuse or make it difficult for drivers to behave safely. An example is displayed in Figure 2 where normal white lane markings have been overlaid by temporary yellow lane markings because of the demands of road construction or maintenance. Yellow lines are added as a less costly option to resealing the road (IPWEA, 2012). The problem exists where older, white markings are left in place and



Source: Wayne Taylor, Herald Sun, 13 September, 2017

Figure 2: Example of confusing lane markings

newer yellow markings are added. Despite signage to direct drivers to follow the yellow lines, the situation can be very confusing to drivers especially where they miss noticing the sign. This increases the changes that drivers inadvertently follow the wrong lane markings, causing unnecessary uncertainty and misunderstanding between drivers. Again, this should not be judged as a driver error, rather it occurs as a result of poor lane marking on roads. The solution is clearly to avoid confusing lane markings.

High visual clutter and complexity in driving environments

The driving environment is often highly complex as shown in the example in Figure 3. Areas of competing road activities such as the one shown, with moving cars, parked cars, trams, bicycle lanes and pedestrians are very common in our urban road systems. There is evidence of increased crash risk on roads with on-street parking compared to similar roads without it (Griebe, 2003) and of behavioural change by drivers in more complex road environments (Edquist, Rudin-Brown and Lenne, 2012). Drivers compensated for the more challenging road environment by slowing speed and moving closer to the centre of the lane, but this was not sufficient to avoid increased crash risk. Other studies also showed that complex road environments increase cognitive demand on drivers and require considerably more attentional resources (eg., Pratten et al., 2004; Stinchcombe and Gagnon, 2010).

In environments such as shown in Figure 3, therefore, the potential is very high for drivers to miss out on important elements such as a pedestrian or cyclist wearing dark clothing, or a lower speed zone sign. In these driving environments where drivers are expected to pick out specific or important information, driver behaviour will often not be perfect and consequently may not be safe. It will certainly also have adverse consequences for vulnerable road users. Again, this failure should not be attributed to driver error, rather it is a consequence of inadequate design of the road system. A primary solution to this problem is to avoid road environments like this through separation of road uses such as only allowing off-street parking, separating all types of vehicles by separating car, tram and bicycle lanes and separating pedestrian traffic.

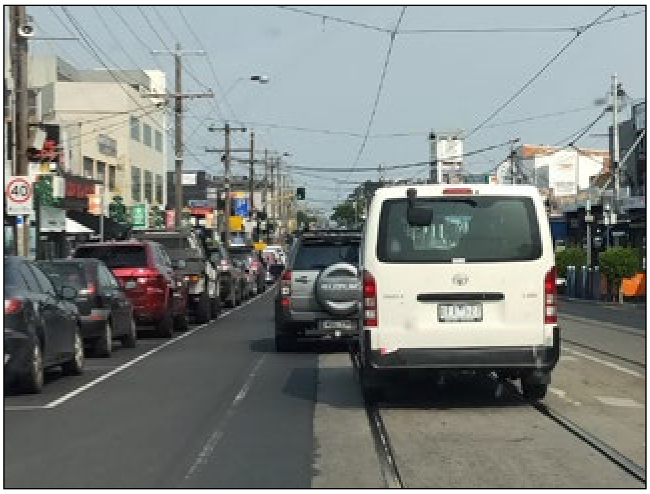


Figure 3: Example of high visual clutter and complexity in the road environment

Figure 4: Example of poor visibility from vehicles showing pedestrian standing close to the vehicle is completely obscured by the A pillar

These three examples show that even when the foundations of good, safe, human-user centred road design are available in principle, such as for signage, they often do not appear in use. If the prevailing road safety philosophy assumes that driver and road user errors are inevitable, it is perhaps not surprising that this situation is allowed to persist with little attempt to prevent errors.

Problems of vehicle design

Vision from vehicles

Modern car design is applauded as one of the contributors to a safer road system. Certainly, improved crashworthiness of vehicles has helped to reduce the severity of crashes and likelihood of fatalities (Glassbrenner, 2012). On the other hand, some aspects of vehicle design, especially those relating to the driving task have not improved and some have even become poorer. Visibility from vehicles is a good example. Being able to see the road to the front and side are primary prerequisites for drivers to safely negotiate the road system. Even so, the view from the driver seat is often occluded to the front and side of the vehicle by wider A-pillars designed to accommodate airbags and to increase roof strength and to the front by higher and more crashworthy vehicle fronts for vehicles with shorter front crumple zones such as vans or people movers. The problem is that these design features can restrict driver vision of important road features such as pedestrians, cyclists and road signs (see Figure 4). This effect is most pronounced in larger vehicles such as trucks (Kim, Ulfarsson, Shankar et al, 2010) and emergency vehicles (Hsaio, Change, Simeonov, 2014). An analysis of

Figure 5: Example of the false visual information from convex side mirrors

fatal crashes involving pedestrians and trucks in the USA (Retting, 1993), for example, highlighted the problem of increased pedestrian safety risk due to poor visibility from trucks and called for better design of truck cabs to enhance the drivers forward field of view. Despite this, there has been little change in truck design since then. A search of the literature could locate no studies of the influence of poor vision from smaller vehicles like cars on crash risk despite obvious problems of vision in car design as shown in Figure 4. Ignoring this potential problem means poor vision from vehicles is highly unlikely to be acknowledged as a reason for drivers failing to see and respond to pedestrians so will not be solved, again increasing pedestrian injury risk. The problem is unlikely to be solved until its evidence is acknowledged.

Side mirrors

Another example of vision problems in vehicles is the design of sidemirrors. Many vehicles now have convex mirrors on the passenger and driver side of the vehicle. These mirrors are promoted as safety features that reduce the blind spot to vehicles approaching from the rear in the adjacent lane by providing a wider field of view. The problem is that the convexity of the mirror also gives false information about the distance from the vehicle coming up behind in the adjacent lane as they appear smaller than they actually are. This means that drivers will overestimate the time they have to safely move into the overtaking or adjacent lane and so increase the risk of crashes. Drivers appear to be able to adapt to this false information as they become more experienced with it (Hahnel and Hecht, 2012), but are unlikely to do so in circumstances of haste, stress or fatigue when safety risk for overtaking and lane changing will be high. Despite this evidence, there has been no analysis of the role of convex mirrors in these types of crashes, and again, this would just be attributed to driver error. The problem of convex sidemirrors has been acknowledged in Australia (eg., RACV, 2016) and there is debate around the world on whether convex mirrors should be used in vehicles. Yet they are still included as standard in many vehicles and are permitted in Europe, sometimes with a warning on the mirror that 'Objects in mirror are closer than they appear', a solution unlikely to be effective. Why do we include features in vehicles that make safe behaviour harder for drivers and increase crash risk?

Technology in vehicles

New technologies are being added to vehicles on the premise that they assist or even replace drivers and so prevent driver error. Unfortunately, the claims of benefits for many technologies are only partially supported by research evidence. There are many examples, some emerging in prototype vehicles and others already in standard vehicles.

For example, Visibility Enhancement Systems (VES) are promoted as positive safety features as they selectively enhance features of the roadway to drivers especially under conditions of low visibility. Evaluation of these systems shows that when using VES, drivers reported greater confidence and less stress but, contrary to conventional wisdom, reaction time to objects is slowed and collisions increased (Sharfi and Shinar, 2014). As these authors point out, the safety benefits of new technologies cannot be assumed and that they must be evaluated before being used on-road.

Another example is cruise control and adaptive cruise control. These technologies have been standard in vehicles for some years. Yet multiple studies show consistently that cruise control and adaptive cruise control significantly slow driver reaction times in emergency situations when drivers are required to take-over, and speedy responses are most needed (eg., Vollrath, Schleicher and Gelau, 2011; Pauwelussen and Feenstra, 2010; Piccinini Rodrigues et al., 2014; Jammes, Behr et al, 2017). These findings of increased crash risk when drivers return to manual control of speed, are rarely acknowledged by road safety authorities and drivers are not educated on this adverse side-effect of using this technology. Experience using cruise control reduces the higher crash risk (Larsson, Kircher and Hultgren, 2014), but it takes around 400km of driving experience to know and understand adaptive cruise control (Hynd et al., 2015). This means that even if drivers do get used to this technology, there is a significant period of higher safety risk involving slow responses to unexpected events and we do not know how drivers cope with this technology in times of pressure.

This problem is even more pronounced with newer automated driving technologies that partially or fully take over control of aspects of the driving task. Growing evidence on transitions from autonomous to manual driving control when automation requests it or where it fails, indicates a period of high safety risk. Multiple studies show that drivers need at least two to five seconds to regain initial control (see Vogelpohl, Kuhn et al, 2018 for review) and that stable control only returns 35 to 40 seconds after disengagement (Merat, Jamson, Lai et al, 2014). Even in takeovers that were not time-critical, takeover time was not affected but the quality of driving deteriorated in terms of poorer lane-keeping performance (Zeeb, Buchner and Schrauf, 2016). In the time to transfer control the vehicle can cover significant distances and many events can be missed. Again, these failures should not be regarded as driver errors as they occur due to poor design and implementation of a supposedly assistive technology. Transition of vehicle control is a major concern for automation that must be addressed before automated technology is allowed in vehicles on-road.

Many in-vehicle technologies operate by auditory warnings to drivers of a hazard while driving, including front and rear obstacles, blind spot, lane departure or speeding. While it might be assumed that drivers would benefit from

Table 1. Principles of the Safe System philosophy used in the National Road Safety Strategy 2011-2020 and the proposed Expanded principles of Safe System philosophy to include human-user-centric values.

	Current Australian Safe System principles (National Road Safety Strategy 2011-2020)	**ITF/OECD Safe System guiding principles (2016)**	**Expanded Safe System principles to include human-user centric values**
Objective	The transport system should not result in death or serious injury as a consequence of errors on the roads.	The design and operation of the road transport system should guide the road user to safe behaviour and mitigate the consequences of common human errors.	The transport system should not result in death or serious injury on the roads.
Principle 1	**People make mistakes.** Humans will continue to make mistakes, and the transport system must accommodate these.	**People make mistakes** that can lead to road crashes.	**A Safe System is designed to be easy for humans to use**. People make mistakes for many reasons. In designing roads, environments, vehicles and road rules, we need to design for human capabilities and limitations to avoid increased likelihood of road-user error.
Principle 2	**Human physical frailty.** There are known physical limits to the amount of force our bodies can take before we are injured.	**The human body has a limited physical ability to tolerate crash forces** before harm occurs.	**Human physical frailty.** There are known physical limits to the amount of force our bodies can take before we are injured.
Principle 3	**A 'forgiving' road transport system.** A Safe System ensures that the forces in collisions do not exceed the limits of human tolerance. Speeds must be managed so that humans are not exposed to impact forces beyond their physical tolerance. System designers and operators need to take into account the limits of the human body in designing and maintaining roads, vehicles and speeds.	**A shared responsibility** exists amongst those who design, build, manage and use roads and vehicles and provide post-crash care to prevent crashes resulting in serious injury or death	**A shared responsibility** exists amongst those who design, build, manage and use roads and vehicles to prevent road-user errors where possible and provide post-crash care to prevent crashes resulting in serious injury or death
Principle 4		All parts of the system must be strengthened to multiply their effects; and if one part fails road users are still protected.	**Encourage resilience of system solutions so if one part fails, road users are still protected.**

extra inputs about hazards, the sensors often lack precision with many false alarms, are redundant as they do not provide new information to the driver and just increase driver irritation (eg., Varhelyi, Kaufmann and Persson, 2015). Given a choice, many drivers would not continue to use them (Thompson, MacKenzie et al., 2018) as shown from survey of drivers who had trialed Intelligent Speed Adaptation technology.

