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Journal of Road Safety

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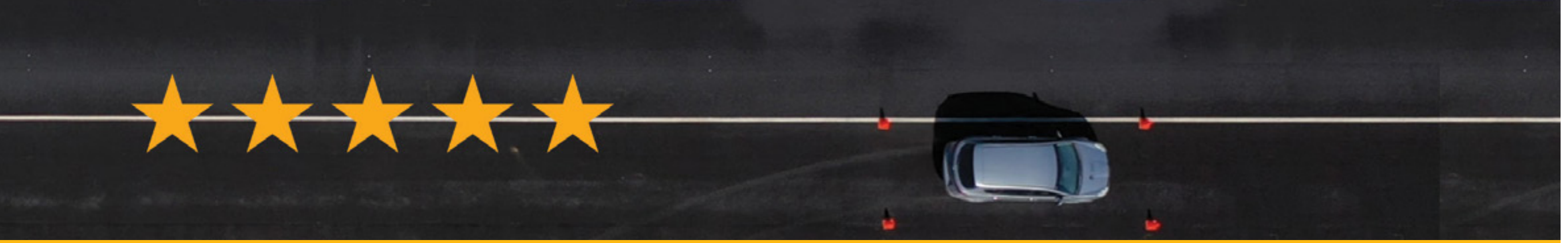
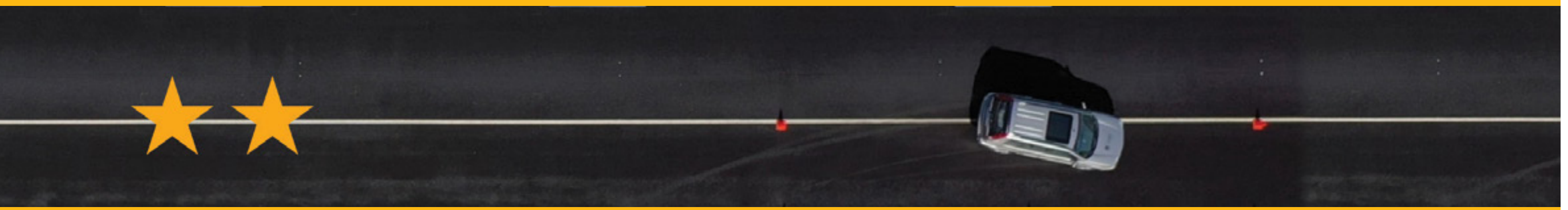


Find the safest choice for your next car



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Vehicles labelled 'Safer Pick' go beyond the driver protection rating. This label is assigned to a vehicle based on an estimate of the death or serious-injury risk the vehicle poses to other road users in a crash. It also considers the likelihood of the vehicle being involved in a crash based on the crash avoidance features fitted such as Electronic Stability Control and Automatic Emergency Braking.

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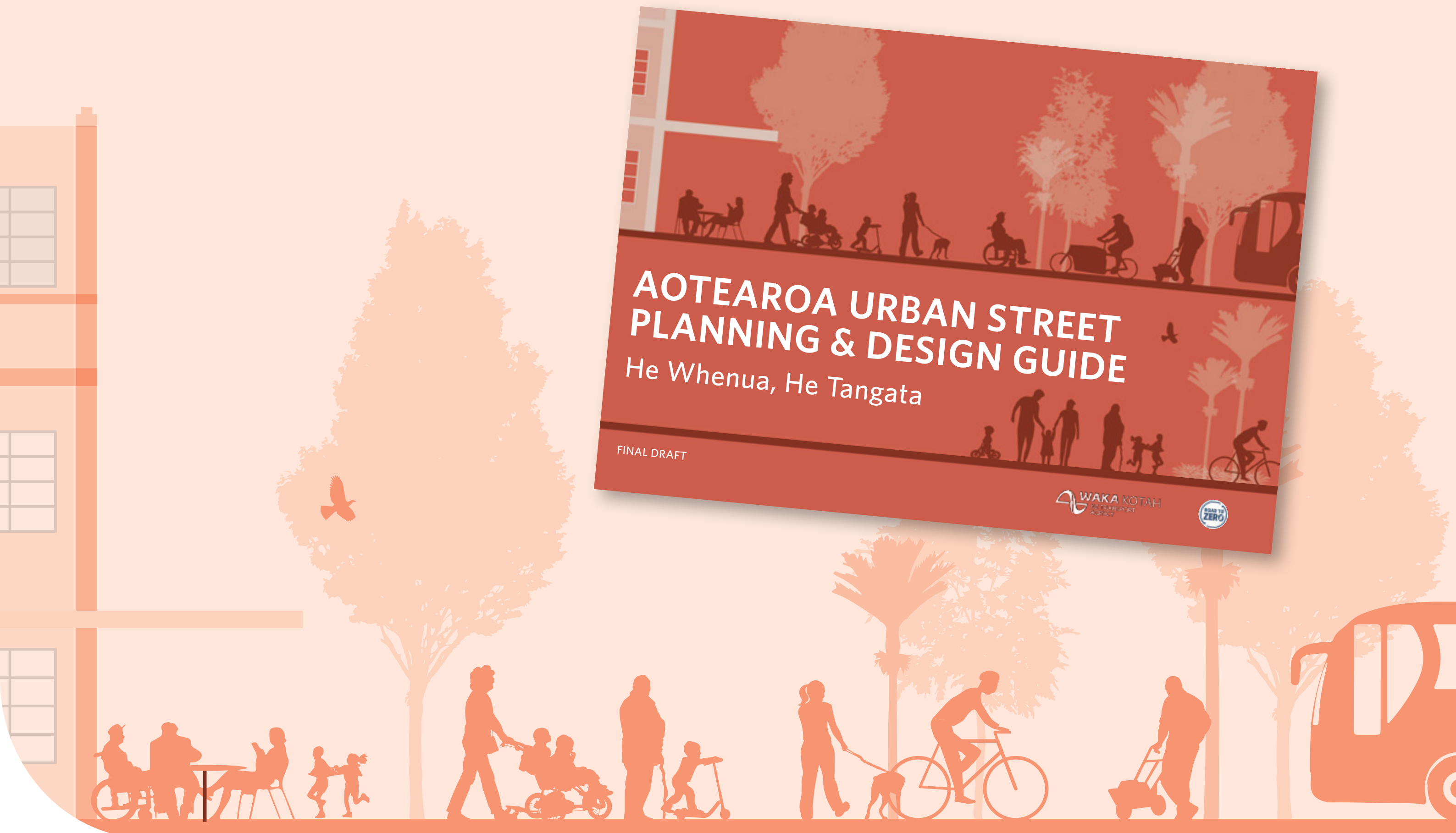

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Cover image

The Asia-Pacific region currently accounts for 60% of global road fatalities. Within Asia, the South and South-West Asia subregion have the highest fatality rate of 20.3 fatalities per 100,000 population followed by South-East Asia with a fatality rate of 17.8 per 100,000 population. Learn about the road safety situation and implementation of road safety policies and practices in Asian countries in the Road Safety Policy & Practice article: Regmi, M. B. (2021). "What does it Take to Improve Road Safety in Asia?" *Journal of Road Safety*, 32(4), 29-39. https://doi.org/10.33492/JRS-D-21-00040 Motorcycles are a common sight in Asian countries such as Thailand. Photo kindly provided by Mr. Madan B. Regmi.

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

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

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.

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Peer-reviewed papers

Original Road Safety Research

First-Stage Evaluation of a Prototype Driver Distraction Human-Machine-Interface Warning System

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This peer-reviewed paper was first submitted as an Extended Abstract and an Oral Presentation was recommended by two reviewers at the 2021 Australasian Road Safety Conference (ARSC2021) held online, 28-30 September 2021. The two Reviewers also recommended that the Extended Abstract be expanded into a 'Full Paper' and undergo further peer-review as a journal submission by three independent experts in the field. The Extended Abstract is published in the ARSC2021 Proceedings with a link guiding readers to this 'Full Paper' version which is being reproduced here with the kind permission of the authors and will only be available in this edition of the JRS.

Key Findings

- Four variations of the Human Machine Interface (HMI) of a multi-modal driver distraction warning system developed by the authors were evaluated in a truck simulator;
- Driver acceptance of the HMIs was assessed using the System Acceptance Scale; and salience, comprehension and perceived effectiveness of components of the HMIs (modality, intensity of warning) were assessed using likert scales;
- Participants accepted the HMIs and understood the warning components and considered these to be effective;
- Further testing is recommended to validate the findings and assess their safety impact on road.

Abstract

Recent advances in vehicle technology permit the real-time monitoring of driver state to reduce distraction-related crashes, particularly within the heavy vehicle industry. Relatively little published research has evaluated the human machine interface (HMI) design for these systems. However, the efficacy of in-vehicle technology depends in large part on the acceptability among drivers of the system's interface. Four variations of the HMI of a prototype multi-modal warning system developed by the authors for driver distraction were evaluated in a truck simulator with eight car drivers and six truck drivers. Driver acceptance of the HMIs was assessed using the System Acceptability Scale; and salience, comprehension and perceived effectiveness of components of the HMIs (modality, intensity of warning) were assessed using likert scales. The results showed that participants considered the HMIs to be acceptable and useful, and that the warning components were largely noticed, understood correctly, and perceived to be effective. Although this study identified no major design flaws with the recently developed HMIs, further simulator testing with a larger sample size is recommended to validate the findings. On-road evaluations to assess the impact of the HMIs on real world safety are a necessary pre-requisite for implementation.

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Keywords

Driver Distraction, Human Machine Interface, Warning Systems, Simulation, In-Vehicle Technology.

Introduction

Inattention is a significant contributing factor to crashes and occurs when a driver fails to pay sufficient attention to activities that are required for safe driving (Lee, Young & Regan, 2009; Regan, Hallet & Gordon, 2011). Data from the Australian National Crash In-depth Study found that driver inattention contributed to 63% of serious casualty crashes in which a known crash contributing factor was identified (Beanland, Fitzharris, Young & Lenné, 2013). In 25% of these crashes the driver was distracted by a competing activity, most commonly a non-driving related activity within the vehicle. Distraction has been identified as a major challenge in the commercial vehicle safety context particularly given the high mileage that truck drivers routinely cover and the greater severity of injuries associated with heavy vehicle collisions (BITRE, 2019).

Alongside regulation and enforcement, recent advances in vehicle technology permit the real-time monitoring of driver state to mitigate driver impairment (e.g., Lenné et al., 2018). Evidence suggests that driver monitoring systems (DMS) are a promising approach for detecting driver distraction (e.g., Liang, Reyes, & Lee, 2007; Miyaji, Kawanaka & Oguri, 2009) as well as other forms of driver inattention including fatigue (e.g., Fitzharris, Lui, Stephens & Lenné, 2017).

From an end-user perspective, relatively little published research has evaluated the Human Machine Interface (HMI) design for the warning component of DMS. This represents an important knowledge gap since the efficacy of any in-vehicle technology depends as much on its acceptance by the driver as it does on optimal system performance (van der Laan, Heino & de Waard, 1997; Regan, Stevens & Horberry, 2014). Research also suggests that drivers with favourable opinions of DMS tend to experience more or greater safety benefits than drivers with unfavourable attitudes (e.g., Blanco et al., 2009).

Although acceptance has been variously defined in the scientific literature (see Regan et al., 2014 for a full review), the term can be broadly defined as the degree to which a driver perceives the benefits derived from a system as greater than the costs (Blanco et al., 2009). This is important because technology is likely to be ignored or even circumvented if its safety benefit is outweighed by factors such as annoyance, mistrust or lack of effectiveness.