The common problem with new technologies is that they are assumed to be assistive and safer and are introduced into vehicles on that basis alone. Evaluation of effectiveness focusses only on demonstrating that the technology works as intended and does not include how drivers interact with it in use. Drivers often report finding these technologies useful and use them willingly but may not be aware of their limitations. Despite good evidence of poor design or implementation, such as take-over problems for cruise control and autonomous control, little or no attempts are made to correct them and their potential role in causing crashes is either ignored or attributed to driver error. It seems that we are far more prepared to attribute crashes where a driver misses a pedestrian due to a large "A" pillar or overtakes into the path of a vehicle in the next lane due to the false information provided by their convex side mirror, as a fault of the driver not looking carefully or risky driving, rather than acknowledging that design of the vehicle makes it extremely difficult if not impossible to obtain the information drivers need to be safe. To improve safety on our roads, vehicle design including all new technologies must become more driver and road-user focussed.

An expanded version of Safe System for road safety

This paper describes a few examples of poor road system design that make safe behaviour difficult for drivers and increase the likelihood of crashes involving them and often vulnerable road users as well. If we are serious about road safety, we cannot continue to ignore these problems and must take active steps to solve them. A first step must be to amend the concept of Safe System for road safety and expand it to include prevention of road-user error through better human-user centred system design. Table 1 contrasts the current safe system philosophy used in Australia and that included in the most recent ITF/OECD report (2016) and proposes amendments to become more human-user centric. Note that the primary proposed change is to the first principle of the Safe System philosophy advocated by both OECD and Australia; that errors are inevitable. The proposed approach instead calls for this principle to encourage better usability of the road system through action to prevent road-user errors caused by poor system design.

Like the other two approaches, the proposal retains the second principle that acknowledges the physical frailty of human-users of the road system. The third principle in both Australian and ITF approaches emphasises crash mitigation that limits the level of injury to road-users, but the ITF also accentuates the shared responsibility of all road system partners in doing so. The proposed approach builds on the ITF version by incorporating shared responsibilities but expands it again by calling for the responsibility to extend to prevention of road-user error as well. Unlike the Australian version, the ITF also included a fourth principle that relates to creation of resilience in the road system such that if one element of the system fails, others will protect. This calls up concepts of resilience which have been used to describe the maintenance of safety in general (eg., Woods et al.,2012) and in the road system (eg., Van der Horst, 2012) through ensuring that failures of one part of the system do not result in crashes. To reflect this broader foundation, the proposed fourth principle includes this concept.

Conclusions

We need to expand the focus of road safety to take account of the needs of road users. There is little point in implementing poorly designed elements of the road system and simply calling it error when road users are unable to compensate for it. We should not be implementing strategies and practices that make safe behaviour more difficult for road users. Rather than road user error being inevitable and to be forgiven through making vehicles and infrastructure more crashworthy, focus needs change to include reduction or prevention of error in the first place in addition to minimising the effects of errors if they cannot be prevented. There are multiple examples of poor road system elements that make it difficult for road users to behave safely and, with the advent of new technologies in vehicles, this is becoming more evident. We are ignoring evidence that many strategies and practices in use, even those based on the Safe System approach, create problems for users and reduce the likelihood of improving safety.

The traditional targets for improving road safety of engineering, education and enforcement are necessary strategies to improved road safety, but they are not sufficient. These alone will not address the problem of crashes for road safety because they are not adequately addressing road user behaviour. Engineering approaches to roads and vehicles must incorporate good human-user centred design. This means implementing good ergonomic design that considers human information processing principles and stereotypes in the way humans behave naturally and expect the world around them to behave. While education is essential to ensure that road users are aware of important attributes of their road system, it should not be expected to be enough to produce changed behaviour. Similarly, rules and enforcement can be effective for behaviour change but if handled poorly have unintended consequences. Rather than changing behaviour permanently, it can produce only temporary compliance and lack support from road-users, resulting in an endless spiral of ever-increasing penalties. Better approaches are to make the targeted behaviour consistent with the preferred, natural response of drivers, such as limiting speed on self-explaining roads and encouraging driver perceptions of the risk of not doing so.

Humans can learn and adapt or compensate for poor design in the road system. This is almost certainly why we don't have more crashes, but in all of these examples where the road system is not designed to accommodate human behaviour, the risks that road-users do not cope with the challenging conditions increases, behaviour becomes less safe and crashes more likely. The point in this paper is not that the Safe System approach is contributing to failures, but that the approach is missing opportunities to reduce road user errors where they occur due to elements in the system that do not acknowledge the human user. Not all road user errors occur due to poor usability (eg., factors like driver impairment) but a substantial proportion do. Making the road system more usable will enhance safe system by making user errors far less likely. We are missing an enormous opportunity to improve road safety by ignoring the interaction of the human road user elements in the system with other parts of the system. At a time when we are making too little progress in reducing the number of people killed and seriously injured on our roads, this is an opportunity to do better.

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

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Key Findings

- Historical safety metrics in the tendering process are typically based on a minimum compliance model, which may encourage improving other performance areas to the detriment of safety.
- Use of Safe System Assessment Framework provides a quantified assessment of safety which can be used as a Key Performance Indicator to encourage prioritisation of safety outcomes in conjunction with other performance targets.
- The project data provided valuable insights into aspects of current road design that achieved greatest conformance with Safe System principles, and where gaps still lie. The greatest risks in the project suite related to large complex intersections in high speed environments (findings based on over 100 Safe System Assessments undertaken as part of this project).
- Breaking down project designs into homogeneous sections or stereotypes when undertaking a Safe System Assessment provides a greater level of understanding of road safety risk associated with different aspects of designs within and across projects.

Abstract

As part of the Northern and South-Eastern Suburban Roads Upgrade packages, Major Road Projects Victoria has sought to incorporate road safety metrics into the tender designs review process. The Australian Road Research Board adapted the Safe System Assessment Framework (Austroads 2016) to meet this need. Twelve road projects were assessed to provide baselines scores for the reference designs. The submitted tender designs will then be reassessed to provide an assessment of road safety in the designs. This work provided an extension in use of Safe System Assessment Framework as well as insight into current gaps in road safety design practice.

Keywords

Safe System, Key Performance Indicator, Safe System Infrastructure, Safe System Assessment Framework

Glossary

KPI – Key Performance Indicator

MRPV – Major Road Projects Victoria

SSA – Safe System Assessment

SSAF – Safe System Assessment Framework

Reference design – Baseline designs prepared by MRPV that formed the basis of the tenderer's design responses (see Tenderer's Design).

Tenderer's design – The tenderer's design response to the reference design.

Introduction

Major Road Projects Victoria (MRPV) are implementing a suite of outer suburban arterial road upgrade (SRU) projects transforming the arterial road network across Melbourne. The projects are to be undertaken via public private partnership (PPP) and involve an investment of over $2 billion by the state government.

As part of the PPP arrangement the projects are to be put out to competitive tender. To ensure that safety was not sacrificed to achieve other performance targets it was desirable to incorporate a safety Key Performance Indicator (KPI) — or KPIs — into the tender assessment criterion. MRPV engaged the Australian Road Research Board (ARRB). To that end, the Australian Road Research Board (ARRB) developed a method for scoring each of the tweleve road projects included in the SRU program using the Safe System Assessment Framework (SSAF).

The Suburban Roads Upgrade Program

The Suburban Road upgrades program is a suite of road infrastructure upgrade projects being undertaken across Melbourne. The program consisted of three works packages based on geographical location known as the 'western', 'northern' and 'south-eastern' packages. Each of the packages were advertised for competitive public tender to be designed, constructed and maintained under a PPP arrangement.

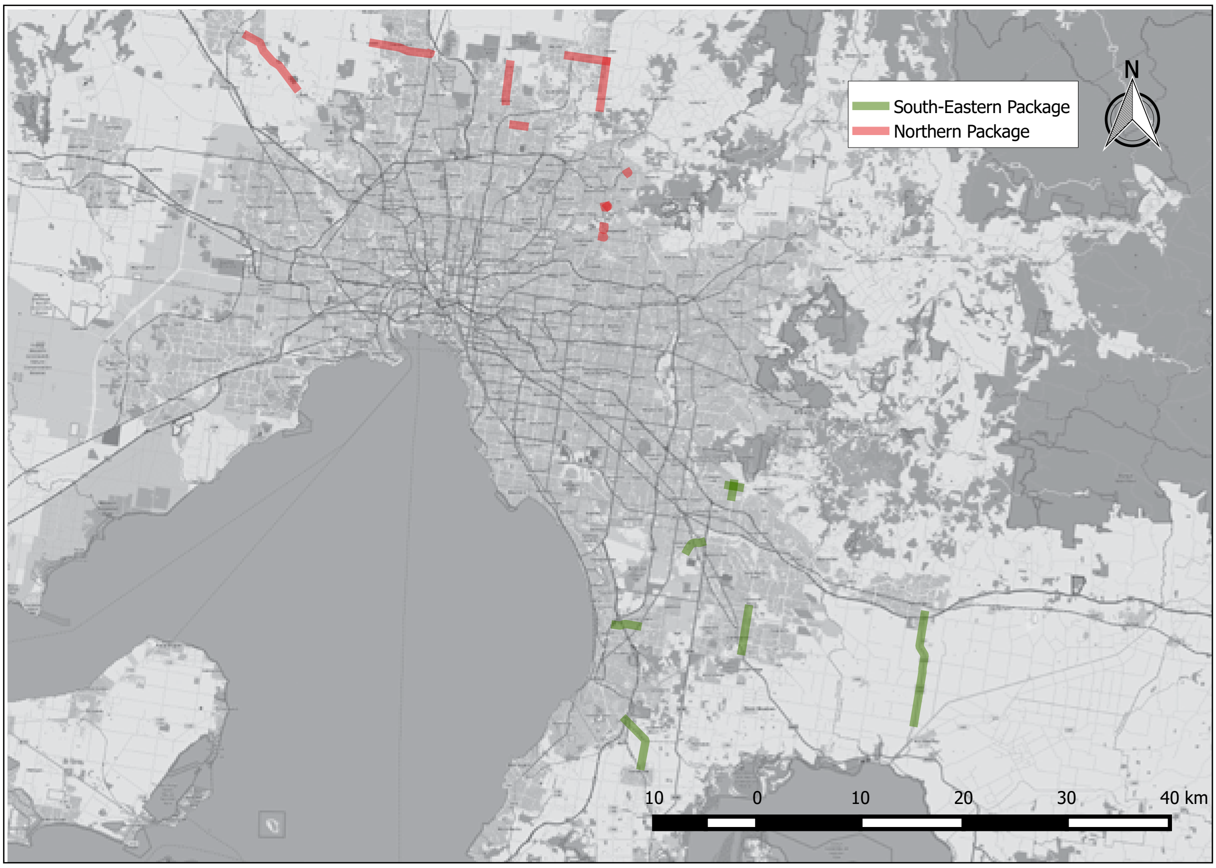
As part of this work, SSA were undertaken for the northern and south-eastern packages consisting of twelve road projects. These were, from the northern package:

- Childs Road, from Beaumont Crescent to Prince of Wales Avenue, Mill Park;
- Craigieburn Road, from Mickleham Road to the Hume Highway, Craigieburn;
- Epping Road, from Craigieburn Road East to Memorial Avenue, Epping;
- Fitzsimons Lane, consisting of various intersection upgrades in Eltham and Templestowe,
- Sunbury Road, from Bulla-Diggers Rest Road to Powlett Street, Sunbury;
- Yan Yean Road from Bridge Inn Road to Heard Avenue, and
- Bridge Inn Road, from Plenty Road to Yan Yean Road, Doreen.