A handful of HMI design evaluations for warning systems conducted under driver distraction have examined various dimensions of user acceptance including: perceived usefulness, trust, annoyance and distraction (Anund & Nilsson, 2020; Biondi, Strayer, Rossi, Gastaldi & Mulatti, 2017; Donmez, Boyle & Lee, 2007; Kircher, Kircher & Ahlstrom, 2009; Kujala, Karvonen & Mäkelä, 2016; Lee, Hoffman & Hayes, 2004; Maltz & Shinar, 2007; Roberts, Ghazizadeh & Lee, 2012). Collectively, the results of these studies suggest generally high levels of driver acceptance of the warning systems. However, while perceived usefulness and trust were rated highly in most of the studies, drivers still rated the systems as annoying or distracting in about half of the studies.

Three of these evaluations included comparisons of different warning types. Lee et al. (2004) found that cognitively distracted drivers were more trusting of multi-stage than single stage visual-tactile alerts. Maltz and Shinar (2007) found that drivers perceived multi-stage auditory alarms to be more annoying and less helpful than single stage auditory alarms when drivers were distracted by a visual-manual task. Biondi et al. (2017) found that multimodal auditory-tactile warnings were no more frustrating than single modality auditory or tactile warnings when drivers were cognitively distracted. Less is known about drivers' perceptions of specific sub-components of warnings such as modality type (visual, haptic, auditory), warning intensity, and timing of the warnings. These factors contribute to the overall acceptance of warnings and are important in optimising the design of the system for final implementation. In the optimisation process, understanding the extent to which drivers notice and understand the warnings is critical. This is particularly important in the commercial vehicle context where drivers must attend to many other technologies present in modern day truck cabs. Surprisingly, there has been little research done in this area for driver distraction.

A tertiary goal of the Advanced Safe Truck Concept project (Lenné et al., 2017) was to develop a prototype driver distraction warning system. The prototype system was developed by the authors using human centred design (HCD) principles (Horberry et al., 2021) and issued warnings to drivers when they were distracted by a visual-manual secondary task. A multi-stage iterative process was adopted to design the prototype system. This included a comprehensive review of literature and HMI design guidelines; interviews and design workshops with truck drivers and stakeholders; HMI evaluation studies and finalising the HMI concepts (See Horberry et al., 2021, for full details of this process). As part of this, an evaluation method was formalised and is described in this paper.

Using the adopted evaluation methods, this paper provides an initial examination of four variations of the HMI of the prototype driver distraction warning system. The HMI was a two-level system that comprised a cautionary warning (level 1) followed by an urgent warning (level 2) if distraction persisted after the initial alert. The system was multimodal with simultaneously presented auditory alerts at both levels comprising ‘beep’ tones, a spoken warning and tactile vibration through the seat. A visual alert was also issued at the urgent (i.e., level 2) warning stage.

The primary aim was to determine whether drivers considered each of the four HMIs to be acceptable and to determine which one was most effective for alerting the driver. A secondary aim was to determine whether drivers understood and considered effective the various components of the HMIs (modality, intensity of warning) so that refinements could be made for future testing. Although the warning system was developed primarily for use in a commercial vehicle safety context, both car and truck drivers were tested given the likely applicability of the system across a range of vehicle types.

Methods

Participants

Fourteen drivers were included in the study. Eight were car drivers recruited from the Monash University Accident Research Centre (MUARC) Participant Database and six were truck drivers recruited from the general population. The mean age of the drivers was 38.4 years and three were female (21.5%). The drivers had an average of 19 years' driving experience (15 years for car drivers, and nearly 24 years for truck drivers). None reported having a diagnosed hearing impairment while one truck driver reported being colour blind. Drivers reported that they generally listened to the radio when driving and had a wide range of experience with in-vehicle technology.

Car drivers were paid $50 for their participation. Truck drivers were paid $100 as they were required to answer additional questions following the simulator drive. The study was approved by the Monash University Human Research Ethics Committee (Project Number: 8247).

Interface conditions

Two escalation timings for the driver distraction HMI prototype were tested between presentation of the first (cautionary) and second (urgent) level warnings: short-escalating (1.5 seconds from cautionary to urgent warning) and long-escalating (4 seconds from cautionary to urgent warning). The cautionary (level 1) and urgent (level 2) warnings were also tested separately in addition to a ‘no warnings’ (control) condition. The order of presentation of the interface conditions was counterbalanced between participants, with the exception of the control which was always presented third to prevent drivers expecting a warning after every distraction event. The four interface conditions are described in Table 1. Full details of the warning specifications can be found in Horberry et al. (2021).

System Acceptance Scale (SAS) and perceived effectiveness of interface conditions

Participants' subjective experience of the four interface conditions was measured using the System Acceptance Scale (SAS) (van der Laan, Heino & de Waard, 1997). The SAS comprised nine questions on two dimensions: usefulness and affective satisfying. Participants provided responses on 5-point likert scales from -2 to 2, with zero being the mid-point and higher scores indicating positive ratings. Overall system acceptance was the mean score on the usefulness and satisfying dimensions.

Table 1. Interface conditions tested

Interface condition	Description/device components
Control	No warning issued
Cautionary (Level 1)	Auditory alerting tone (70 dBA) 500 m/s later, spoken message, Australian female voice (70 dBA) ‘Pay attention’ Tactile warning (5 pulses in driver's seat, duty cycle 1), triggered at the same time as the speech message
Urgent (Level 2)	Auditory alerting tone (90 dBA) 350 m/s later, spoken message, Australian female voice (70 dBA) ‘Pay attention!’ Tactile warning (5 pulses in driver's seat, duty cycle 0.3), triggered at the same time as the speech message Visual warning: eye on road graphic as a Head Up Display (HUD) on the windscreen, triggered at the same time as the tactile and speech message
Short-escalating	The cautionary warning (level 1) followed 1.5 seconds later by the urgent warning (level 2)
Long-escalating	The cautionary warning (level 1) followed 4 seconds later by the urgent warning (level 2)

Participants were asked to rate how effective was the multimodal warning presentation for each interface condition on a four-point likert scale with: 4 very effective, 3 effective, 2 ineffective and 1 very ineffective. They were also asked to rank the four interface conditions in order of their effectiveness for alerting the driver (1 being most effective and 4 being least effective).

Comprehension

To assess whether participants understood the various modalities within the four interface conditions, the experimenter asked, 'What does the audio/speech/vibration/visual warning mean?' and 'What do the two different levels of warning mean?' Comprehension was assessed by the experimenter and measured on a scale from 0-2, where 0 represented no or incorrect understanding, 1 represented partial understanding and 2 represented full understanding.

Perceived effectiveness

To measure participants' ratings of perceived effectiveness of the various modalities within the four interface conditions the experimenter asked i) 'How effective was the audio/speech/vibration/visual warning in altering you?' overall and then separately for each level across the four interface conditions (where applicable) and ii) 'How effective was presenting all of the different warning modalities at the same time?' Participants were also asked to rate how effective was the time gap between the first and second level warnings in the short-escalating and long-escalating conditions. These were all measured on a four-point scale with: 4 very effective, 3 effective, 2 ineffective and 1 very ineffective.

Salience

To assess whether participants noticed the four interface conditions, the experimenter asked 'What warnings did you notice?' This question always preceded administration of the SAS and the comprehension and perceived effectiveness questions to ensure that participants were aware of the warnings they were being asked to evaluate and could provide valid assessments.

Post-drive open questions

Participants were asked a general question about what they thought of each of the interface conditions and to provide any further views about the HMI overall.

MUARC advanced truck driving simulator

The experiment was conducted using the Advanced Truck Driving Simulator at MUARC, which comprised a full-size Volvo truck cab with automatic transmission, a real steering wheel, brake and accelerator pedals, engine noise and low frequency vibration to simulate a running engine and cabin vibration. The simulated driving scenario was projected onto a 180-degree cylinder forward screen and a flat rear screen. Figure 1 shows the outside of the truck simulator with the front image projected.

Figure 1. Truck simulator exterior with forward road scene projection

Distraction task

Participants completed a distraction task four times throughout the drive. The distraction task was a self-paced text messaging task implemented with a 7-inch Samsung Galaxy Tab A touch screen tablet computer (Model Number SM-T280) mounted on the centre console. The distraction task required participants to read pre-generated text messages that contained phases with one word missing and type in the missing word(s) (or "pass") to complete the phrase. This task was selected to induce visual and manual input from the driver which have been shown to be significant sources of distraction when driving.

Procedure

Participants were tested individually in MUARC's advanced truck driving simulator. Upon arrival, the study was explained to participants after which they provided informed consent and completed a questionnaire designed to capture demographic and driving experience data.

Before driving, and whilst seated in the truck looking at the forward roadway, participants received each of the four interface conditions presented in counterbalanced order. Participants provided feedback after each interface condition using the salience questions and the SAS.

Participants then completed a 20-minute drive in the truck simulator. The drive took place on a single carriageway country road at between 80-100 km/h with infrequent traffic. Approximately five minutes into the drive, participants were instructed to engage in the distraction task (about 30 seconds) and were then presented with one of the four interface conditions. Participants were informed that they should 'respond in the way that you think is appropriate' after each warning. About 15 seconds after the warning had ceased, they were asked to stop the truck and provide feedback using the salience, comprehension and perceived effectiveness questions. This cycle was repeated four times (including the control, i.e., no warning) with each interface condition presented in the same counterbalanced order as per the pre-drive. At the conclusion of the drive, each interface condition was again played in turn whilst the participant was still seated in the truck, and feedback was given using the SAS. Participants then completed the post-drive open questions and were paid for their participation.

Data analysis

To test for differences across the different interface conditions and modalities, participant responses were analysed using IBM SPSS Statistics (Version 26). Given the small sample size, non-parametric testing was used. Friedman's test was used for comparisons of acceptance and effectiveness. Where significant differences were found, Wilcoxon signed-ranked tests for multiple comparisons were used with a Bonferroni correction applied to the alpha level. Wilcoxon signed-ranked tests were used to compare ratings of effectiveness between the cautionary and urgent levels within each of the audio tone, audio speech and tactile modalities. Statistical significance was set at $p \leq 0.05$.

Results

Comparisons between the four interface conditions

Salience

Prior to administration of the SAS participants were asked 'What warnings did you notice?' The warnings were issued a second time if participants reported that they did not notice one or more components. During the drive, between 1-2 participants reported not noticing the auditory tone in each condition while one participant reported not noticing the speech warning and one reported not noticing the visual warning.

Acceptability

The mean scores obtained for usefulness, satisfying and acceptance for each interface condition on the SAS are shown in Table 2. All systems were considered useful, as evidenced by all the scores being strongly positive on the usefulness dimension. In contrast, the scores for the satisfying dimension were mostly neutral or slightly negative, with only the cautionary condition achieving a positive rating. Overall acceptance was rated positively across all conditions, although slightly less so than for usefulness.

The mean ratings for the satisfying dimension differed significantly across the four conditions $\chi2(3) = 17.182$, $p = 0.001$. Post-hoc tests revealed that the cautionary condition was rated as significantly more satisfying than each of the other conditions: $Z_{long\text{-}escalating} = -3.049$, $p = 0.002$; $Z_{short\text{-}escalating} = -2.982$, $p = 0.003$; $Z_{urgent} = -2.831$, $p = 0.005$. The four interface conditions did not differ significantly on usefulness $\chi2(3) = 4.514$, $p > 0.05$, or overall acceptance $\chi2(3) = 8.951$, p = $p > 0.05$.