From the south-eastern package:

- Golf Links Road, from Peninsula Link to Baxter-Tooradin Road, and Grant Road, from Baxter-Tooradin Road to Frankston-Flinders Road, Langwarrin South;
- Healesville – Koo Wee Rup Road, from Princes Freeway to Manks Road, Pakenham South;
- Hallam North Road, from Heatherton Road to James Cook Drive, Endeavour Hills;
- Lathams Road, from Oliphant Way to Frankston-Dandenong Road, Seaford;
- Narre Warren – Cranbourne Road, from Thompsons Road to the South Gippsland Highway, Cranbourne; and
- Pound Road West, with a new bridge over Cranbourne rail line to connect to Remington Drive, Dandenong South.

The majority of the roads within both project suites are dual carriageways with signals the most common control type for significant intersections. The locations of the works are shown in Figure 1.



Fgure 1. Northern and South-Easter Package Locations (Base map source: OpenStreetMap)

Safety in the Tendering Process

Given the long term nature of a Public Private Partnership (PPP) procurement model it is essential to ensure that safety outcomes are appropriately addressed in the contractual agreement. Also, while it is tempting to rely purely on performance based measures (i.e. injuries and deaths) there are drawbacks with this from both the public and private perspectives. Relying on a pattern of crashes is a reactive measure to assessing road safety as it relies on addressing road trauma after it occurs and often focuses thinking on localised issues and treatments rather than taking a network wide view. For tenderers there may be concerns about contractual penalties for road trauma that is due to systemic (or other) factors beyond their direct control.

Adopting an infrastructure focussed, lead indicator will help ensure a best practice approach to reducing the likelihood that a road user will experience trauma. It is important to be able to quantifiably measure and compare the relative performance of a range of road designs as part of the tender evaluation process. Use of the Safe System Assessment Framework presented an opportunity to quantify road safety risk within the tender process so as that a comparison of competitive tenders safety performance could be made against contractual requirements.

Methodology

This section introduces the Safe System Assessment Framework approach and outlines how it was used as a Key Performance Indicator into the tender assessment criterion for the project suite.

The Safe System Assessment Framework

The underlying principle of the Safe System is that humans are fallible, and sooner or later mistakes (and hence crashes) will happen. When they do, the system should be designed so as that a fatal or serious injury outcome does not occur.

The Safe System Assessment Framework (SSAF) is a practitioner assessment tool to assist in the methodical consideration of Safe System objectives in road infrastructure projects. The tool was developed by ARRB and contributing partners for Austroads (2016) to ensure Safe System objectives are met by prompting consideration of a number of key crash types that most commonly result in death or serious injury on our roads. The crash types addressed by the SSAF are:

- Run-off-road (ROR)
- Head-on (HO)
- Intersection (INT)
- Other (any other crash type considered relevant, typically including rear-end/side-swipe)
- Pedestrian (PED)
- Cyclist
- Motorcyclist (M/C)

For each crash type, the three components that constitute risk are assessed. These components are the exposure (generally synonymous with volume of traffic), the likelihood (how likely that a crash would occur given the infrastructure and other local considerations) and the severity (in the event that a crash does occur, how likely is it someone will be killed or seriously injured). Each of these risk components are scored out of 4 (with half scores permissible) for each crash type and multiplied to provide a maximum score of 64. Multiplication is used as it demonstrates how a hazard can be effectively eliminated by removing any of the three risk components (i.e. it is given a zero score). The crash types are then summed for a maximum score of 448 for a design.

The assessments that were undertaken for this project were an extended rapid SSA that has been conducted in accordance with VicRoads Safe System Assessment template (VicRoads 2018) and Austroads Safe System Assessment Framework (Austroads 2016). An example of how to undertake a Safe System Assessment is given in the Austroads guidance.

Assessment Scope

The focus of the assessments were reference designs prepared by MRPV as part of the request for tender documentation. No assessment of existing conditions was made as the intent was to provide insight into the safety performance of the reference designs rather than to make comment on existing conditions. This establishes a baseline level of safety against which the tenderer's designs can be compared and presents the opportunity for tenderers to focus their efforts on the elements of the reference designs where the greatest safety performance improvements are likely to be gained.

Given the scale of the projects, providing a single assessment was not considered appropriate as it would not provide an adequate level of granularity to allow for the easy identification of specific risks. As such, the projects were broken down into homogenous stereotypes, each of which were individually assessed. The identification of what constituted a different stereotype for a project was based on assessor judgement with key considerations including not only the design of the infrastructure but also factors such as adjacent land use. Some of the key considerations included, for midblock stereotypes:

- Road cross-section (number and widths of lanes, presence of a median, road-side barriers etc.).

- Road geometry (horizontal and vertical alignment).
- Adjacent land use (residential vs industrial, presence of schools or aged care facitilies etc.).
- Access control (whether properties have direct access to the road, frequency and nature of side road intersections).
- Speed (both speed limit and design speed).

And for intersections:

- Intersection type (signalised, roundabout, uncontrolled etc.).
- Size (number of lanes and lane width).
- Presence of slip lanes.
- Geometry (alignment of approaches both vertical and horizontal etc.).
- Proximity to other other intersections.
- Adjacent land use.
- Speed (both speed limit and design speed).

As these are transformative projects often on the urban fringe, it was also key that the assessment considered the future use of the road; it is anticipated that there will be considerable changes over the life of infrastructure. Much of the adjacent land for a number of the projects was noted to be undeveloped. As this land is developed the manner in which in interacts with the road environment will change, most notably, higher intensity land use will bring more road users to the area. The projects themselves are also expected to change road user behavior. An example of this is the construction of cycling facilities where there were none previously, which is expected to increase cyclist numbers in the area.

To help account for these anticipated future changes , the assessors drew upon Movement and Place assessments that had been undertaken for each of the roads within the project area. The Movement and Place classifications had been developed with the project upgrades in-mind and as such provided insights into the types of future activity expected on the roads based on the road's functional classification within the Movement and Place framework. It is noted that the VicRoads Movement and Place Framework provides classifications by mode, demonstrating a road's strategic importance as a freight, bus or cycling link. This information was supplemented by current and predicted traffic volumes, as available, and in the case of cyclists, whether the road formed part of the current or proposed Principal Bicycle Network (the principal bicycle network is a bicycle infrastructure planning tool used in Victoria that identifies existing and proposed bicycle infrastructure).

The assessments were undertaken by ARRB staff over a period of three months in early 2019 with MRPV staff joining the assessment team on a number of projects to provide additional localized knowledge.

A comparative metric

The intended use of the assessment scores was to provide a safety comparison between baseline reference designs and tenderer's submitted designs to allow for an assessment of safety performance to be built into the tendering process. As such, the final metric used for the comparison needed to be flexible enough to account for the fact that a tender design may vary substantially enough from the reference design to change both the number and types of stereotypes defined for the project. For instance, if the baseline reference design has a single homogeneous midblock stereotype and the tenderer decided to improve a key cycling route by introducing an off-road cycle path for path of that length — reducing cyclist risk — this would introduce a second stereotype. As it was not considered appropriate to compare these two 'new' stereotypes to the single stereotype in the reference design, an overall project score was needed in order to provide a comparative metric between baseline and tender designs.

Several methods for calculating the project score were considered. The first was a simple average of the scores of like elements (midblocks and intersections), however this was considered too simplistic as it did not consider the relative exposure to each of the stereotypes. Returning to the above example with the cycle path, if the path is only introduced only for a 500m section of a 5km road, a simple average would weight the cycle path stereotype too highly. In addition to not providing a realistic reflection of total risk, this method could be easily 'gamed' by making substantial improvements to a small section of the project.

A simple total was also considered, where the score for each stereotype is summed to form a total score, but the potential for the number of stereotypes to change made this problematic. Again, returning the cycle path example, the addition of a second stereotype would have the potential to double the final score for the same length of road, which again, would not provide a realistic reflection of the risk.

More complex methodologies using volumes to weight road user exposure to the different stereotypes were also considered, however was also not considered appropriate. As exposure is already a key input into the undertaking of SSAs, weighting the scores by volume would count road user exposure twice in the final score.

Ultimately, it was decided that a weighted average would be the best approach. This was done through the calculation of a weighted average of like elements (midblocks and intersections) with the (1) total length of midblock and (2) the number of intersections used for the weighting. This allowed for overall average midblock and intersection scores to be calculated which were in turn averaged to provide the final score, termed the 'total baseline SSA score', for each project design. An example of this scoring process is shown in Table 1.

Table 1. Example Total Baseline SSA Score Calculation

Stereotype	Extent	Key Crash Risk Scores							Total Risk Score per stereotype	Mid-block / Int average	Total baseline SSA score
		ROR	HO	Int	Other	Ped	Cyclist	M/C			
Midblock Type 1	0.5 km	4/64	0/64	48/64	24/64	32/64	48/64	40/64	278/448	181/448	208/448
Midblock Type 2	3.3 km	12/64	0/64	24/64	30/64	20/64	40/64	40/64	166/448		
Intersection Type 1	1	6/64	4/64	40/64	16/64	24/64	32/64	40/64	162/448	235/448	
Intersection Type 2	1	12/64	6/64	56/64	32/64	40/64	48/64	48/64	242/448		
Intersection Type 3	2	12/64	12/64	48/64	36/64	36/64	40/64	40/64	224/448		
Intersection Type 4	1	10/64	12/64	64/64	42/64	56/64	56/64	40/64	280/448		
Intersection Type 5	1	8/64	12/64	64/64	42/64	56/64	56/64	40/64	278/448		

For this example, there were two midblock stereotypes, dubbed 'Midblock 1' and 'Midblock 2'. Midblock 2 was considerably longer than Midblock 1 (3.3km vs 0.5km) and as such was weighted proportionally as follows:

$$\frac{Extent_{MB1} \times Total\ Risk_{MB1} + Extent_{MB2} \times Total\ Risk_{MB2}}{Extent_{MB1} + Extent_{MB2}}$$
$$= \frac{0.5km \times 278 + 3.3km \times 166}{0.5km + 3.3km}$$
$$=181$$

The same approach was taken for the intersections, with the 'extent' being the number of intersections present for that particular stereotype. For instance, in this example there were two intersections contained within Intersection Type 3 as opposed to one for the others. As such, Intersection Type 3 would be weighted twice as heavily.

By determining an overall score of this nature, flexibility is allowed in the comparison of the designs. Risk may increase, compared to the baseline design, for some aspects and/or stereotypes of a tenderer's design, but this can be offset by safety improvements elsewhere in the design.

Applications in Tendering Process

Historically, road safety requirements within PPP projects have typically been based on a compliance model. For example, stating the proposed designs must be in accordance with the relevant standards and guidelines. If this is so, it is considered 'safe' for the purposes of the contract. In practice, this approach is essentially a pass/fail and no weighting is given to designs providing a higher degree of safety. This is not in line with the current Safe System and 'Vision Zero' philosophy of eliminating fatal and serious road trauma by 2050. Indeed, the historical approach may encourage tenderers to provide less safe designs if it means improving the score on a quantified metric — such as traffic capacity — provided the minimum levels of compliance are met. Some additional contract components may be included, such as financial penalties for poor crash performance post-construction, but these are, at best, reactive measures.

The use of the SSAF supports prioritisation of safety, and the Safe System alignment of designs by providing a quantified measure of safety. In the case of this suite of projects, the requirement was that all tender designs were encouraged to achieve an SSA score better than the baseline designs with poorer results in the SSA score considered a design weakness. This approach encourages tenderes to maintain or improve safety in the design. The proactive nature of the assessment also allows for changes in the design to be made when it is most cost effective to do so – i.e. without any abortive works - and without relying on reactive safety indicators such as crash history.

Results and Discussion

Although the project's key focus was to produce metrics to compare the road safety performance of different tender designs to baseline designs, a useful by-product was that a large amount of data on Safe System conformance of designs was accumulated. This has provided valuable insight into the aspects of current road design where greatest conformance with Safe System principles has been achieved, and where gaps still lie. The authors note that the use of the Safe System Assessment Framework is a relatively new approach, and in particular practitioners use and application of the approach is varied and evolving. The approach and observations outlined below are based on the authors' experience.