Perceived effectiveness

For each interface condition, participants were asked to rate how effective was the multimodal warning presentation (i.e., presenting all the warnings at the same time).

Across the four conditions the majority of participants rated the multimodal warning presentation as effective or very effective (see Figure 2). Overall, 21% of ratings were ineffective or very ineffective because participants thought the warnings created too much sensory overload or were too startling. The mean effectiveness ratings (See Table 3) did not differ significantly across the four conditions $\chi2(3) = 2.824$, $p > 0.05$.

Participants were asked to rank the four interface conditions in order of effectiveness from 1 being the most effective to 4 being the least effective. The ranking sum, and the mean, median and mode for the rankings are shown in Table 4, along with the number and percentage of participants who rated each condition as most effective.

Table 4 shows that, overall, the condition regarded as most effective was the short-escalating condition, followed by the long-escalating condition (with the cautionary and urgent conditions being equally ranked lower). However, the rankings were not significantly different $\chi2(3) = 3.794$, $p > 0.05$.

Table 2. Scores on usefulness, satisfying and acceptance for the four interface conditions

Metric Mean (SD)	**Cautionary**	**Urgent**	**Short-escalating**	**Long-escalating**
Usefulness	0.97 (0.93)	1.46 (0.61)	1.43 (0.59)	1.26 (0.74)
Satisfying	0.70 (1.0)	-0.21 (1.2)	-0.07 (1.1)	1.26 (0.74)
Acceptance	0.83 (0.78)	0.62 (0.79)	0.68 (0.68)	0.37 (0.77)

Scores ranged from -2 to 2.

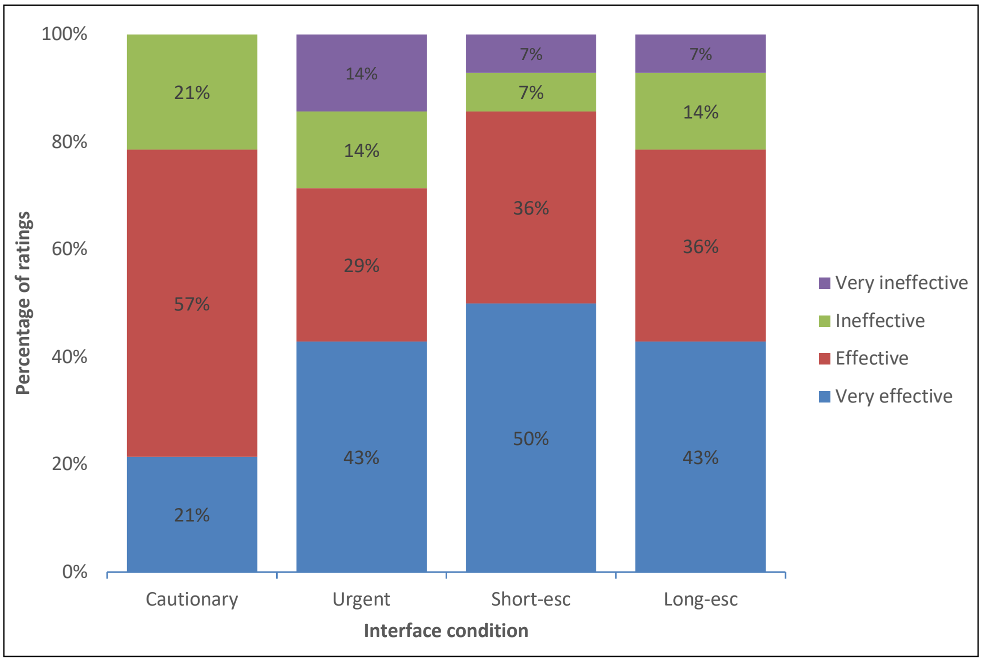

Figure 2: Percentage of effectiveness ratings for the four interface conditions

Comparison between warning modalities (audio, tactile and visual)

Salience

Participants were asked what warnings they noticed. The warnings were issued a second time if participants failed to notice one or more components. Across each of the four conditions, between 2-3 participants did not report hearing the cautionary tone warning or the urgent tone warning, and between 1-2 participants missed the speech, vibration or visual warnings.

Participants were asked whether and to what extent any background noise affected their ability to notice the warnings. All participants except one said that background noise did not affect the noticeability of the warnings.

Comprehension

Table 3. Mean effectiveness ratings (multimodal presentation) for the four interface conditions

	Cautionary	Urgent	Short-escalating	Long-escalating
Mean	3	3	3.28	3.14

Table 4. Rankings of perceived effectiveness for the four interface conditions

	Cautionary	Urgent	Short-escalating	Long-escalating
Ranking sum*	40	40	30	33
Mean ranking	2.86	2.86	2.14	2.36
Median ranking	4	3	2	2
Mode	4	3	1	1
Number of drivers who ranked as most effective	4	1	5	4
Percent of drivers who ranked as most effective	28.6%	7.1%	35.7%	28.6%

*Lower number means a higher ranking

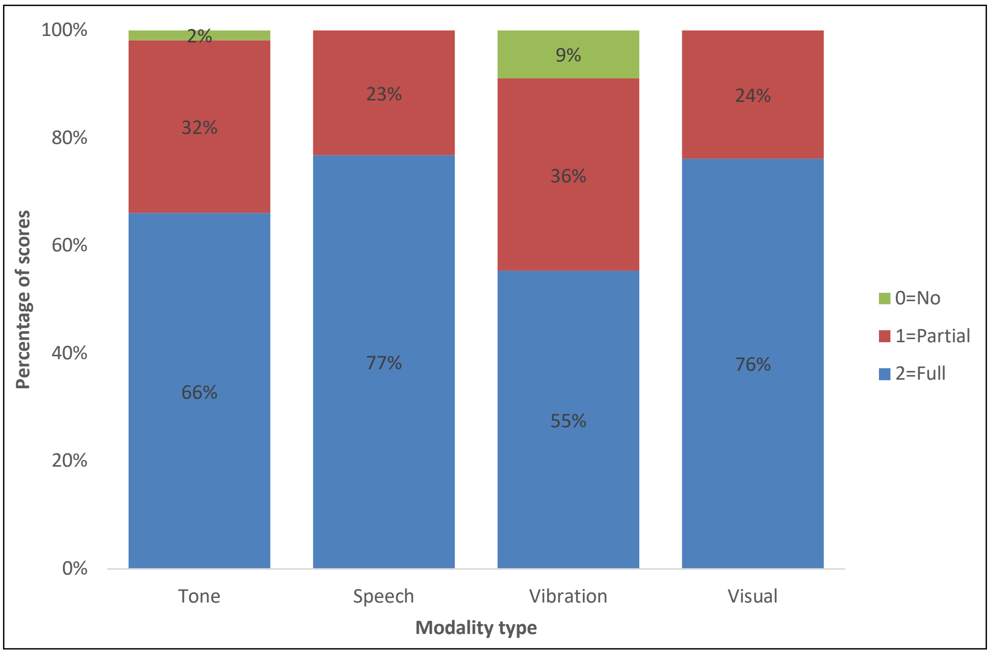

Figure 3. Percentage of no, partial and full understanding scores for the different warning modalities

For each of the four conditions participants were asked to state their understanding of each of the warning modalities - tone, speech, seat vibration, and visual warning. Figure 3 presents the percentage of comprehension scores rated as no (0), partial (1) or full (2) understanding for each modality averaged across the four conditions.

Most participants achieved full understanding across each of the four warning modalities (Figure 2). This ranged from 55% (vibration) to 77% (speech). All participants understood – either partially or fully - the audio speech and the visual warnings, while one did not understand the audio tone (i.e., scored zero) (2%) and five did not understand the seat vibration (9%). Those who did not understand the seat vibration warning thought it was a seat belt warning or audio tactile line markings.

Participants were asked to state their understanding of what the two different levels of warning meant in the short-escalating and long-escalating conditions. In the long-escalating condition, 71.4% of participants had a full understanding of the intent of the warning while the remaining 28.6% indicated partial understanding. For the short-escalating warning, 42.9% had a full understanding of the intent of the warning and 57.1% indicated partial understanding.

Perceived effectiveness

Participants were asked to provide a rating of effectiveness using a 4-point scale ranging from 1 (very ineffective) to 4 (very effective) for each of the two levels of warning separately, and then another rating for the warning overall 'as a package'. Figure 4 shows the percentage of effectiveness ratings by modality type averaged across the four warning conditions.

Participants were more likely to rate the speech warnings (Level 2 and Overall) and the Level 2 vibration warning as 'very effective' compared to the other modalities. All remaining modalities were more likely to be rated as 'effective'. The visual warning was more likely to be rated as 'ineffective' (31%) or 'very ineffective' (14%) than the other modalities. All modalities were considered slightly more effective in the escalated state, (noting that the visual warning was not used for a cautionary warning), however none of the differences were significant ($p > 0.05$).

There was a significant difference in perceived effectiveness across the four warnings ($\chi2(3) = 9.637$, $p = 0.022$) (See Table 5). Post-hoc tests showed that none of the differences were significant at the stringent Bonferroni alpha level of 0.0008, although the overall speech and the overall tone warnings were rated as significantly more effective than the visual warning at the 0.05 alpha level: $Z_{Speech} = -2.550$, $p = 0.011$; $Z_{Tone} = -2.227$, $p = 0.026$.

Participants were asked to rate how effective was the timing from the first to the second level warning. The majority rated the time gap in both conditions as effective, although this was slightly higher in the short-escalating condition (57.1%) than the long-escalating condition (50%).

Post drive open questions

All 14 participants provided feedback about the four interface conditions. In all responses the main comment was that the warnings were effective in attracting the driver's attention. Eleven participants (78%) indicated that the cautionary warning was not as noticeable as the other warnings and five (35%) noted the urgent warning was startling or a 'bit sudden' compared to the other warnings. Three participants (21%) thought the urgent or long-

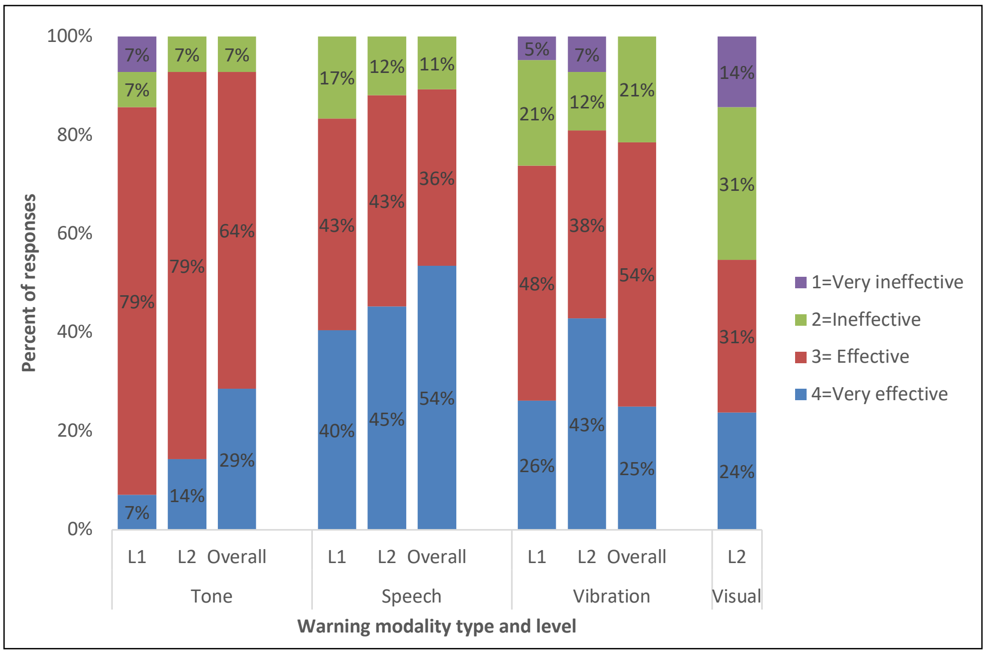

Figure 4: Percentage of effectiveness ratings for the different warning levels and modalities

escalating warnings were annoying, particularly in relation to the cautionary warning.