Use as a Key Performance Indicator

This paper presents a method that was developed for using the Safe System Assessment Framework as a Key Performance Indicator in the review of road design options. In this instance, the total weighted average scores were used, as it allowed for a flexible, holistic view of the safety performance of the project – but it is by no means the only way the framework can be used. Due to the level of disaggregation between crash types, any of the assessed scores could be used as a measure of safety performance. For instance, the pedestrian and cyclist scores could be used for a vulnerable road user project to provide particular emphasis on these types of user groups. This flexibility allows this method to be applied in a variety of manners to incentivise the achievement of safety objectives of any given road project. The next step would be a review and evaluation of the tenderer's submitted designs in order to assess the methodology's effectiveness in encouraging safer designs.

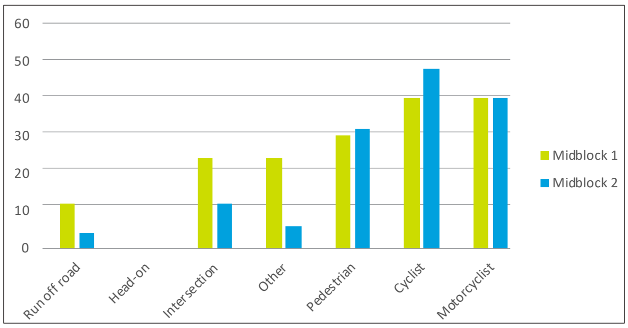


Figure 2. Midblock Stereotypes – Epping Road Example

Use of Stereotypes

The use of stereotypes in the undertaking of the assessments proved to be essential to providing a useful indication of crash risk within projects, as the characteristics of the road can vary substantially across the project length. An example of this is given in Figure 2 from the assessment of the two midblock stereotypes for the Epping Road project. Both midblock stereotypes consisted of very similar stereotypes; both were dual carriageways with road-side and median safety barriers provided. As they were contiguous sections of road, the AADT was also expected to be similar.

A key difference between the two sections was the speed limit; the speed limit for Midblock 1 was 80km/h compared to 60km/h for Midblock 2. This lead to higher risk of 'run-off-road', 'intersection' and 'other' related crashes. Perhaps counterintuitively, the pedestrian and cyclist risk was assessed to be higher in the lower speed environment. This was due to a higher intensity of land use in the vicinity of Midblock 2 — including a shopping precinct — which meant anticipated pedestrian exposure was higher and that fact that off-road cycling facilities were included in the design for Midblock 1, while Midblock 2 featured on-road, non-segregated facilities.

Table 2. Assessed crash risk components by intersection and crash type

	Exposure			**Likelihood**			**Severity**		
	X-Int	**T-Int**	**Rndabt**	**X-Int**	**T-Int**	**Rndabt**	**X-Int**	**T-Int**	**Rndabt**
ROR	4	4	3.75	2.34	2.23	2.5	1.05	1.13	1.13
HO	4	4	3.75	1.57	1.02	0.81	1.75	1.67	1
Int	4	4	3.75	3.7	3.02	1.56	4	3.79	2.06
Other	4	4	3.75	3.5	3.02	2.88	2.93	2.67	1.63
Ped	3.21	3.04	2.13	3.16	2.31	2.06	4	3.96	3.19
Cyclist	3.64	3.29	2.38	3.23	2.38	1.75	4	3.98	3.25
M/C	4	4	3.75	2.73	2.75	2.88	4	4	4
Total	26.85	26.33	23.02	20.23	16.73	14.44	21.73	21.2	16.26

These kinds of details would not have been adequately quantified if only providing a project level assessment.

It is noted that the use of the term 'stereotypes' is perhaps misleading in this context, as it implies only a high-level assessment of standard designs, without consideration of the site-specific details or design variances which were assessed in this work. Future applications of the SSAF in this way may benefit from alternative terminology such as 'sections' which may be more appropriate however for the purposes of this work the discrepancy is considered innocuous.

Safe System Alignment of Midblocks vs Intersections

There were a total of 29 midblock and 73 intersection stereotype variations across the suite of projects. The average risk score recorded for midblocks was 158 compared to 205 for intersections out of a maximum risk score of 448. This higher risk, on average, at intersections compared to midblocks aligns with current understanding for the potential for high severity crashes due to the typical collision forces and impact angles at intersections.

Midblock Features

Three general types of midblock were observed within the project suite these were dual carriageways (21 stereotypes), single carriageways (5 stereotypes) and service roads (3 stereotypes).

Service roads were assessed to be of lowest risk with an average risk score of 80/448. This was largely due to their lower speed limit — 50km/h in all cases — limiting both the likelihood of all crash types and the severity of all non-vulnerable road user crash types (noting the Safe System speed for vulnerable road users is 30km/h). In many cases, service roads were also one-way; reducing the number of possible conflicts.

Somewhat counter-intuitively, single carriageways were assessed to be of lower risk on average than dual carriageways (105 vs 151). On closer inspection however, this was due to four of the five single carriageway stereotypes occurring on lower volume roads with little to no pedestrian and cycling activity. This mitigated the risk by reducing exposure scores across all crash types, with very low exposure for pedestrian and cycling crashes. It is noted that the one high-volume single carriageway stereotype recorded the third highest midblock risk score which was again partially mitigated by low pedestrian and cyclist numbers.

Common midblock design features included excellent access control (majority of minor road access points were left-in/left-out only and often via a service road), divided carriageways and use of wire rope safety barriers. This was effective in reducing the risk associated with the intersection, head-on and run-off-road type crashes in particular (intersection risk in the midblock environment was typically associated with left-in/left-out arrangements of lower order local roads and property accesses that did not warrant their own intersection stereotype). The way in which these risks were managed is also a good demonstration of how risk can be reduced overall by managing any of the three risk components; exposure, likelihood and severity. Head-on risk may be managed by reducing or in some instances virtually eliminating the likelihood of a head-on crash by separating the opposing traffic streams with a median and wire rope safety barrier (thereby managing likelihood). In the case of run-off-road crashes, where roadside wire rope safety barriers are present the likelihood of a crash occurring remains unchanged (as a vehicle can still run off the road) however in the event one does occur the WRSB will help manage the kinetic energy of the impact such that the opportunity for an FSI outcome is reduced or eliminated (i.e. reducing severity).

Intersection Features

There were a number of variations in intersection stereotypes in the project suite, however by far the most common were signalized intersections (52 of the 73 intersection stereotypes), consisting of 28 cross- and 24 T-intersections. The majority of these were in an 80km/h speed limit environment (32 of 52) with the remaining 20 intersections split between 60 and 70km/h environments. Cross- and T-intersections were assessed as having the highest risk across any of the stereotypes in the project suite with average scores of 256 and 212 respectively, particularly in higher speed environments.

The primary drivers of risk for these intersection stereotypes related to intersection size and complexity(often featuring multiple through and turning lanes), high-speed environments and the potential for severe right-angle crashes. This resulted in high likelihood and severity scores across the majority of crash types, and a high overall SSA score.

Comparatively, roundabouts – of which there were six (6) stereotypes – were amongst the best performing stereotypes overall with an average SSA score of 97. The lower speeds, reduced number of conflict points and lower impact angles associated with roundabouts helped drive down both likelihood and severity of crashes at these locations. It was noted that one of the proposed roundabout locations was on a lower volume road, which meant a lower exposure score for this location also contributed to a low overall SSA score for this location.

The comparison between signalised cross- and T-intersections and roundabouts can be more directly observed by disaggregating the scores by crash type and the three risk components (exposure, likelihood and severity), as shown in Table 2 below.

Table 2 illustrates the greatest differences between crash risk at roundabouts and the other intersection types relate to crash likelihood and severity. The design of roundabouts mean that vehicle speeds and impact angles are managed such that both the likelihood and severity outcome of a crash are likely to be far lower than at cross- or T-intersections.

Safe System alignment of designs

In the undertaking of this work, a significant amount of data was gathered, with over 100 Safe System Assessments undertaken as part of the project. Across the twelve projects, the number of stereotypes assessed varied from five to 15 stereotypes per project. In all, 102 stereotypes were assessed across the 12 projects. This allowed for significant insight into the current safety performance of top tier road infrastructure projects and best practice. The overall trend is clear. Midblock performance was generally seen to be good where medians and safety barriers are used, significantly limiting the risks associated with run-off-road and head-on crashes. Conversely high risk was often associated with large, high speed cross- and T-intersections where high severity conflicts – well in excess of Safe System thresholds – were possible. Roundabouts were seen to perform much better due to their fewer conflict points and managed angles of conflict and speed. It was noted that many of the roads within the upgrade packages included three lanes of traffic in either direction to accommodate high traffic volumes, and as such conventional roundabouts may not be an appropriate solution due to the number of lanes required.

Solutions to this problem are not clear. Investigation of innovative design solutions may be beneficial to identify safer solutions that also meet design objectives, for example raised intersection platforms to manage speeds or signalised roundabouts to provide enhanced safety without significantly sacrificing intersection capacity.

In greenfield areas, a fundamental rethink in the way the urban realm is designed may be beneficial, with a shift away from a small number of large arterial routes to a larger number of smaller arterials, or, alternatively greater use of urban expressways with full access control and grade separation.

Reflection on SSAF scoring system

It was noted throughout the process that almost all of the roads evaluated were scored 4/4 for exposure for motor vehicle crash types (run-off-road, head-on, intersection, other and motorcycle). As per the Austroads guidance, the volume threshold to for an exposure score of 4 is 10,000 vpd. For significant road projects such as the SRU, this is a relatively low threshold to meet. This may indicate that a review of the SSAF scoring system may be beneficial in order to provide further disaggregation of volumes and/or a higher threshold set for achieving ‘maximum’ exposure.

Conclusions

The use of Safe System Assessments as key performance indicator presents the opportunity to shine a spotlight on the safe design of infrastructure and its alignment with Safe System objectives, within the major road infrastructure tender process so that safety is not sacrificed to accommodate other design objectives. The paper also outlines an approach for breaking project designs into homogeneous sections or stereotypes to provide a greater level of detail regarding of road safety risk within designs. The approaches and applications of the SSAF detailed in this paper is one such example of its use. The paper also reflects on aspects of current road design with greatest alignment with Safe System principles, and how an evolution of the SSAF scoring system may provide further benefit. The authors note that the use of the Safe System Assessment Framework is a relatively new approach, and that the flexibility of the framework provides great opportunity to adapt it for a variety of road safety project objectives.

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School Road Safety Education in Uganda: Progress and Lessons Learned

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Key Findings

- URRENO has led advancement in school road safety education in Uganda since 2003;
- Government launched URRENO's primary school pilot as a national curriculum;
- Students' road skills increased, with 66% reduction in crashes near their schools;
- Teachers retained capacity, lost in some (esp. rural) schools due to transfers;
- URRENO efforts continue, with valuable lessons learned shared for others.

Abstract

The Uganda Road Accident Reduction Network Organisation (URRENO) is a non-profit, non-government organisation (NGO) mandated in 1997. From a modest pilot project funded by the World Bank in 2003, it has become a leader in the development, implementation and advocacy for road safety education in primary schools across Uganda. Through URRENO efforts, the pilot program was adopted as the national curriculum and was shown to improve students' road safety skills and behaviours and reduce their involvement in crashes from 15% to 5%. Many other related worthwhile initiatives followed, including: improvements in pedestrian facilities; integrated road safety publicity and enforcement campaigns; and expansion of road safety NGOs to supplement Government efforts. Lessons learned of value for like organisations include: striving to collect and analyse data to attain a project evidence base; building strong partnerships with influential individuals, community groups, businesses and Government stakeholders; adopting participatory approaches in which stakeholders and beneficiaries play significant roles in project implementation; and building capacities and empowering beneficiaries. URRENO continues in its efforts to strengthen and further roll-out the road safety education curriculum across Uganda, following evidence that transfers of trained teachers has contributed to decayed expertise and attention to road safety, particularly among schools in rural areas. URRENO will continue to strive to empower young people to learn and strengthen their capacity in road safety, to grow out of dependence and become independent safe road users.