Five participants (35%) made mention of the two-stage conditions being especially useful for attracting attention because they provided more time for the driver to respond and were not as startling as the urgent (single level) warning. For example, '*It is better to have the warnings build up over time and with the shorter (1.5s) gap in between*' and '*the urgent warning is least preferred as it happens too suddenly*'. Two of these participants thought the gap should be reduced in the long-escalating condition while one thought it should be increased in the short-escalating condition. Conversely, two drivers thought the two-level warnings were more annoying than the single level warnings: '*My preference is for single level warnings because they are not as annoying but the multiple level warnings were more alerting and so they are probably more effective*'.

Table 5: Mean effectiveness ratings and SDs for the different warning levels and modalities

	Level	Mean & SD
Modality		
Tone	Level 1	2.93 (0.40)
	Level 2	3.07 (0.32)
	Overall	3.21 (0.51)
Speech	Level 1	3.18 (0.62)
	Level 2	3.31 (0.56)
	Overall	3.43 (0.61)
Vibration	Level 1	2.95 (0.64)
	Level 2	3.17 (0.85)
	Overall	3.03 (0.66)
Visual	Level 2	2.59 (0.91)

One participant disliked the multimodal warning presentations for the reason that '*There are already a lot of warnings especially on the dashboard and it could end up startling you so that you do something unsafe like run off the road*'. Conversely, another participant thought the warning redundancy was useful because '*if you miss one warning you'll notice another one*'.

Three participants (21%) gave positive feedback about the tactile warnings which were regarded as preferable for their unique alerting potential. '*The seat vibration is good because it is unlike any other warning*'. Two participants (14%) thought the visual warning could be distracting, particularly if drivers were drawn to look at it rather than at the road, while three participants thought the visual warning could easily be overlooked if the driver was looking away from the road. Three drivers thought the auditory speech warning was too loud/starling and two thought the auditory tone was too weak. Overall, no major issues or consistent design deficiencies were reported.

The truck drivers were asked if they thought the warnings could interfere with other in-cab devices. Only the truck drivers were asked this question due to their having direct exposure to DMS technology as part of their regular employment. Of the five drivers who answered this question, two thought the warnings might interfere with other in-cab devices because *'there are already a lot of warnings in the cabin and lots happening to distract you (especially the auditory warnings)'.* Two drivers who disagreed stated that *'all the warnings are different to each other'* and consequently there was little perceived risk of interference with other in-cab devices. One driver gave a more neutral view in which interference was thought to occur only in specific situations: *'Potentially if, for example, a low oil warning alert goes off at the same time as the distraction warning'.* No major interference from the HMI with other in-cab systems was therefore noted, overall.

Discussion

The primary aim of this study was to determine whether drivers considered each of the four HMI conditions to be acceptable and to determine which one was most effective for alerting the driver. A secondary aim was to determine whether drivers understood and considered effective the various components of the HMI conditions (modality, intensity of warning, etc.) so that refinements could be made for future testing. The four HMI conditions tested in this study were accepted by the participant group that included both experienced truck and car drivers. Although the short-escalating system was ranked as the most effective of the four HMIs, the differences were not significant. Assessment of the different warning modalities demonstrated that each one was generally noticed, correctly understood and considered effective. Equally, they were largely perceived as not likely to excessively interfere with other in-cab warnings in a truck.

As the HMI was a warning system, it is unsurprising that the scores for the satisfying dimension were neutral or slightly negative, despite an overall high level of system acceptance of the four HMIs. The cautionary warning was the only one to receive a positive score on this dimension and was rated as being significantly more satisfying than the other three warning conditions. This is likely because the cautionary warning was the least intrusive of the four warnings; it was single level, had fewer sensory modalities (i.e. no visual warning) and was issued at a lower audible volume and tactile vibrational frequency. Notably, however, some level of annoyance may be necessary in achieving the alerting function of a warning system. For example, some participants suggested that the cautionary warning was the only one that was not regarded as being overly alerting. Indeed, previous studies have also found that, despite an overall high level of acceptance of distraction warning systems, drivers also found them annoying and/or distracting (Kujala et al., 2016; Lee et al., 2004; Maltz & Shinar, 2007; Roberts et al., 2012).

Although the short-escalating system scored highest for usefulness and was ranked as the most effective of the four HMIs, the differences were not significant. A larger sample size may be necessary to verify the current findings.

All systems were generally well detected during the drive despite the simulated engine noise and cabin vibration designed to represent a typical truck use environment. Although up to three participants failed to notice one or more warning modalities during the drive, only one participant stated that background noise affected their ability to detect the vibration warning. Nonetheless, these findings underscore the importance of warning redundancy in that if one warning modality is missed, other modalities still should be detected. Previous studies have shown that multimodal warning presentations were more effective than unimodal warning presentations in reducing visual and cognitive distraction because redundancy provides an additional means of attracting the driver's attention (Biondi et al., 2017; Ho, Reed & Spence, 2007). This is supported by the results of the current study in which the majority of participants rated 'presenting all the warnings at the same time' as being effective or very effective for each condition. Four participants gave a rating of ineffective or very ineffective for at least one of the four interface conditions because they thought the warnings were too startling or could have potential to overload a driver. Thus, a balance needs to be achieved between providing adequate warning for the driver but not overloading or startling them from the use of multimodal presentations.

The auditory and speech modalities in the current warnings were perceived to be more effective than the visual warning, although these differences failed to reach statistical significance once the stringent Bonferroni adjustment for multiple comparisons was applied. A larger sample size would likely provide a better test of any real differences between warning modalities. Previous research has shown that visual warnings were not effective for attracting the attention of drivers who were looking away from the road (Campbell, Richard, Brown & McCallum, 2007) and were also ineffective, or not as effective, as collision warnings presented in the auditory or tactile modalities for attentive drivers (e.g., Campbell et al., 2007; Scott & Gray, 2008; Kiefer et al., 1999). These findings are also consistent with a number of comments made by participants that the visual warning could easily be overlooked if the driver was looking away from the road, or could be distracting, particularly if drivers were drawn to look at the warning itself rather than at the road. Future research should test the effectiveness of each of the warnings without the visual component. This would also provide a means of testing whether there is a reduction in the potential for drivers to feel overloaded and/or startled by presenting multiple warnings at once, as identified by a small proportion of participants in this study.

About a third of all drivers stated that they preferred the two-level warnings because they provided more time for the driver to respond. The two-level warnings were also thought to be beneficial because their intensity built up over time, unlike the single level urgent warning which was perceived by some to be too sudden. The gaps between the two-level warning systems were rated as being equally effective. However, some participants suggested that the four second gap was too long while the 1.5 second gap was too short to allow sufficient time for drivers to correct their behaviour and then re-orient their attention back to the road. Notably, the shorter gap was also less likely to be fully understood compared to the longer gap. Future research could test the efficacy of a two-second gap between the first and second level warning. This period is consistent with the average time it takes drivers to 'safely' avert their eyes from the road without deviating from their lane and/or experiencing a collision.

Conclusions

Overall, this study found that participants accepted the HMIs and understood the warning components and considered these to be effective. Further simulator testing with a larger sample size is recommended to validate the findings, particularly with respect to driver acceptability of the visual warning and the relative effectiveness of the two multi-level warning interfaces. On-road testing to assess the impact of the HMI on real world safety is also a necessary pre-requisite for implementation.

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Investigation of Contributing Factors to Traffic Crash Severity in Southeast Texas Using Multiple Correspondence Analysis

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Key Findings

- Contributing factors like weather condition, lighting condition, crash time, speed limit, road class, surface condition and driving risk factors are significantly associated with crash severity.
- Multiple correspondence analysis (MCA) has been successfully applied to detect patterns and identify groups of contributing factors and combinatorial influence on the severity of traffic crashes.
- Driving in adverse climate conditions such as rain and extreme weather on the wet road surface is susceptible to traffic crashes with severe injuries or even fatality.
- Driving in the dark during non-rush time is more likely to cause serious traffic accidents even with the presence of street lights.
- Young male drivers are more prone to experience severe traffic crashes when driving used vehicles in high speed under the influence of drug use and driving mistakes.

Abstract

Driving is the essential means of travel in Southeast Texas, a highly urbanized and populous area that serves as an economic powerhouse of the whole state. However, driving in Southeast Texas is subject to many risks as this region features a typical humid subtropical climate with long hot summers and short mild winters. Local drivers would encounter intense precipitation, heavy fog, strong sunlight, standing water, slick road surface, and even frequent extreme weather such as tropical storms, hurricanes and flood during their year-around travels. Meanwhile, research has revealed that the fatality rate per 100 million vehicle miles driven in urban Texas became considerably higher than national average since 2010, and no conclusive study has elucidated the association between Southeast Texas crash severity and potential contributing factors. This study used multiple correspondence analysis (MCA) to examine a group of contributing factors on how their combinatorial influences determine crash severity by creating combination clouds on a factor map. Results revealed numerous significant combinatorial effects. For example, driving in rain and extreme weather on a wet road surface has a higher chance in causing crashes that incur severe or deadly injuries. Besides, other contributing factors involving risky behavioral factors, road designs, and vehicle factors were well discussed. The research outcomes could inspire local traffic administration to take more effective countermeasures to systematically mitigate road crash severity.

Keywords

Contributing factors, Crash severity, Southeast Texas, MCA, Categorical Variable, Combination Clouds.

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Introduction

Traffic crash is widely considered as one of the leading causes of accidental human death around the world. World Health Organization (WHO) (WHO, 2018) estimates that more than 1.35 million people lose their lives every year as a result of traffic crash, and 20-50 million more victims suffer a variety of traffic crash-related injuries. Without effective countermeasures, traffic crash is anticipated to become the seventh leading cause of human death by 2030 (WHO, 2017). Within the year of 2018, 22,697 passenger vehicle occupants died, and an estimated 2.43 million people were injured from motor vehicle crashes on US roads (National Center for Statistics and Analysis, 2020). Apart from life losses and health damages, road crashes cost the U.S. $230.6 billion annually, or an average of $820 per person every year (Association of Safe International Road Travel, 2019).

Southeast Texas geographically covers Greater Houston, and Beaumont-Port Arthur metropolitan areas. The economy of Southeast Texas is composed primarily by industries relating to energy, petrochemicals, fishing, aerospace, agriculture, and tourism. Particularly, with a population of 7,066,141 residents by July 2019 and Gross Domestic Product (GDP) at 478.8 billion in 2018, Houston-The Woodlands-Sugar Land Metropolitan Statistical Area (MSA) makes it one of the largest and most economically vibrant metropolitans in the US (Greater Houston Partnership, 2020).