Keywords

road safety education, children, school, advocacy, resources, low-income country

Glossary

MoWHC Ministry of Works, Housing and Communications, Uganda

PEMSIS Production of Engineering Manuals, Specifications and Institutional Support project

RSE Road Safety Education

URRENO The Uganda Road Accident Reduction Network Organisation

Introduction

Uganda Road Accident Reduction Network Organisation (URRENO) is one of the largest non-political, non-profit organisations in Uganda. Established in 1995 from humble beginnings it has grown into the leading NGO for road safety promotion in Uganda. Through its dedication, advocacy, select funding applications and collaboration with local and international partners, it has made a number of achievements in progressing road safety awareness, investment and improvements in Uganda.

The objective of this paper is to document URRENO's progress in advancing road safety education (RSE) in Ugandan primary schools and to share the lessons learned, as efforts continue to expand the reach and evaluate impacts. URRENO implemented a Road Safety Education project to enhance safer road use behaviors in order to reduce and minimize the impact of injury and death caused by road crashes involving pupils in primary schools in Uganda. To set the scene for this body of work, a brief introduction to Uganda and its road safety history, and URRENO activities and achievements, is first provided.

Uganda and Road Safety Context

Uganda is a landlocked country in Africa with a population of over 40 million (UBOS, 2014). During the financial year 2018-19, the total national road length was 20,856 kilometres and the total number of registered vehicles was 1,594,962, including an increase of 136,977 privately-owned newly-registered motor vehicles.

The Uganda Government has invested in the transport sector particularly in upgrading the national road network to paved bituminous standard over the years. The Government budgetary allocation to the transport sector has grown from UGX 564 billion in 2007-08 to 5,317 billion in 2019-20, the bulk of which is spent on the roads sub-sector (over 76%). However, a recent United Nations performance review (UNECA & UNECE, 2018) found that road safety has not benefitted from the increased funding: while transport represented 18-19% of the national budget in recent years, road safety allocations remained at less than 1%.

Whereas there are efforts by the Uganda Government to address road safety management, the overall national results are far short of the changes urgently needed to reduce road fatalities and injuries. According to the Uganda Police (2019), over 3,407 people were killed and 9,451 injured in road crashes during 2018; continuing the trend of annual increases as motorisation also increases. The majority of fatalities were vulnerable road users, pedestrians (38%) and motorcyclists (27%), with passengers and drivers of car-type vehicles proportionally much smaller (12% and 5% respectively). Among those of known age, approximately 17% of fatalities and 13% of serious injuries were aged under 18, which includes those of school age, of interest in this article. This is in part due to Uganda having a young population, with the median age just 16.7 years.

However, the actual size of the problem is likely to be greater than this because of significant under-reporting of road crashes; a problem known to exist in many low- and middle-income countries. Many road casualties are working men and women whose families depend on their income; as a consequence, the social cost of crashes often goes far beyond the simple statistics of those actually involved. In addition, road crashes put considerable strain on an already over-stretched health service – with annual costs currently estimated at UGX 4.4 trillion ($1.2 billion), representing more than 2% of Uganda's gross domestic product.

The Government of Uganda passed the Traffic and Road Safety Act 1998 to formalise the administration structure, rules and requirements for registration and licensing of vehicles, driving permits, licences for public service/private omnibus/goods, use of motor vehicles, control of traffic and enforcement, and to establish a National Road Safety Council. After passing the Act, URRENO and other road safety partners carried out road safety advocacy for Government to implement interventions to reduce crashes.

URRENO's arguments for RSE were based on key reports at the time (GRSP, 2000; Thomson, Tolmie, Foot, McLaren, & Department for Transport, 1996) and advice from the British Council when delivering in-country training in 2000: "if road safety education could be introduced in primary schools in Uganda it would be the single most important contribution to road safety ever seen in the country" (unpublished communication). The GRSP report emphasised that younger children are not yet aware of the concept of danger unless they learn this through RSE. In addition, a survey conducted in Kampala Schools in 1999 revealed that primary children were receiving no formal RSE and were generally unaware of safety rules.

Following passing of the Act, the Uganda Government, with assistance from the World Bank, began a Road Safety Audit and Improvement Study. The study comprised a 5-year Accident Site Improvement Programme and a 3-year Road Safety Action Plan focused on capacity building and institutional support. Both programs were tasked to a unit within the Ministry of Works, Housing and Communications (MoWHC), with the latter program implemented as the Production of Engineering Manuals, Specifications, and Provision of Institutional Support (PEMSIS) project (MoWHC & TRL, 2008).

The PEMSIS project started in September 2003. The Transport Research Laboratory (TRL; United Kingdom (UK)) was chosen as the lead agency supported by URRENO, as well as engineering safety specialists from Sweden (SweRoads, now part of the Swedish Road Administration) and a medical institution in the UK. The PEMSIS project had four main components:

- *Capacity building*: development of road safety engineering manuals and a feasibility study on establishing a road safety unit within the MoWHC.
- *Medical*: a feasibility study on the establishment of a public emergency ambulance system for Kampala, strengthening trauma research capability of the Injury Control Centre, and improvement and expansion of the national trauma care training program into Uganda's main regional/referral hospitals.

- *Education*: development of an up-to-date highway code, novice driver training curriculum and training program for driving instructors, and primary school RSE resource materials.
- *Crash data and safety audit*: improvements to the previously established road crash data collection and analysis system and development of training in road safety audit procedures to help identify and remedy safety problems during the design and monitoring of roads.

This article focuses on URRENO involvement in the PEMSIS school-based RSE component and its subsequent efforts and initiatives to continue to improve and expand school RSE in Uganda.

URRENO Establishment and Scope

The URRENO idea was conceived by a multi-disciplinary group of professionals who perceived the road safety situation of Uganda as precarious and hitherto perceived the need for advocacy and promotion initiatives for a radical transformation of the road safety perspective. It was agreed that an NGO be initiated to articulate strategies to address the fundamental causes of road injury in Uganda. Thereafter, a situation survey and brainstorming meetings were organised and, subsequently, a mission and vision for URRENO collectively developed.

URRENO's mission is to reduce the incidence and impact of road crashes through training and advocacy, research, design and evaluation of interventions and implementation of traffic safety management programs. This includes several key objectives:

- To promote road safety awareness among the public especially school children and other vulnerable road users through seminars, workshops and training programs.
- To increase traffic safety awareness among motorists through community participation, training and sensitisation.
- To enhance safe roads, safe vehicles and safe people through legal and policy framework interventions, research and advocacy.
- To promote post-crash interventions through education, advocacy and rehabilitation.

For more than 20 years, URRENO has established close working links with local and international partners to advocate and implement many safety projects to improve road safety in Uganda. Several early examples include:

- A one-year motorcycle rider safety awareness project in Nakawa Division of Kampala City, funded by World Bank Small Grants Program, 2001, including assessment of road safety compliance, development of resource materials, awareness raising on speed, helmet use, traffic signs, laws and penalties.
- A subcontract from RITES Limited to carry out road safety awareness in the five divisions of Kampala city as part of the Kampala Urban Traffic Improvement Project in 2002, with funding from World Bank.
- With TRL and other safety specialists from the UK and Sweden, implementation of Uganda's National Road Safety Action Plan from 2003 to 2007 (concurrent to PEMSIS).

More recently, URRENO with Civil Society Coalition on Transport Uganda presented to the Parliamentary Committee on Infrastructure on amendments to the 1998 Act, which were subsequently acceded to in May 2020 with the passing of the Traffic and Road Safety 1998 (Amendment) Bill 2019. Some of the key amendments include: strengthening the road transport regulation and road safety management; amending the grouping of motor vehicles to conform to international standards; empowering the Minister to provide for condition of market entry, oversight and exit in public transport services; providing for a demerit point system; and revising offences and penalties due to inflation.

Currently, URRENO with Family Rescue Initiative-Uganda is implementing road safety awareness activities targeting motorcycle riders on speed, helmet use, traffic laws and traffic signs for a Northern by-pass road construction project. Furthermore, URRENO, together with the Ministry of Works and Transport, recently successfully secured a United Nations Road Safety Trust Fund project, currently underway. Objectives include strengthening Uganda's capacity in data collection, analysis and research for evidence-based intervention, including monitoring and evaluation, and establishment of a Road Crash Data Base System.

URRENO and School Road Safety Education

As noted earlier, URRENO's journey in progressing school RSE in Uganda commenced with the PEMSIS project in 2003. This was intended as a short-term, externally-led demonstration project in a small number of schools. However, URRENO contributed to efforts to widen the reach and since has taken on a leadership role to advance school RSE in Uganda.

PEMSIS Demonstration Project

Prior to PEMSIS, URRENO had established a good relationship with TRL as a key source of road safety research information. When the Uganda Government advertised the PEMSIS consultancy, there was an agreement between URRENO and TRL to team up and implement the project. URRENO was chosen to handle the development and full incorporation of RSE into the primary school curriculum from Primary 1 to 4 (P1 to P4) classes, which included much of the writing and supervision of illustration design.

The collaborative team worked with the National Curriculum Development Centre in Kampala to review and revise the then current primary school curriculum to integrate RSE. Originally it was intended for RSE to be a core subject within relevant units such as Science, English and Social Studies. However, at the time of the project, the Ministry of Education decided to progressively introduce a new thematic curriculum. As a result, it was decided to produce dedicated RSE materials that could readily be incorporated into the new curriculum as it was developed year by year. This strategic approach resulted in producing dedicated student textbooks, teacher guides and more specialised materials such as posters, wall charts and videos, as well as a teachers' resource book that demonstrated the need for RSE in Uganda, to motivate and inform teachers about its delivery.

All these materials were pre-tested in a small representative sample of schools (both urban and rural) following teacher training. Feedback from both children and teachers resulted in some redrafting of the materials, converting some to videos tailored to each class learning level, and development of a system of 'training-of-trainers' so that training could be cascaded down in a sustainable way in future.

It should be noted that the PEMSIS RSE element was never intended to be a national program. The project was intended to produce a curriculum that could be fully integrated into the evolving education system in terms of both materials and teacher training. The program was originally intended to last for 41 months (i.e., finish in February 2007) but an extension was agreed to allow additional RSE materials to be accepted, printed and disseminated. In the end, the PEMSIS project provided materials for 80 schools in 20 different districts across Uganda through to 2008.

In all these activities, URRENO played a major role in developing the resource materials and the reorienting and capacity building of primary school teachers in RSE. Importantly, during the project the resource materials were fully approved by the Ministry of Education's Academic Steering Board. As a result, the materials were publicly launched by the Minister of Education at a workshop held in Kampala in May 2008, adopting the materials as part of a full continuing national program. With the Ministry's support, several thousand individual resource materials were placed within all Ugandan schools with support for future teacher training in their use.

Beyond PEMSIS

PEMSIS was a technical project with very specific terms of reference. It aimed to help the Uganda Government lay down *some* of the foundations for a successful, longer term road safety strategy. It was not expected alone to produce an immediate improvement, but to advocate urgent future actions to stakeholders. While accomplishing a national RSE curriculum was a great achievement, this nonetheless related only to four years of primary school without commitment to evaluation or on-going efforts to enhance, sustain and extend RSE into the remaining primary school years (P5-P7).

URRENO had high hopes that an extended RSE curriculum would immediately follow and organised meetings with the Ministry of Works and Transport, Ministry of Education and Sports, National Curriculum Development Centre, Parliamentary Committee on Social Services and Infrastructure Development and the Office of the Prime Minister. However, funding for such extension is yet to be realised, despite further regular national calls and international recommendations, such as the recent United Nations review (UNECE & UNECA, 2018).

Alternatively, opportunity to continue promoting RSE in Ugandan schools was provided by the competitive CrossRoads Challenge Fund 2013 (European Union and UK Aid funded). URRENO's application was approved to implement the Roll-out of Primary 1 to Primary 4 Road Safety Education Curriculum in Ugandan Schools Project: an assessment to both determine the impact of the pilot project and serve as a benchmark on which scaling up of the curriculum would be based.

The first roll-out project activity was a survey to assess outcomes since the pilot project. The focus was the original 80 project schools and additional surrounding schools in the 20 districts. Consultation was undertaken with key stakeholders, including head teachers, classroom teachers, District Education Officers, Inspectors of Schools and Uganda Police officers in charge of traffic in the respective districts. Findings were based on 140 respondents from 75 (93.7%) of the original project schools and 57 surrounding (control) schools. The results were overwhelmingly positive:

- Teachers trained during PEMSIS showed continued capacity and good techniques, with 96% of those interviewed knowledgeable in teaching RSE.
- Pupils from project schools showed a better ability to apply the correct road crossing rules (i.e., look first left, second right and left again before crossing) and to move their gaze within photo-based scenarios in order to identify potential risks compared to control pupils.
- Involvement of school students in road crashes around the schools had reportedly reduced in the targeted schools to 5% compared to 15% before the project had started in the previous year.

Despite these positive findings, however, only 26% of the originally trained teachers were still in their respective schools. This was partly due to the Ministry of Education transferring teachers to different schools and districts without attention to this specialty, such that some schools, particularly in rural areas, were left with no RSE trained teachers. When asked about adequate availability and reliable use of the materials, 83% of project school respondents agreed compared to only 26% of controls. Reported use decreased with increasing rurality. This was particularly concerning as schools in rural areas contribute the highest number of road victims and visual aid charts were found to be more practical in sensitising pupils in rural schools as only a few of the pupils take the initiative to read the resource books. Of the schools that were involved in the project, only half of the schools had the videos, but also half of these did not have other equipment, such as generators, in order to play the videos. This demonstrated the importance of ensuring sufficient saturation of learning throughout the teacher population to ensure sustainability.

Enhanced Roll-out of Primary School RSE

After the survey, the roll-out project was implemented targeting a much larger number of primary schools. A total of 180 primary schools were selected along highways and in urban centres considered to be more prone to road crashes and therefore a more urgent priority for increased capacity in RSE. The roll-out had four main components:

1. Advocacy (road safety stakeholders' fora): two fora were organised by URRENO; one to inform stakeholders of the roll-out project, seek their inputs for successful implementation and to advocate for the promotion of RSE; and another to inform stakeholders of the achievements and success so far reached after the pilot project. The fora resulted in a set of community informed and agreed recommendations to advance RSE in remaining schools.
2. Training of Coordinating Centre Tutors: 30 tutors were selected from 10 core Primary Teachers Colleges and trained in the four-day training-of-trainers program, covering RSE background information and safe road use, and the specific instructional methods and materials for delivering the RSE curriculum.
3. Producing RSE resource materials: the project produced and distributed Trainers' Manuals, P1-P4 Teachers' Guides, P1-P4 Learners' books, Teachers' Resource books, 9 series of posters/charts, road safety DVDs and copies of a specially produced road safety song CD to 180 primary schools in 9 regions of Uganda.
4. Training of teachers: a total of 720 classroom teachers from 180 schools were trained in teaching the RSE curriculum.

Road Safety Education Innovation

The RSE project was a case where URRENO, an NGO, partnered with a Government agency, the National Curriculum Development Centre, to set standards and apply them in road safety teaching resource materials development and amounts to be given to a learner. The resource materials developed demonstrated a high level of compliance and relevance to Uganda's context. The road safety training approach took the format of participatory, instructional and demonstrational approaches to train the Centre Coordinator Tutors, teachers and pupils. The imparting of knowledge and skills to all learners focused on road safety awareness, behaviour change and correct participation in road use. Major contents of the training program included workshop objectives, competencies content, procedure, instructional methods and materials for delivering RSE.

Music, dance and drama were found to be an effective learning method, more especially involving children. URRENO made an innovation by composing a road safety song "I'm On the Road", which has become a road safety anthem for all participating schools in the project and the song carries road safety children's messages.

Continued Advocacy for RSE in Schools

After the completion of the roll-out project, URRENO continued to advocate for RSE funding in primary schools. From July 2014 to June 2016, URRENO carried out serious road safety advocacy among high government official and policymakers to support and promote road safety in Uganda with funding from the European Union and UK Aid. The aim of the project was to gather support from government and legislators to support RSE and reduce road carnage among school children. Activities included: development of evidence-based tools to advocate for RSE and establishing costs-benefit analysis of investing in RSE; a breakfast meeting for Members of Parliament, Ministries of Works and Transport and Education officials, development partners and NGOs to discuss means and ways to improve RSE in Uganda; a meeting with the Ministry of Education's Steering Monitoring Committee to start the discussion about road safety promotion among their planning agenda; and a meeting with the Prime Minister in which he directed the Minister of Works and Transport to start budgeting for RSE in subsequent financial years.

URRENO with Hope for Victims of Traffic Accidents advocated and implemented a Safer School Zone Project in two primary schools in 2018, with support from Global Alliance of NGOs for Road Safety. The Star Rating for Schools project combined an easy-to-use School Assessment Android tablet app and a Global Reporting for Schools web application. The project activities included: collection of data to assess road safety infrastructure around the school to establish how safe school children are using the roads from and to school; analysing the data to establish star ratings for the selected schools; and advocating for safer school zone intervention through establishing road safety partners for the project – including the Parliament, Kampala Capital City Authority, Uganda National Roads Authority, Ministry of Education and Sports and The Global Alliance for NGOs for Road Safety, among others.

URRENO will continue to advocate for RSE promotion and seek funding to complete development and roll-out of the P5-P7 curriculum and to conduct evaluation. URRENO is also seeking funding to further develop the RSE curriculum for Primary Teacher Education in Uganda for sustainability of RSE in primary schools. All teachers need knowledge, skills and resource materials to enable them to understand and apply road safety principles and practices to all school children. This would be done right from the colleges (pre-service and in-service) and to the practicing teachers in the primary schools.

Lessons Learned

With long experience in the field road of safety, there are a number of lessons that URRENO has learnt in advocating for RSE in low-income countries like Uganda. The DOs and DON'Ts helps an organisation to achieve its objectives and targets. The key lessons learnt include:

- Road safety interventions are dependent on evidence-based facts from assessment, surveys and research. One of the main challenges faced in low-income countries is implementation of road safety measures to address road crashes that are not evidence-based and not well researched. Data collection and analysis of any project informs and deepens the content.
- Building strong partnerships in any road safety intervention is one of the keys for success. Working in partnership helps to demonstrate broad-based support. Partners may include (but are not limited to) government ministries, departments and agencies, business communities, civil society organisations and individuals with influence. At every inception of the project URRENO undertakes, there is always a series of consultations with partners and stakeholders to obtain opinions, suggestions and recommendations for successful implementation of the project.
- Participatory approaches where stakeholders and beneficiaries play significant roles in the implementation of the projects are also key. Community participation is applied in most URRENO projects by involving all target groups in all project cycle activities where all participating partners are equal in developing solutions, sharing success and assuming risks.
- URRENO's strategy for sustainability is always building capacities of beneficiaries through training and empowering them with materials, equipment and tools to continue with their activities.

Whereas there are efforts by the Uganda Government to address road safety management, the overall national results are far short of the changes that are urgently needed to reduce a large number of national road fatalities and injuries. This is supported by the recent United Nations review (UNECE & UNECA, 2018), which made several strategic recommendations, including: accession to and implementation of the United Nations road safety conventions; strengthening of the technical and financial capacity of the National Road Safety Council to better conduct the functions expected of a lead national road safety entity and to raise political priority on road safety; strengthening traffic and road safety legislation; establishing and implementing a road crash data base system; improving implementation of road safety audits and assessments, especially in urban areas to address the safety of vulnerable road users; improving vehicle safety through periodic and mandatory vehicle inspections; improving RSE in primary schools; improving driver training and testing; and strengthening and expanding emergency medical services.

Concluding Comments

Uganda has been gradually increasing attention and implementing reforms in road safety over the past two decades. URRENO is striving to ensure school RSE is rolled out and sustained as part of these efforts. The PEMSIS project was a key turning point that attracted Ministerial attention and RSE was established as part of the national primary school curriculum. Five years on, URRENO was able to secure funding and applied innovative methods in the Ugandan context to better understand on-going teachers' RSE activities and children's road safety behaviours. While this determined that great gains had been achieved, it was clear that that these were decaying over time through lack of support and attention to teacher relocations. Therefore, URRENO is continuing its efforts to strengthen and further roll-out RSE through Ugandan schools. Strong data and partnerships, participatory approaches and capacity building with stakeholders and beneficiaries are key elements to this on-going success.

It is important to acknowledge that many factors contribute to safer roads with a lower rate of crashes which can affect school children. Thus it cannot be said that the RSE activities reported alone led to a decrease in the number of road crashes involving school children. Nevertheless, trained pupils in targeted schools showed an improved ability to apply the knowledge needed to cross the roads, which contributed to their ability to move safely along the roads to and from schools, despite the aggravating traffic circumstances in Uganda.

Primary schools that participated in the PEMSIS project expressed their willingness to continue raising road safety awareness for future generations through Road Safety

Club activities. Despite the teachers' ability to retain the awareness-raising capacity years after the initial training, schools will benefit from continuing support, since a number of teachers are either assigned to a different school or retire each school year. The results of this impact assessment will always contribute to a revision of the techniques used to build teacher capacity in RSE and to teach pupils not to memorise rules, but to correctly apply them when facing a real situation.

It is worthwhile to note that many other associated worthwhile initiatives have resulted from these RSE efforts, including: improvements in pedestrian facilities in towns, and villages on main roads; road safety publicity campaigns – integrated with traffic law enforcement campaigns; and expansion of road safety NGOs to supplement government efforts to improve road safety. URRENO will continue to strive to ensure this momentum is not lost, to empower young people to learn and harness skills in road safety education, to grow out of dependence and become independent safe road users.

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Contributed articles

Commentary on Road Safety

Road Traffic Light in New Configuration

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Introduction

The three-color system containing signals of the same circular shape has been in existence for over a hundred years. Each traffic signal has been justifiably selected to have a special color light to correspond to human psycho-emotional reaction (red – stop, yellow – caution, green – go) to a given color signal (British Standards, 2015) and to comply with the laws of physics (The Motivated Engineer, 2015) – Rayleigh's scattering law (Banc SpaceTek, 2017).

The main downsides of the traditional road traffic light include the following:

- The uniform circular shape of light signals results in uncertainty and difficulties for road users with color blindness and visual impairments, resulting in the need for restrictions or bans on driving license issuance in some countries. This uncertainty becomes particularly acute in conditions of low visibility.
- According to the concept of harmony of form and color (Itten, 1961), a green light alone corresponds to the circular (spherical-like) shape of the signal. Red and amber lights harmoniously combine with other geometrical shapes.
- The uniform shape of light signals prevents the implementation of the original compact combined model of traffic lights. For example, during the day, colorblind people can tell which signal is which because there is a standard position assigned: top – bottom or right – left (Oliveira, Souza, Junior, Sales & Ferraz, 2015). This becomes problematic if the compact combined models of traffic lights are used.

Engineers and inventors have been trying to solve these problems by introducing random changes in the light signal shape and complicating the traffic light design. For a long time there have been different proposals about how to eliminate the demerits of the existing traffic lights: from arbitrary changes in the signal shape (Patterson, 1988) to transformation of traffic lights into a single-section display panel (Kulichenko, 2011) which replaces among others stationary road signs. However, technical solutions like these deprive the traffic light of its signal uniformity and conciseness (simplicity, clarity and precision of its controlling effect), features which help safe traffic regulation in a busy and dynamic mode.