The general climate of Southeast Texas is subtropical, warm, moisture with heavy precipitation. Yearly, winds from the Gulf of Mexico mitigate the heat of summer and the cold of winter (Ning & Abdollahi, 2003). Southeast Texas averages more than 55 inches of rain annually and in some parts, rainfall may exceed 60 inches (Lyons, 1990). The two prominent precipitation peaks in Southeast Texas occur in between May and June and during September (Nielson-Gammon, 2011). Extreme weather such as tropical storms and hurricanes pass through the region periodically in summer and fall and would bring destructive gales, storm surges, tornados and floods on local communities (Beaman, 2019). Historically, disastrous hurricanes wreaked havoc on Southeast Texas, among which Galveston Hurricane in 1900 and Hurricane Harvey in 2017 are the most devastating.

Literature Review

Rainfall's effect on vehicle crash has been a global research focus for decades. Previous studies claimed a greater risk of road crash in the presence of rain (Andrey, Mills, Leahy, & Suggett, 2003; Qiu & Nixon, 2008). From a macroscopic view, a statistically significant linear trend exists between the number of traffic crashes and the amount of rainfall (Sherretz & Farhar, 1978). From a microscopic view examining the rainfall's impact on driving performance, people found that drivers in heavy rainfall were 3.8 times more likely to show a higher standard deviation of lane position than in clear weather (Ghasemzadeh & Ahmed, 2017). Further when investigating the crash severity, researchers found that heavy rain, deep water, and roads with a long drainage length are more likely to be associated with aggravated accident severity (Lee, Chae, Yoon, & Yang, 2018). Specifically, rain and warmer air temperatures were discovered to be linked to more serious crash injuries in single-vehicle truck crashes (Naik, Tung, Zhao, & Khattak, 2016). Nonetheless, recent study showed that wet weather, along with other factors such as male and young age tends to decrease driver injury seriousness (Li et al., 2019).

Fog is prevalent in humid regions, and it has a significant impact on driving behavior and the overall traffic safety. It was found that compared to clear day crashes, fog-related crashes tend to result in more severe injuries and involve more vehicles (Abdel-Aty, Ekram, Huang, & Choi, 2011). Foggy weather contributes to a higher odds of vehicle collisions as it deteriorates driver's vision range to less than 100 m (Tu, Li, Sun, & Dai, 2014). Poor visibility significantly increases driver's reaction time, cognitive and physiological demand, thereby impairing their skills to quickly respond to critical traffic events (Harb, Radwan, & Yan, 2007; Harb, Radwan, Yan, & Abdel-Aty, 2007). Moreover, even speed reductions are commonly implemented during fog condition by drivers, it was found to be insufficient to compensate for the crash risk (Brooks et al., 2011; Mueller & Trick, 2012).

Lighting condition invokes a controversy within academia as to how it affects driving safety. On one side, night driving is subject to many risks such as impaired vision, fatigue and inattention (Keall, Frith, & Patterson, 2004; Clarke, Ward, Bartle, & Truman, 2006). A Hong Kong study found that speeding was more likely to happen at night without road lighting, and driving in daylight featured the lowest likelihood of severe crash (Zhang, Yau, & Chen, 2013). Besides, poor illumination aggravates crash damage as some scholars found the ratio of fatal crashes per 100 collisions spiked on roads without street lighting (Plainis, Murray, & Palllikaris, 2006). On the other hand, a study from Mexico did find that drivers face greater risk of highway traffic crash in daytime compared to in nighttime. (Hijar, Carrillo, Flores, Anaya, & Lopez, 2000).

Human factor is another area of interest in traffic safety research. A great amount of research has investigated the association between crash risk and gender. Generally, male drivers have been found more likely to experience traffic crashes than female drivers (Holubowycz & Kloeden, 1994; Hayakawa, Fischloff, & Fischbeck, 2000). Besides, numerous studies have examined the effect of age on traffic crash rate and seriousness, and found that novice (young) drivers are at greater risk of traffic crash (Massie, Campbell, & Williams, 1995; Hijar et al., 2000).

As for road design, research has demonstrated that geometric design of road, traffic sign design and position have significant impacts on drivers' behavior under both normal and emergency conditions (Jamson, Tate, & Jamson, 2005; Wang & Song, 2011; Hang, Yan, Ma, Duan, & Zhang, 2018). It was also discovered that vehicle characteristics such as size, weight, and safety devices impose great impact on the consequence of traffic crashes (Evans & Frick, 1992; Huang, Siddiqui, & Abdel-Aty, 2011).

Research Goal

According to National Highway Traffic Safety Administration (NHTSA) national statistics, traffic fatality rate per 100 million vehicle miles traveled (VMT) in Texas has a higher rate than national average since 2010 (NHTSA, 2021). In 2017 alone, 3,726 people perished, and 17,538 people sustained a serious injury from motor vehicle traffic crashes on Texas roads (Texas Department of Transportation, 2018). Although the Crash Records Information System (CRIS) created by Texas Department of Transportation (TxDOT) stores exhaustive records of crashes on Texas roads since 2010, little research has utilized such database to conduct systematic traffic safety research. This study aims to identify contributing factors to the severity of traffic crashes in Southeast Texas by analyzing CRIS data. The implications of this study would assist traffic administrators in understanding the combinatorial effects of contributing factors on crash severity, thus inspire them to propose effective approaches to mitigate these risks facing local drivers.

Methods

Data Treatment

First, traffic crash data from 2010-2017 in Southeast Texas was retrieved from the TxDOT's CRIS by selecting areas: Houston-Galveston Area Council (HGAC) + Southeast Texas Regional Planning Commission (SETRPC). Then, data cleansing was conducted to remove those records with invalid or insufficient description on contributing factors. As a result, 46,063 records of crashes were retained for further analysis.

Contributing Factors

This study attempts to investigate twelve contributing factors to crash severity from four aspects including 1. Environment factor: weather condition, lighting condition, crash time, day of week and surface condition; 2. Road design factor: speed limit of road, road class; 3. Human factor: driver age, driver gender, risk factor; 4. Vehicle factor: vehicle age and vehicle body style, as shown in Table 1.

Table 1 Contributing factors

Environment factor	Weather condition, Lighting condition, Crash time, Day of week, Surface Condition
Road design factor	Speed limit of road, Road class
Human factor	Driver age, Driver gender, Risk factor
Vehicle factor	Vehicle age, Vehicle body style

All the variables within the contributing factors are transformed into categorical variables for the sake of following statistical analysis.

- Weather conditions are divided into five categories: Clear, Rain, Fog, Cloudy, and Extreme. Severe crosswinds, snow, sleet/hail, blowing sand are included within extreme weather group due to their infrequent occurrence in Southeast Texas.
- Light conditions are divided into five categories: Daylight, Dawn, Dusk, Dark Lighted, Dark Not Lighted.
- Crash time: twenty-four hours are sorted into four periods: Morning rush, Afternoon rush, Non rush daytime, Non rush nighttime.
- Day of week: days from Monday to Friday are grouped as Weekday while Saturday and Sunday are combined as Weekend.
- Surface conditions are categorized into two groups: Dry and Wet.
- Speed limits fall into three groups: Low speed limit (0-30 miles/hour), Medium speed limit (30-50 miles/hour), and High speed limit (50-80 miles/hour).
- Road Class is divided into three categories: Farm to Market, US & State Highways, Interstate.
- Driver age has four categories: 16-30, 31-45, 46-60, 60+.
- Driver gender is divided as Male and Female.
- Risk factors include fourteen groups, according to CRIS, Texas DoT. They are: 1. Cellphone Use 2. Distraction 3. Driver Inattention 4. Driving Errors 5. Drug Driving 6. Drunk Driving 7. Emergency 8. Failure in driving 9. Fatigue 10. Inability 11. Invalid Driver 12. Risky Driving 13. Taking Medication 14. Unsafe vehicle Condition.
- Vehicle body style contains five categories: Big Vehicle, Motorcycle, Pickup, Sedan and SUV.
- Vehicle age is divided as New, Used, Old.

Definitions of the relevant terms are provided in an appendix at the end of this research article.

Chi-squared Test

Firstly, an approach of nonparametric statistical analysis called chi-squared test for independence is performed to examine whether there exists statistically significant association between multiple contributing factors and the seriousness of crash injury in 3 levels: minor injury, severe injury and fatality. For each contributing factor, the Pearson statistic is calculated by summing up the variabilities between the actual observed frequency (O) in different crash severities and expected frequency (E) corresponding to that type of severity at a given categorical level of contributing factor, shown as Equation (1):

$$\mathcal{X}^2 = \sum \frac{(O-E)^2}{E} \tag{1}$$

The summary of chi-squared test results with significance level set to 5% is presented in Table 2.

Table 2. Chi-squared test examining associations between contributing factors and crash severity

Contributing Factor	Crash Severity		
	*	DOF	P-value
Crash time	950.25	6	< 0.001
Day of week	209.09	2	< 0.001
Light Condition	927.11	8	< 0.001
Road Class	73.559	4	< 0.001
Speed Limit	278.13	4	< 0.001
Surface Condition	38.143	2	< 0.001
Weather Condition	61.032	8	< 0.001
Vehicle Body Style	924.35	8	< 0.001
Vehicle Age	39.765	4	< 0.001
Driver Age	11.236	6	0.08136
Driver Gender	246.23	2	< 0.001
Risk Factor	961.79	26	< 0.001

Note: * Significant at 5% level.

Multiple Correspondence Analysis (MCA)

In addition to the chi-squared test for examining the associations between each contributing factor and the levels of crash severity from a quantitative perspective, we propose the use of multiple correspondence analysis (MCA) as a type of geometric data analysis technique (Le Roux & Rouanet, 2004) to implement unsupervised (machine) learning for clustering and identifying traffic contributing factors with similar frequency of coincidence from the large, complex multivariate dataset of crash records. Graphical illustrations of these clusters in the form of "combination clouds" (Das & Sun, 2015). are developed on the dimensionality-reduced factor map, allowing us to recognize the distribution pattern of variable groupings on a lucid 2-dimensional space and study the combinatorial effects of clustered variable categories on the crash severity. Other advantage from utilizing MCA approach involves that it does not require any pre-assumption of underlying relationships between responses and predictor variables before the analysis of data (Das & Sun, 2016).

In this research, the application of MCA primarily focuses on the clustering and identification of significant contributing factors responsible for traffic crashes where drivers get severely injuried or even killed. Therefore, only traffic crash records with crash severity specified as "Severe Injury" and "Killed" are considered in the MCA study, consequently the total number of selected crash records reduces to 11,650. Table 3 enlists a summary of all the categorical variables in contributing factors that participate in the MCA with corresponding levels of category, frequency and percentage specified, the statistical significance of involved factors has been examined in the Chi-squared tests. To implement the MCA computation, an open source statistical software R Version 4.0.2 is used with the aid of FactoMineR package for data analysis and factoextra package for data visualization (Husson & Pagès, 2011).

Historically developed in Benzécri's treatise on data analysis in 1973 (Benzécri, 1973; Beaudouin, 2016), multiple correspondence analysis is regarded as an extension of the simple correspondence analysis (CA) which allows the user to analyze the pattern of relationships between multiple dependent nominal variables with a large amount of data. It can be also seen as analogous to principal component analysis (PCA) where the variables to be analyzed are categorical instead of quantitative (Abdi & Valentin, 2007; Abdi & Williams, 2010). Similar as PCA, MCA also employs a dimension-reducing technique to extract the most important information from a given data set and produces a low-dimensional representation of the data while containing maximum variation (Abdi & Valentin, 2007; James, Witten, Hastie, & Tibshirani, 2013). For years, Bourdieu (Lebaron, 2009; Duval, 2018) has contributed significantly to the popularization of CA and MCA

Table 3. Summary of contributing factors

Categorical Variables	Category Level	Frequency	Percentage (%)
Driver Age	16-30	5514	47.33
	31-45	3117	26.755
	46-60	1998	17.15
	60+	1021	8.764
Driver Gender	Female	4007	34.395
	Male	7643	65.605
Vehicle Age	New	6476	55.588
	Used	4811	41.296
	Old	363	3.116
Crash Time	Afternoon Rush	1831	15.717
	Morning Rush	1285	11.03
	Non Rush Daytime	4101	35.202
	Non Rush Nighttime	4433	38.052
Day of Week	Weekday	7549	64.798
	Weekend	4101	35.202
Light Condition	Dark, Lighted	3043	26.12
	Dark, Not Lighted	2137	18.343
	Dawn	174	1.494
	Daylight	6130	52.618
	Dusk	166	1.425
Weather Condition	Clear	8513	73.073
	Cloudy	2080	17.854
	Extreme	9	0.077
	Fog	127	1.09
	Rain	921	7.906
Road Class	Farm to Market	3435	29.485
	Interstate	3016	25.888
	US & State Highways	5199	44.627

Categorical Variables	Category Level	Frequency	Percentage (%)
Speed Limit	High Speed Limit	6283	53.931
	Medium Speed Limit	13	0.112
	Low Speed Limit	5354	45.957
Surface Condition	Dry	10266	88.12
	Wet	1384	11.88
Vehicle Body Style	Big Vehicle	946	8.12
	Motorcycle	997	8.558
	Pickup	2696	23.142
	Sedan	4855	41.674
	SUV	2156	18.506
Risk Factor	Cellphone Use	21	0.18
	Distraction	62	0.532
	Driver Inattention	491	4.215
	Driving Mistake	535	4.592
	Drug Driving	132	1.133
	Drunk Driving	835	7.167
	Emergency	62	0.532
	Failure in Driving	6261	53.742
	Fatigue	177	1.519
	Inability	86	0.738
	Invalid Driver	121	1.039
	Risky Driving	2837	24.352
	Taking Medication	5	0.043
	Unsafe Vehicle Condition	25	0.215

applications in French-language scientific communities. In spite of a certain rarity of MCA-related research published in English-language publications that promote hypothetico-deductive approaches (Beaudouin, 2016), multiple correspondence analysis has recently found extensive applications in academic fields in social science including economics (Parchomenko, Nelen, Gillabel, & Rechberger, 2019), education (Costa, Santos, Cunha, Cotter, & Sousa, 2013; Kalayci & Basaran, 2014), psychology (Rodriguez-Sabate, Morales, Sanchez, & Rodriguez, 2017), public policy (Esmaelian, Tavana, Di Caprio, & Ansari,2017), and archaeology, etc. (Macheridis & Magnell, 2020) In particular, the use of MCA in transportation research receives increasing attention in recent years: Das and Sun studied vehicle-pedestrian crashes and fatal run-off-road crashes by using MCA approach (Das & Sun, 2016). Other researchers applied the same methodology into various traffic crash scenarios through different angles of research. (Factor, Yair, & Mahalel, 2010; Mitchell, Senserrick, Bambach, & Mattos, 2015; Jalayer & Zhou, 2016; Jalayer, Pour-Rouholamin, & Zhou, 2018). In addition, Chauvina expanded the application scope of MCA to maritime accidents analysis (Chauvin, Lardjane, Morel, Clostermann, & Langard, 2013). To our knowledge, no previous study using multiple correspondence analysis has been performed to recognize the associated contributing factors in severe traffic crashes from Texas area, where the regional traffic fatality rate is considerably high compared with the national average (NHTSA, 2021) and underlying causes need to be ascertained.

The theoretical foundation of multiple correspondence analysis (MCA) is intricate and has been well elucidated in previous publications (Benzécri, 1973; Roux & Rouanet, 2010). The core component in MCA is an indicator matrix (also called complete disjunctive table) in which the columns of table refer to the categories of qualitative variables corresponding to various contributing factors in crash analysis while the rows represent each individual crash record (Greenacre, 1993; Greenacre & Blasius, 2006). The point clouds of individuals and categories (Le Roux & Rouanet, 2004) are built through the calculation of inter-individual and inter-category distances, distance of points to the origin and total inertia of point clouds based on the components in the complete disjunctive table. The relevant mathematical description is accessible from the online tutorial of Husson's textbook and previous MCA-related publications (Das & Sun, 2015; Das & Sun, 2016); thus, it will not be detailed in this research. Table 4 provides a summary of relevant parameters in the indicator matrix and equations for creating point cloud of individuals and categories, respectively.

Results

From Table 2, it is shown that the majority of the selected contributing factors have large and P-values lower than 0.05, which suggests they are significantly associated with the crash severity levels. One exception comes from the factor of driver age with a P-value larger than the specified significance level. While this implies the current classification of driver's age as "16-30", "31-45", "46-60", "60+" is not sensitive to the variance in crash severity, we do find other way of grouping driver's age with fewer bins can yield a P-value less than 0.5 and larger . For the purpose of doing comprehensive cluster analysis on contributing factors in the following research, the current categorization of the factor "Driver Age" is preserved for further discussion.

In Figure 1, a panoramic 2-dimensional MCA factor map is presented in which a point cloud of all variable categories and associations among categories can be explicitly visualized based on the closeness between category points on the map. The factor plot shows the distribution of coordinates of all the variable categories on an orthogonal coordinate system constituted by two principal dimensions: Dim1 and Dim2. Like Principal Component Analysis (PCA), MCA assumes the dimension with largest variance is perceived as the most principal direction which has the maximum eigenvalue. Shown in Table 5, the eigenvalue, percentage of variance of first 10 dimensions are listed in a descending order with corresponding cumulative percentage of variance. It is observed that the first two principal dimensions only account for 10% variation of the original data. This reveals the heterogeneous and complex nature of the contributing factors involved in traffic crash dataset where there are 12 categorical variables and 11,650 individual data points, leading to high level of variability and uncorrelatedness.

The pattern of the point cloud of category can be interpreted in three aspects: first, the distance between any variable categories reflects a measure of their correlations, combination clouds can be created when some variable categories are relatively close (Das & Sun, 2016). Second, negatively correlated variable categories are located on the opposite sides of the origin of the factor plot, i.e., the coordinates of "Morning Rush" and "Weekend" (see dashed box), alluding that the occurrence of morning rush is not likely to happen on the weekend which is line with common sense. Third, the distance between category points and the origin reflects the quality of the variable category in a 2-dimensional orthogonal coordinate. From Figure 1, it is clear to see category points of "Daylight", "Dark, Lighted", "Dark, Not Lighted" and "Non Rush Nighttime", "Non Rush Daytime" are spreading out over the 1st principal dimension which indicates the categorical levels in the contributing factors "Crash Time" and "Light Condition" can be distinctly classified along the Dim 1. Similarly, the weather condition of "Rain", "clear" and surface condition of "Wet", "Dry" can be easily characterized by using Dim 2. As a result, these particular variable categories are better represented among other categories on the current factor map.

Table 4. Description of relevant parameters and equations for point clouds of individuals and categories

Parameters	Description
G_I	Center of gravity of the point cloud of individuals
G_J	Center of gravity of the point cloud of categories
I	Total number of the individuals i
$1/I$	The weight of an individual
J	Total number of the qualitative categorical variables j
K	Total number of categories k in all variables
K_j	The number of categories in the given variable j
N_I	Total inertia of the point cloud with I individuals
N_J	Total inertia of the point cloud with J categorical variables
O_{R^I}	The origin in the space R^I, $G_I = O_{R^I}$
O_{R^J}	The origin in the space R^J, $G_J = O_{R^J}$
p_k	The proportion of individuals in category k
v_{ij}	Category of j-th variable possessed by the i-th individual
y_{ik}	= 1 if the i-th individual is in k-th category of the j-th variable (for each p_k); = 0 otherwise

Point cloud	Distance between a pair of points in the cloud	Distance between points and origin	Total inertia
Individuals	$d^2_{(i,i')} = \frac{1}{J}\sum_{k=1}^{K}\frac{1}{p_k}(y_{ik} - y_{i'k})^2$	$d^2_{(i,G_I)} = \frac{1}{J}\sum_{k=1}^{K}\frac{y_{ij}}{p_k} - 1$	$N_I = \frac{K}{J} - 1$
Categories	$d^2_{(k,k')} = \frac{p_k + p_{k'} - 2p_{kk'}}{p_{kk'}}$	$d^2_{(k,G_J)} = \frac{1}{p_k} - 1$	$N_J = \frac{K}{J} - 1$

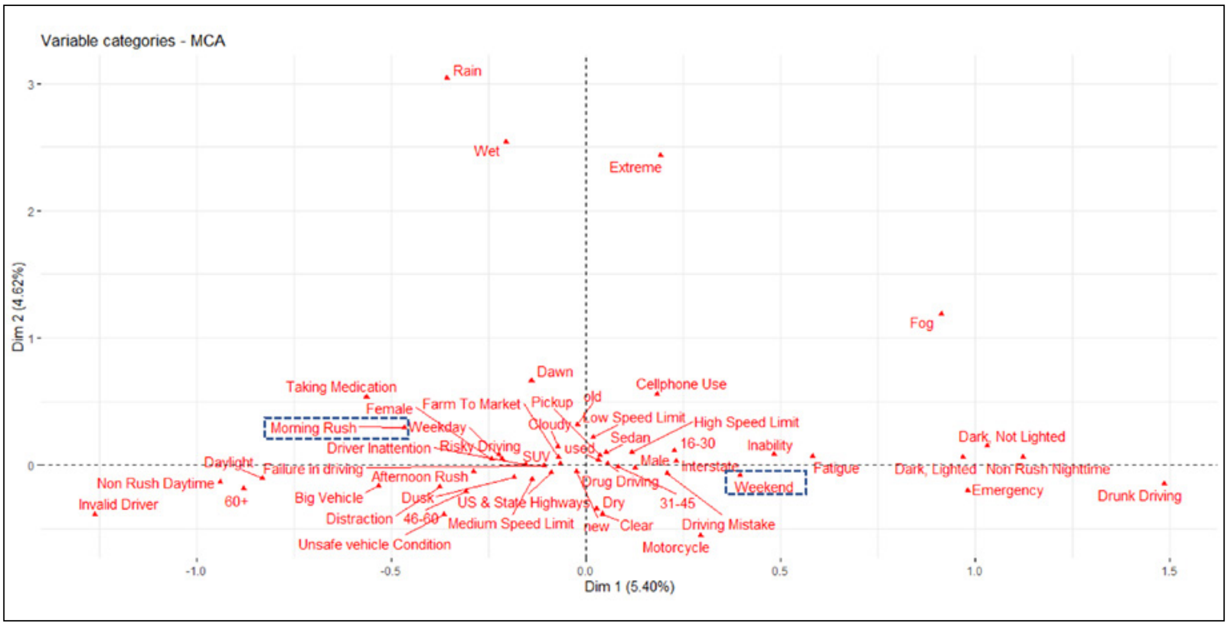

Figure 1. MCA factor map for variable categories

Table 5. Eigenvalues and percentages of variance of the first 10 dimensions

	Eigenvalue	Percentage of Variance	Cumulative Percentage of Variance
Dim 1	0.1801	5.4033	5.4033
Dim 2	0.1541	4.6224	10.0257
Dim 3	0.1223	3.6703	13.6960
Dim 4	0.1141	3.4230	17.1190
Dim 5	0.1065	3.1943	20.3133
Dim 6	0.1029	3.0879	23.4012
Dim 7	0.1003	3.0103	26.4115
Dim 8	0.0959	2.8756	29.2871
Dim 9	0.0933	2.7979	32.0851
Dim 10	0.0907	2.7208	34.8059

The quality of a variable category can be quantified by its contribution (in %) to the definition of principal dimensions. The larger the percentage value of a category to a given dimension, the more it can explain the variability in the dataset along that dimension. Shown in the Figure 2(a), 2(b), two bar plots demonstrate the most contributed variable categories to Dim 1 and Dim 2, respectively, only top 10 categories are displayed in each plot. It is evident to see contributing factors of "Crash Time" and "Light Condition" are the dominant categorical variables in the 1st principal dimension while "Weather Condition" and "Surface condition" account for the most variances in the 2nd principal dimension.