Technical modernization of individual signal components has been going hand in hand with technological developments as light sources, diffusers, lenses, controllers, materials, control systems, timers, etc. are improved. However, adequate design and aesthetic proposals are considerably behind.

The aim of this paper is to propose a concept of creating control signals of traffic light that harmonize color and form, and, as a result, to create a new model of traffic light that will be convenient for all road users.

Color and form

The shape of an object is known to have as much impact on human perception as does its color, because these characteristics are an aspect of a single object (Enders, 2010). Visualizing an object through a harmonious combination of color and form is most effective for visual perception and impression (Itten, 1975). For example, psychologists and teachers, designers and marketers apply this in practice: Psycho-Geometrics Testing using geometrical shapes (Dellinger, 1989), Charles Moore's "Supergraphics" in architecture and design (Lange, 2014), Brand's core identifiers: colors and shapes, symbols and words (Goldstein, 2015).

Art theorists of the twentieth century also wrote about association of colors with corresponding geometric shapes. "The square corresponds to red, the color of matter. The weight and opacity of red agree with the static and grave shape of the square. The triangle owes its nature to three intersecting diagonals. Its acute angles produce an effect of pugnacity and aggression. The triangle assimilates all shapes of diagonal character, such as the rhombus, trapezoid, zig-zag, and their derivatives. It is symbol of thought, and among colors its weightless character is matched by lucid yellow" (Johannes Itten, 1970, p. 75). Wassily Kandinsky (1947) created the "diagrammatic indication of the line-plane-colour relationships" (pp. 74-75) and also said that red corresponds to the right angle and the square shape while yellow corresponds to the sharp angle and the triangular shape.

In the case of a traffic light system, the synchronisation of such chromatic and geometric features may result in a greater degree of visual and psycho-emotional signal identification. This may help the traffic signals to be more readable from a longer distance and identified more accurately and reliably.

Proposed traffic light configuration

While retaining the color, position and signal sequence of the current configuration, it is possible to produce a traffic light where the shape of a signal corresponds to its color.

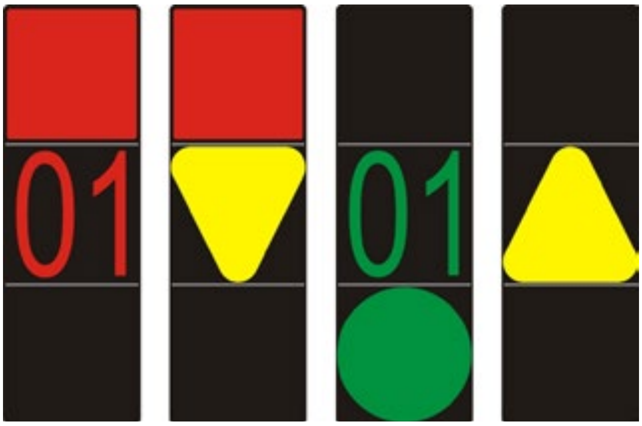

Figure 1. A three-section system with a timer and the light sequence

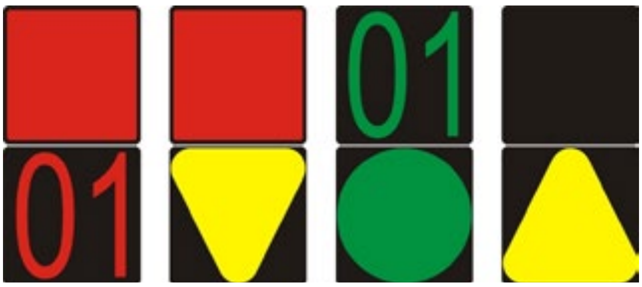

Figure 2. A two-section system with a timer and the light sequence

Figure 3. A monosection system and the light sequence

The red light signal has a square shape and the amber light signal has a triangular shape with its apex pointing to the signal – green or red – that is about to appear. The green signal retains its circular shape. A traditional three-section system may be used (Figure 1).

The basic three-section model of proposed traffic light may be transformed (Tole Rant, 2018). A more compact and economical traffic light – two-section (Figure 2) or one-section (Figure 3) system – may be used, for example, in urban environments in order to increase the field of view and reduce street congestion.

The functions of the red, amber, green arrows and additional green arrows of the conventional traffic light (UNECE, 2006) are unchanged. For example, UNECE The Convention on Road Signs and Signals (2006) specifies: "Black arrows on a red, amber or green background may be used" (p. 16).

The newly proposed traffic light configuration provides the following advantages:

- **Social advantages and safety:**
  The differently shaped lights may remove ambiguity for people with color perception disorders (color blinders) and those visually impaired. This may allow lifting restrictions/bans on driving license issuance currently applied to them in some countries.
- **Information benefits and safety:**
  The apex of the amber triangle markedly signaling the forthcoming (red/green) light signals allows road users to anticipate the control signals in advance. Information uncertainty of traffic light signals of the same circular shape is eliminated.
- **Economic advantages:**
  Manufacturing, installation and maintenance of compact traffic light (two-section or one-section system) in comparison with traditional three-section model is more cost-effective (reduced material intensity, size, transportation costs, etc.) and may help reduce street congestion.

Conclusions

The proposed traffic light configuration will be convenient for all road users. Modern technologies make it possible to create the proposed traffic light in new configuration, for example, using LEDs – light-emitting diodes (NHSaves, 2020), Bi-color LEDs (Karthick Kumar Reddy, Jagadeesh & Venkatramana Reddy, 2011), Tri-color LEDs, etc.
The newly proposed traffic light configuration may be implemented in two phases: 1) introduce the basic three-section system (Figure 1); 2) introduce the compact systems (Figures 2 and 3) after recognition of the new basic three-section model by users in the first phase.

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ACRS updates

From the President

Happy New Year. Those wishful words have never felt so important and so relevant to so many in my lifetime. Everyone has been touched by the impact of the pandemic, and we face uncertainty in all aspects of our lives. Some of us are in a position to reflect and learn, but others of us are facing much more immediate pressures. My very best thoughts and wishes go to all our members and supporters as this year gets underway. Let's stay in touch, and let's try our best to help everyone through.

As I have noted previously, the professional frustration is that the public health crisis we are living through has engendered such negatively geared investments – investments aimed at limiting the extent to which our lives are worse. For years, road traffic safety, and many other areas of public health, has been offering forward positively geared investments – investments aimed at improving human life.

But we road safety people are an optimistic bunch, and there are some important signs of a correction in favour of safety and health on our roads. The Australian national road safety strategy which is due for release in draft form will be an important litmus test. In line with the College's position, we can now anticipate a vision statement to eliminate both fatalities and serious injuries by 2050, and a 50% reduction target by 2030 (even if this is measured by rate not number). A short reflection on other areas of public policy which are bogged down in argument and division suggests we are succeeding.

The major down-payment of $2 Billion in safety projects announced by Australia's Deputy Prime Minister is a big step forward. This places a significant onus on the State and Territory road agencies to deliver the safety that the community demands, and to set in place a means of demonstrating real progress. Surely less than half of 1% of those funds can be assigned to a national safety star rating program which allows the community to understand the ongoing safety issues we need to confront on our road networks.

It was interesting to hear from the Federal Leader of the Opposition over the festive season who directly benefited when predictable failures in one part of the road traffic system (young driver error) were covered by a stronger part of the system (vehicle safety technology). We must keep up with the European regulatory platform for autonomous emergency braking and intelligent speed adaptation over this decade. And of course, for a point of reflection, what about the systematic lowering of urban speed limits across the city of Auckland in June? We must be ready to continue our advocacy for safety in this new year. Our policy positions are important across Australia and New Zealand and would resonate across many other countries in the world.

The College itself has of course needed to adapt and respond, such as the major shift from Chapters to delivering remote professional development and networking activities. The Australasian Road Safety Conference was a major pre-occupation for many of us. At the beginning of the year, as the pandemic revealed itself, and it became clear to the Conference Organising Committee that we could not hold it as scheduled in September in Melbourne, we needed to talk with partners and sponsors to make sure of our next steps. We postponed to September 2021.

At the end of the year, as the pandemic rumbled on, we needed to reconsider what this event could and should look like. The conference brings together our four points of focus – advocacy, professional development, knowledge transfer and networking. It provides an important marker in the research world and links directly with our peer-reviewed *Journal of Road Safety*, of which we are rightly proud. And so the College's Executive Committee decided to deliver a hybrid conference, a conference which provides opportunity for people to connect in Melbourne, and virtually.

Of course, uncertainty brings complexity, but we know more about this uncertainty, and I'm confident that our staff and the Organising Committee can bring a new energy and dynamism to this event. We know that realising our vision of eliminating fatal and serious injury on the road requires more people, in more organisations, and in more places connecting with proven and emerging safety practices and professionals. I'm particularly excited about the future opportunity that a deliberate shift into the virtual world will provide us into the future. This year's conference is more vital than ever before.

Our organisation will stand and fall on the basis of our membership, and our capacity to renew our efforts and deliver on our members' behalf. As President, I chair the Executive Committee elected by members, and one of our most important tasks this year will be to recruit a new Chief Executive. This is a critical time for road safety, and this role provides a great opportunity for someone to make their mark, and take our efforts to another level. Spread the word. We only have 30 years to deliver, and we have to get cracking now.

Martin Small
ACRS President

From the CEO

By the time this goes to print I am hopeful that the horrors of 2020 will be put behind us and that 2021 is a restorative and happier year for us all. It has been a delight to return to the road safety field as your interim CEO. I have already renewed my links to so many of you with whom I worked during my decade at ANCAP. Most of the work of the College during 2020 happened before my appointment, but I have endeavoured to continue this work as we all look for more positive road safety outcomes.

The College felt the impact of the departure of Ms Claire Howe, the former CEO, in October. Claire's dedication, tireless efforts and leadership have played a significant role in the growth and success of the College for more than a decade.

The Executive Committee is currently undertaking a comprehensive recruitment effort to secure a new CEO. In the meantime, I continue to work with our operational staff, our Executive Committee, and other volunteers across Australasia to ensure that we remain focused on supporting you as we work Towards Zero.

Australasian Road Safety Conference (ARSC) 2021

We are delighted to announce that preparations for ARSC2021 are well underway. ARSC2021 will be presented as a hybrid conference 28-30 September 2021. A first for the conference, the hybrid format will allow in-person participation in Melbourne, while also allowing delegates to attend online. The flexible hybrid conference format will allow access to road safety professionals who have previously not been able to attend in person.

We extend our thanks to the ARSC2021 Organising Committee co-Chaired by Mr Chris Brennan (Manager Road Safety Planning, Victorian Department of Transport) and Dr Jeff Potter (Principal Safety Policy Advisor, National Transport Commission). We have a fantastic team in place with our Scientific, Sponsorship, Social and International sub committees. We look forward to you joining us at ARSC2021 in September 2021.

International Outreach

The International Outreach Chapter (IOC) is being developed as part of our outreach efforts to Low- and Middle-Income Countries (LMIC's) with the goal of supporting road safety in Asia through the integration of global best practices to eliminate road trauma. With the World Health Organization estimating that 93% of all traffic accident fatalities occur in LMICs, the urgency of this work is clear. The establishment of the IOC has been made possible through a $400,000 grant from the Federal Road Safety Awareness and Enablers Fund.

Since 2016, the Australian Government has provided funding for scholarships to attend the ARSC for LMIC delegates from the Asia-Pacific and African regions at our conferences. The 22 delegates have come from 11 LMIC countries – Cambodia, Malaysia, Indonesia, Vietnam, Philippines, Laos, India, Nepal, Iran, Pakistan and Bangladesh.

In 2020, ACRS received a 4-year commitment from the Australian Government through the Federal Road Safety Awareness and Enablers Fund; this support includes a Gold Sponsorship and funding to support multiple LMIC Scholarships.