Discussion

Four combination clouds are created on the factor map shown collectively in Figure 3. In each cloud, several points of variable category are clustered together based on their relative proximity and interestingness. In the combination cloud 1, three types of variable categories are grouped into the cloud: "Rain", "Wet" and "Extreme", which indicates the occurrences of traffic crashes leading to severe injuries and fatality are significantly correlated with adverse weather conditions like rain and extreme climate events. The wet and slippery road surface, as the byproduct of rainy and humid climate is very likely to cause the serious traffic crashes. These findings accord with the conclusions drew from previous studies (Sherretz & Farhar, 1978; Andrey, Mills, Leahy, & Suggett, 2003). The second combination cloud encompasses variable categories of "Dark, Not Lighted", "Dark, Lighted", "Non Rush Nighttime" and other categories like "Fatigue", "Emergency" and "Drunk Driving". This combination can be explained by the fact that driving in complete darkness during non-rush time at night can be risky to cause severe or even fatal traffic crashes even in the presence of street lights. The inclusion of other two risk factors implies that drunk driving can be dangerous and should be strictly prohibited by law while driving in an emergency condition is also prone to severe traffic crashes partly due to the prevalence of incompetence and inexperience of drivers in safely handling emergency driving situations.

Combination cloud 3 and 4 are relatively closer to the origin of the coordinate, implying the included variable categories are less-represented by the current two principal dimensions. However, a careful examination of these two combination clouds still yields some meaningful information about the potential contributing factors linked to severe traffic crashes. In combination cloud 3, it is obvious to see male drivers in their young and early middle adulthood (ages between 16 to 45), driving used sedans

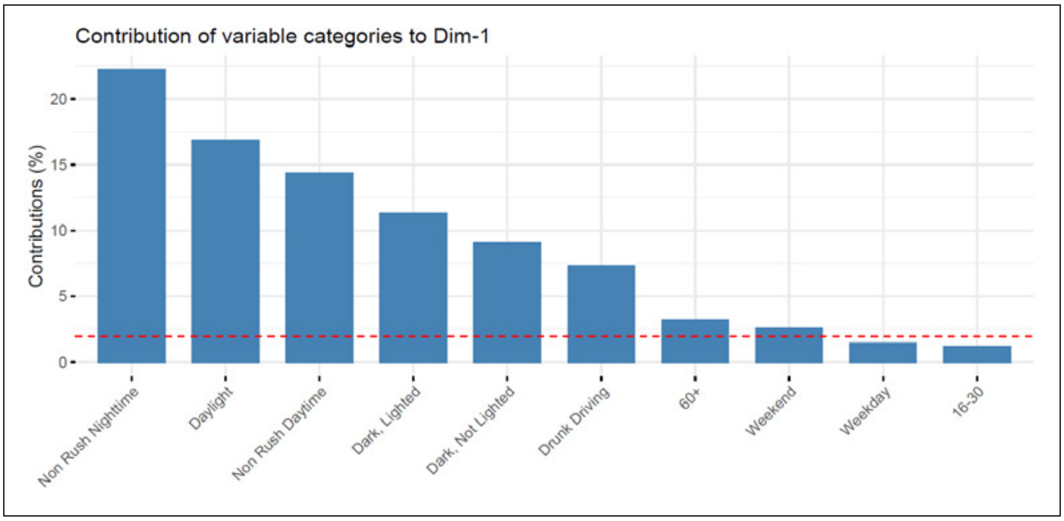

Figure 2(a). of variable categories to the 1st principal dimension

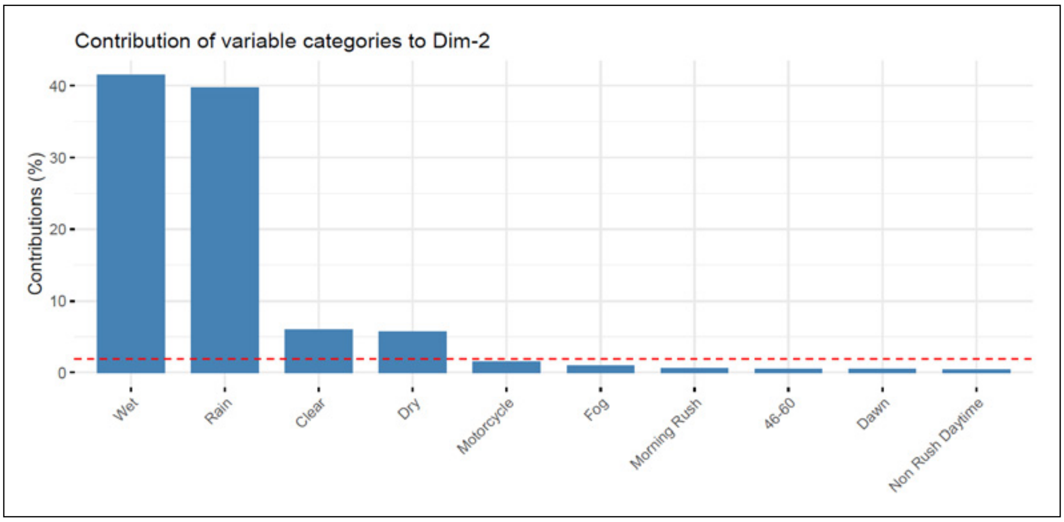

Figure 2(b). Contribution of variable categories to the 2nd principal dimension

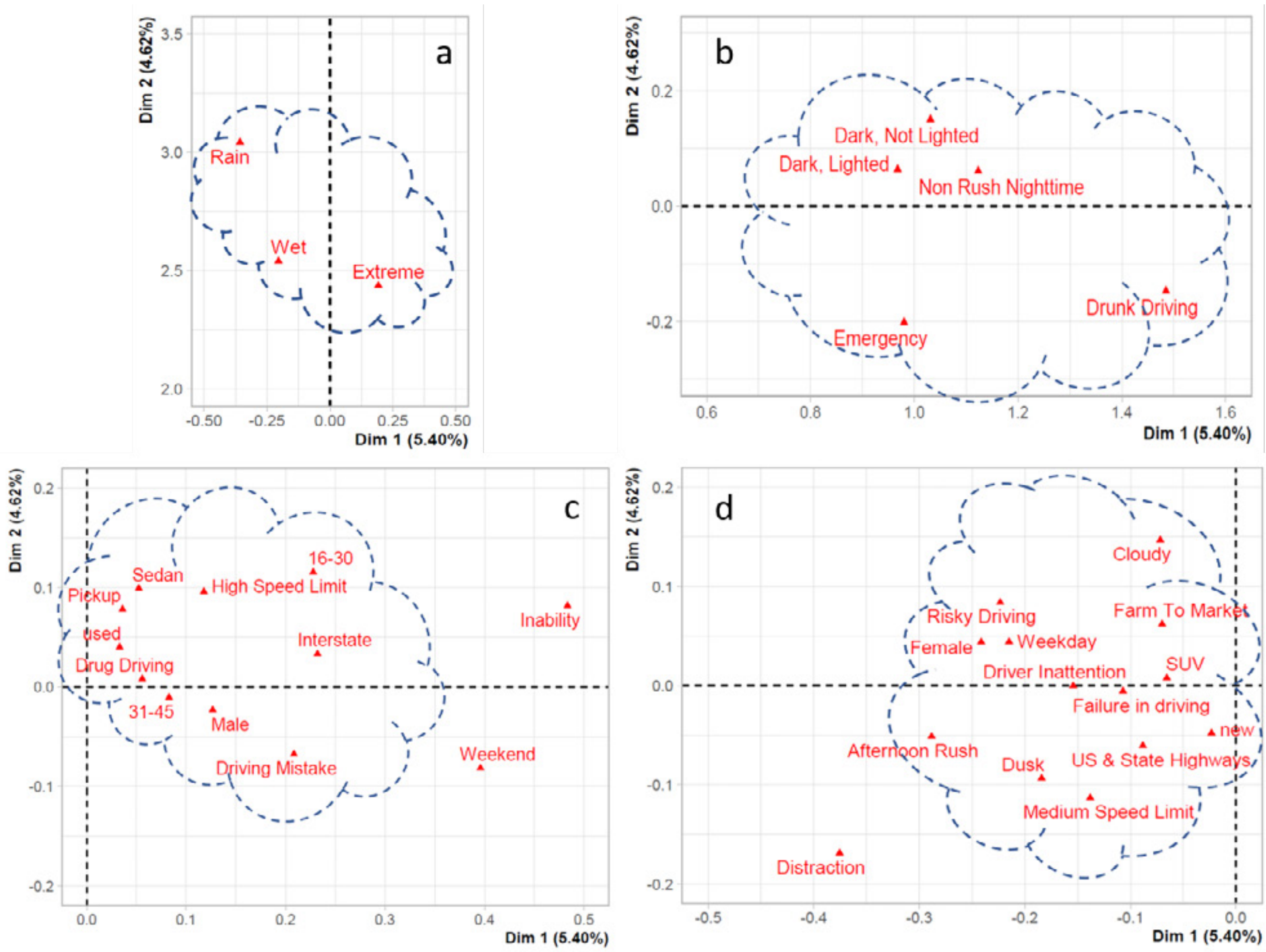

Figure 3 (a-d) Combination cloud 1; Combination cloud 2; Combination cloud 3; Combination cloud 4

or pickups on interstate roads in high speed are highly associated with traffic crashes resulted in serious injuries and fatality. In addition, risky behavioral factors like drug driving and driving mistakes are usually concurrent with the traffic accident scenarios described above, the underlying association is also confirmed by previous studies where evidences of link between drug consumption and motor vehicle crashes with high morbidity were provided (Sewell, Poling, & Sofuoglu, 2009; Romano & Voas, 2011). Therefore, stricter drug-related traffic laws need to be enacted to curb drugged driving among young drivers in the future. Combination cloud 4 relates some different variable categories such as “Driver Inattention”, “Failure in driving”, “Risky Driving”, “Female”, “Afternoon rush” and “Dusk”, etc. This combination indicates insufficient attention to driving details and improper driving habits are likely to cause severe crashes among female drivers during the afternoon rush hour in weekdays. Moreover, driving on Farm-to-market road and State Highways in the rural area where street lights are usually sparsely distributed in a cloudy weather or at dusk is more likely to cause higher traffic crash severity and fatality, this might be due to the insufficient lighting in the abovementioned scenarios that reduce the drivers’ visibility and perception to the ambient environment. This analysis is endorsed by other research (Jägerbrand & Sjöbergh, 2016) which confirms the relationship between road lighting and traffic safety because of light condition’s impact on visual performance during driving.