Ministerial Roundtables

During 2020 ACRS facilitated two Ministerial Roundtable discussions focused on Vulnerable Road Users and Heavy Vehicles. These were Chaired by Hon. Scott Buchholz MP, Assistant Minister for Road Safety and Freight Transport and included key stakeholders within the industry. The College will host a further roundtable discussion in early 2021.

ACRS Awards

We were fortunate to be able to host the 2020 ACRS Awards Ceremony, despite COVID-19 restrictions and the postponement of the ARSC. The Awards were announced as part of the official launch of National Road Safety Week in November. The event featured Hon. Michael McCormack MP, Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development and Mr Peter Frazer, President of the Safer Australian Roads and Highways (SARAH) Group and Founder of National Road Safety Week.

The 2020 Fellowship was awarded to Ms Antonietta Cavallo in recognition of an exemplary contribution being made by an individual to road safety in Australasia. The 2020 3M-ACRS Diamond Road Safety Award winning project was “Low Cost Implanted Compact Roundabout” and was led by Mr Christopher Davis, Road Safety Officer at Mildura Rural City Council. The winner of the 2020 Young Leader’s Oration Award was Dr Tana Tan and recognises inspiring work and the potential for future leadership in the field of road safety.

Journal of Road Safety

2020 marked a name change of ACRS’ long time valued Journal (previously The Journal of Australasian College of Road Safety) to align with the growing international outreach and influence of the Journal as well as the ACRS. The change brings with it the additional enhancement of providing a broader frame of evidence and discussion for our ACRS members.

During the past year we launched the Journal of Road Safety mentorship program to provide support for road safety professionals from LMIC countries to increase their publication opportunities. In August 2020 we published a Special Issue: Road Safety in Low- and Middle-Income Countries.

I would like to thank the ACRS staff and volunteers who have contributed so much over the past year, and to all ACRS members, for your continued support of the College. It is because of your efforts that ACRS will continue to grow in this evolving environment.

Best wishes,

Nick Clarke
Chief Executive Officer (Interim) - 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 has focussed on two specific projects this year: Wildlife and Older Drivers. Although progress has been slower than desired because of the current issues in the community, advances have been made that will enable both to be addressed early in 2021.

Wildlife Project

Action has been taken by the executive to work with stakeholders in progressing the project. The following is a brief summary of its aims and current status.

Aims

To save lives and serious injury to

- ACT and regional NSW motorists, passengers, and vulnerable road users; and
- Regional wildlife, especially endangered species.

To improve the effectiveness of efforts in this area through improved coordination of data and efforts, for example

- Sharing of data, experiences, and the effectiveness of interventions
- Joint initiatives between all key stakeholders, supported by integrated funding support from Government and the private and community sectors.

Immediate Tasks

Bring some cohesion to current data available and identify important gaps.

A project brief has been prepared for a consultant to:

1. identify and collate existing data on crashes, costs and existing interventions;
2. Identify data gaps, risks, and current views on community costs to humans, equipment, wildlife, support for injured animals and people and indirect costs to the society;
3. Provide an initial review of potential pathways to
   - Improve data coordination and identify how data gaps can be filled
   - Improve community awareness and understanding of the issues
   - Develop improved community partnerships and communication
   - Create specific programs and proposals to

a. Improve knowledge and understanding of the risks and potential interventions

b. Create effective, ongoing partnerships and deliver these improvements

c. Secure joint funding to address the key issues from all of road safety, health, community safety and wildlife protection perspectives.

Longer Term

Establishing longer term data requirements can be quite complex as it may involve negotiating and complying with national health and data requirements; and similar national data requirements that exist in the transport and road safety sector.

Our intention continues to be to present progress publicly at the 2021 Australasian Road Safety Conference.

Older Drivers

The Chapter and COTA have been actively considering alternatives for the delivery of road safety advice for older drivers in the ACT. Recent discussions have focussed on the possibility of updating the form and content of information currently provided to older drivers. This will involve seeking community advice on possible new proposals and on the launch of any new program.

Discussions with the ACT Government on these alternatives have been held over to early 2021 given the recent ACT Legislative Assembly elections and the appointment of a new Minister for Road Safety.

ACT Chapter Chair & Secretary
Mr Eric Chalmers & Mr Keith Wheatley

South Australia (SA)

The South Australian Chapter hosted a well-attended webinar to hear Sarah Clark outline the overall process for the development of South Australia's Road Safety Strategy to 2031. Sarah is the Director Road Safety, Policy and Research at the Department for Infrastructure and Transport. Highlighting the complexity of the challenge, Sarah spoke to the values based approach being taken to understanding community values. Evidence led foundations are also inputting into strategy development, particularly the safe systems pillars, application of research and Centre for Automotive Safety Research modelling.

Using a four phase approach, the second phase is nearing completion being stakeholder and community input. Submissions have been received along with over 1300 on-line survey responses from the community. The evidence led focus areas for the strategy are regional South Australia, fatigue, and older road users. Sarah highlighted aligning with the National Road Safety Strategy 2021-2030 which is also currently being developed.

Sarah expects the release of the draft strategy for comment in the first half of 2021, followed by publication of the final strategy and implementation.

Thank you to Sarah for proving this timely and informative presentation. Thanks also to the University of Adelaide for hosting the webinar on their Microsoft Teams platform. A recording is available on the ACRS YouTube Channel - https://www.youtube.com/watch?v=meIgkBa2J5U

Next Event - Hydrogen Fuel Vehicles

The SA Chapter is arranging a lunchtime webinar for 12 February 2021 on Hydrogen Fuel Vehicles, with a focus on their safety.

SA Chapter Chair & Secretary
Jamie MacKenzie and Phil Blake

New South Wales (NSW)

Continuing our 2020/21 direction

The NSW Chapter has continued to progress its focus for 2020/21 on collaboration, consultation, and communication. This quarter we continued our work reaching out to the Australian Driver Trainers Associations as well as state MPs, to further promote what we do at the ACRS and to support their road safety initiatives. Our impact was even acknowledged by the NSW Minister for Transport and Roads, Hon Andrew Constance MP. As always, these relationships, combined with existing connections across road safety, will support a united, strategic push to reduce road trauma.

In October 2020, the NSW chapter also made a submission to the NSW Legislative Council's Standing Committee on Law and Justice regarding the 2020 Review of the Compulsory Third Party insurance scheme and 2020 Review of the Lifetime Care and Support scheme. Special commendation to our Chapter Treasurer, Mr. Mick Timm, for leading this submission, drawing on his extensive career in the NSW Police Force.

Seminars series

We continued to conduct online presentations of seminars, which have been very well received by our members. One seminar was conducted in the last quarter, around the ever-growing issue of driver inattention and distraction. The distinguished presenters focused on the effectiveness of countermeasures and the benefits of collaborating with stakeholders in striving towards zero.

Driver inattention and distraction – 24 November 2020

Presented by:

- **Professor Michael Regan** (Research Centre for Integrated Transport Innovation [rCITI], UNSW Sydney) and
- **Nicole Downing** (Director, Road and Rail Safety, Qld Department of Transport and Main Roads [TMR]).

Delivered online via GoToMeetings with ~100 registered attendees.

Details of this and previous seminars are available on the Chapter webpage:

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

NSW Chapter Chair & Vice Chair
Mr. Duncan McRae & Dr. Prasannah Prabhakharan

ACRS News

ACRS JOURNAL OF ROAD SAFETY (JRS): THANK YOU FOR YOUR CONTINUED SUPPORT IN 2020

On behalf of the ACRS Journal of Road Safety (JRS) we offer a massive thank you for your continued support and contributions in 2020.

2020 marked a name change of ACRS' long time valued Journal to align with the growing international outreach & influence of the Journal as well as the ACRS, with the additional enhancement of providing a broader frame of evidence and discussion for our ACRS members.

Under the new brand name Journal of Road Safety (JRS), ACRS' Journal has continued to undergo significant improvements this year with big thanks to your vital input via the JRS survey as well as expert guidance and contributions from the highly esteemed international JRS Editorial Board, consisting of diverse road safety experts from highly credentialed academics to highly experienced practitioners in road safety delivery.

It is with profound gratitude to the JRS sponsors (Centre for Road Safety NSW Transport, LB Australia, New Zealand Transport Agency, Department of Transport Victoria) & regular advertisers (Ingal Civil Products and Winston Churchill Trust) that we are able to continue to produce and grow one of the highly valued products of the ACRS. Huge thank you for your generous and loyal support.

The exciting initiatives of the JRS in 2020 included:

- Launch and implementation of the JRS mentorship program to provide capacity development support for road safety professionals from low and middle income countries (LMICs) and help increase their publication opportunities – sincere gratitude to the mentors who have kindly volunteered to contribute to this program and generously given their time and expertise.
- Publication of the JRS Special Issue: Road Safety in Low- and Middle-Income Countries – big thank you to the Guest Editors for their generous support and input: Dr Lori Mooren, Dr Ray Shuey, and Dr Mark King.
- JRS webpages invigorated to help further lift the profile and credibility of the JRS including online JRS catalogue to allow improved access to JRS papers.
- Direct digital mailout of the JRS with DOI links & Suggested Citations to help further increase the exposure & uptake of the excellent JRS articles.
- Display of JRS contents in the order of Peer-reviewed papers - Contributed Articles - ACRS Updates to showcase upfront the critically reviewed evidence-generating work by the JRS authors while keeping the other contents valued by ACRS members and JRS readers. Thank you for your regular contributions – ACRS President, Mr Martin Small, ACRS former CEO, Ms Claire Howe and ACRS Chapters.
- Introduction of Road Safety Best Practice Guidance and Road Safety Theory to our collection of Article Types.

Implementation of these initiatives was made possible with ACRS Head Office support, dedicated assistance from ACRS Administration Officer, Ms Molly Stanley, and significant commitment and expert input from Editor-in-Chief, Professor Raphael Grzebieta.

Much of the increased LMIC outreach such as the JRS mentorship program and JRS Special Issue: Road Safety in Low- and Middle-Income Countries which was a larger than usual issue are with special thanks to the *Australian Department of Infrastructure, Transport, Regional Development and Communications.*

The JRS, of course, could not exist without the support of members and the significant contributions from the **authors** – please make the most of the excellent papers published in 2020 – see Reference list below. We owe a lot to the many **reviewers** who give their valuable time and expertise to help us ensure the scientific credibility and genuine contributions of the peer-review papers published in the JRS. Huge thanks for your vital input.

ACRS remains proud of the key features of JRS that sets it apart from other journals:

- JRS remains one of the few remaining open access journals that do not charge authors any fee for publication.
- JRS has a unique feature of the contributed article (non peer-review) stream that other scientific journals do not offer because we highly value and welcome evidence sharing from practitioners.
- JRS has always had and will continue to have dedicated singular focus on road safety as indicated by the title.

Further uptake of citations will further strengthen the JRS towards an Impact Factor & I look forward to sharing more exciting news in 2021 with your continued support.

With much gratitude,

Dr Chika Sakashita
JRS Managing Editor, ACRS
journaleditor@acrs.org.au

JRS 2020 papers

Penmetsa, P. and Pulugurtha, S.S. (2020). “Risk Perceptions of Crash Related Traffic Rule Violations”. *Journal of Road Safety*, 31(4), 4-12. https://doi.org/10.33492/JRS-D-19-00231

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Diary

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

UN Global Road Safety Week
17-23 May 2021
https://www.unroadsafetyweek.org/en/home

ICRS 2021: International Conference on Road Safety
9-10 August, Lagos, Nigeria
https://waset.org/road-safety-conference-in-august-2021-in-lagos

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

ICRS 2021: International Conference on Road Safety
25-26 October, Barcelona, Spain
https://waset.org/road-safety-conference-in-october-2021-in-barcelona

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