In sum, a multivariate statistical method of multiple correspondence analysis (MCA) has been applied to identify the associated contributing factors that contribute to traffic crashes resulting in severe injuries and fatality to the drivers. The use of combination clouds gives explicit graphical display of multiple clusters of variable categories, from which the impact and combinatorial effect of various factors can be easily interpreted in different traffic crash scenarios. Despite the achievements from applying MCA approach in this crash factor analysis, a limitation should be pointed out that because of the highly uncorrelated structure of the traffic crash dataset that contains a dozen of categorical variables and a large volume of individual crash data points, only 10% of the total variance is retained by the selected two principal dimensions. This may lead to an underrepresentation of some contributing factors based on the current 2-dimensional factor plot. Therefore, further analysis on the MCA factor map constituted by 3rd and 4th principal dimensions might be needed to ensure the significance of other combinations of variables is examined.

Conclusions

In this study, traffic crash analysis based on the historical crash data from Southeast Texas area has been performed to identify the significant contributing factors that affect the severity of traffic crashes. Pearson’s chi-squared test reveals that factors like weather condition, lighting condition, crash time, speed limit, road class, surface condition, risk factor have statistically significant associations with different levels of crash severity. Moreover, multiple correspondence analysis (MCA) is implemented to identify groups of contributing factors and study their combinatorial influence on severe crash-induced injuries and fatality by creating a number of combination clouds on the factor map. Based on the relative closeness of variable categories on the 2-dimensional space, category points from multiple contributing factors are clustered together and form combination clouds that provide a collective graphical view of the potential traffic scenarios in which deadly crash can take place. Upon the analysis on the elements contained in these combination clouds, following indications can be achieved:

- Driving in adverse climate conditions like rain and extreme weather on the wet road surface has a higher chance to cause traffic crashes with severe injuries or even fatality.
- Driving in a complete dark environment during non-rush time regardless of the presence of street lights is more likely to induce serious traffic accidents mainly because of the poor light condition. Behaviors like drunk driving and driving in emergency condition can impose more risks on the drivers and result in severely injured or fatal crashes.
- Male drivers in youth and early middle adulthood are more prone to traffic crashes ended up in being seriously injured and killed when they are driving used vehicles in high speed on the interstate road under the detrimental effects of drug use and resultant driving mistakes.
- Risk factors like driving inattention, risky driving and failure in driving are likely to the cause crashes with high severity among female drivers during the afternoon rush in the weekdays.
- Driving on Farm-to-market roads and State Highways at dusk or in the cloudy weather is subject to traffic crashes with higher crash severity and fatality, which can be explained by the insufficiency of ambient light condition that leads to reduced visibility and shorter reaction time of drivers to avoid the accident.

In spite of the limitation of MCA application in this research which might underrepresent the significance of other clusters of contributing factors due to the relatively low variance explained by the first two principal dimensions, the graphical representation of the clustered factors helpfully shed light on the traffic crashes causing severe injuries and death, where assorted contributing factors are playing a combinatorial role in the occurrence of the crash. Based on the results from this crash analysis using MCA method, the following improvements are advised: 1. Remediation of road infrastructure issues related to surface and light conditions on the roads. 2. Modification of current traffic codes and enactment of stricter law to control risky driving behaviors. 3. Delivering more targeted driving safety education to drivers of different ages and genders accordingly

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Appendix

Definitions of traffic safety related terms

Term	Definition
Driving mistake	The term driving mistake is synonym for driving error which can be classified into four categories according to 1. recognition errors (inadequate surveillance, internal distraction, and external distraction), 2. decision errors (speeding, illegal maneuver, aggressive driving) 3. performance errors (overcompensation, poor directional control) 4. critical non-performance errors (fatigue, sleeping, physical impairment) [6,8] [6] K. Rumar, The basic driving error: late detection, Ergonomics 33 (1990) 1281-1290. [8] J. Treat, A study of pre-crash factors involved in traffic accidents, HSRI Res. Rev. 10 (1980) 1-35.
Failure in driving	Failure in driving is a general term that encompasses any types of human error that take place during driving (e.g. fail to control speed, fail to pass to left safely). Details are listed in https://cris.dot.state.tx.us/public/Query/app/query-results/list
Emergency	In this study emergency refers to any sudden, abnormal circumstance that affects safe driving and calls for immediate action to cope with, e.g. animals crossing the road.
Big vehicle	Big vehicle generally refers to any large and heavy vehicles weighing more than 4.5t, such as truck, bus, fire truck.
New vehicle	In this research, we group the vehicles with ‘Vehicle Age’ from 0 to 9 years as ‘New vehicle’, ‘Vehicle Age’ means the age of a vehicle computed by totaling the number of the years in between and including both the calendar year and the model year.
Used vehicle	‘Vehicle Age’ from 10 to 19 years as ‘Used vehicle’
Old vehicle	‘Vehicle Age’ from 20 to 27 (maximum year in the dataset) as ‘Old vehicle’.
Crash time	Crash time is divided into 24 groups: 00:00-00:59 as “0”; 01:00-01:59 as “1”; 02:00- 02:59 as “2”; 03:00-03:59 as “3”; 04:00-04:59 as “4”; 05:00-05:59 as “5”; 06:00-06:59 as “6”; 07:00-07:59 as “7”; 08:00-08:59 as “8”; 09:00-09:59 as “9”; 10:00-10:59 as “10”; 11:00-11:59 as “11”; 12:00-12:59 as “12”; 13:00-13:59 as “13”; 14:00-14:59 as “14”; 15:00-15:59 as “15”; 16:00-16:59 as “16”; 17:00-17:59 as “17”; 18:00-18:59 as “18”; 19:00-19:59 as “19”; 20:00-20:59 as “20” 21:00-21:59 as “21”; 22:00-22:59 as “22”; 23:00-23:59 as “23”. Next, numbers of 6,7,8 are grouped as “Morning Rush”, numbers of 17,18,19 are grouped as “Afternoon Rush”, numbers of 20, 21, 22, 23, 0, 1, 2, 3, 4, 5 are grouped as “Non Rush Nighttime”, numbers of 9, 10, 11, 12, 13, 14, 15, 16 are “Non rush daytime”

Road Safety Policy & Practice

What does it Take to Improve Road Safety in Asia?

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Key Findings

- Critically reviews road safety policy and practices in Asian countries;
- Despite government efforts, road fatalities are increasing in Asia;
- Accurate fatality data, VRUs, long-haul trucks, leadership and stakeholder coordination are major issues;
- Suggest taking comprehesive and holistic low-cost approach appropriate for LMICs along with best practice successful demonstration LMIC road safety projects to improve safety.

Abstract

Despite global, regional, and national efforts in reducing the number of road crashes, the number of fatalities from these crashes is increasing globally as well as in Asia. The Asia-Pacific region currently accounts for 60% of global road fatalities. There are wide variations in the number of road fatalities among the regions, subregions, and countries. Within Asia, the South and South-West Asia subregion has the highest fatality rate of 20.3 fatalities per 100,000 population followed by South-East Asia with a fatality rate of 17.8 per 100,000 population. This paper reviews and analyses the road safety situation and implementation of road safety policies and practices in Asian countries. Identified are distinct risk factors that demand priority consideration. Some of the actions suggested for improving road safety in Asia are: Ensuring the availability of accurate road safety data, addressing the challenges of Vulnerable Road Users and powered two-wheelers, changing behaviors of road users and long haul drivers, ensuring safety features in trunk routes, improving infrastructure and facilities for non-motorised and public transport in cities, prioritising safety in rural and remote areas, empowering road safety institutions with accountability, focusing on low-cost solutions, and advocacy and education.

Keywords

Road safety, fatalities, Asia, policies, vulnerable road users, data, governance

Introduction

Road safety has attracted considerable global, regional and national attention after the adoption of the period 2011-2020 as the Decade of Action for Road Safety (WHO, 2011), the inclusion of road safety in two targets of the Sustainable Development Goals (SDG) (UN, 2015) and the adoption of several resolutions on road safety by the United Nations. Asian countries are implementing various road safety policies, action plans and projects. Despite these efforts, the number of road crashes and fatalities is increasing in Asia (WHO, 2018), with the fatality rate being especially high in many Asian countries. Progress in improving road safety varies between countries (Wegman, 2017).

The first Decade of Action (2011-2020) has ended with many Asian countries missing the SDG target 3.6 to halve the number of global deaths and injuries from road traffic crashes by 2020. Given that road crashes still represent a leading cause of mortality, the United Nations again proclaimed the period 2021-2030 as the Second Decade of Action for Road Safety with the objective of reducing fatalities and injuries by 50% by 2030 and encouraging efforts to improve road safety in developing countries (UN, 2020). Development of a new global plan of action for the second decade is progressing and provides the opportunity for countries to refine their national road safety policies and practices to reduce traffic crashes, injuries, and fatalities. The World Health Organisation (WHO) has

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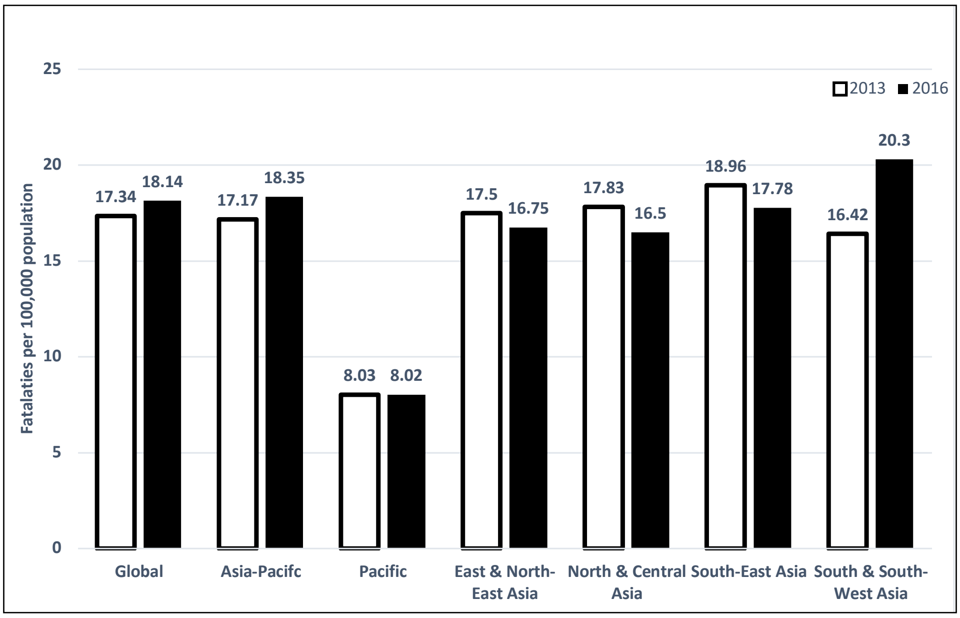

Figure 1: Fatalities per 100,000 population (Source: WHO, 2015 and 2018)

also recently published "Towards the 12 voluntary global targets for road safety", a guidance note on 12 road safety risk factors which were identified by several members of the United Nations Road Safety Collaboration (Van den Berghe, et al., 2020).

A revisit of national policies and action plans, tackling of key risk factors and a thorough analysis of local environment and practices is necessary to determine why global and national responses to road safety did not bring anticipated results.

In this context, the paper reviews the current situation of road safety in Asia and analyses the challenges and causes for limited progress. It will focus on identifying key risk factors and potential low-cost priority areas to improve road safety.

Method

The paper includes both quantitative and qualitative analyses of road safety data, policies, and practices. It reviews the road safety situation and implementation of road safety policies, action plans and practices in Asian countries. It also reviews relevant materials and literature on road safety and compiles some good practices in the Asian context. It utilises information from WHO and country reports, and data and feedback received from road safety stakeholders at three meetings held in Kathmandu[1],

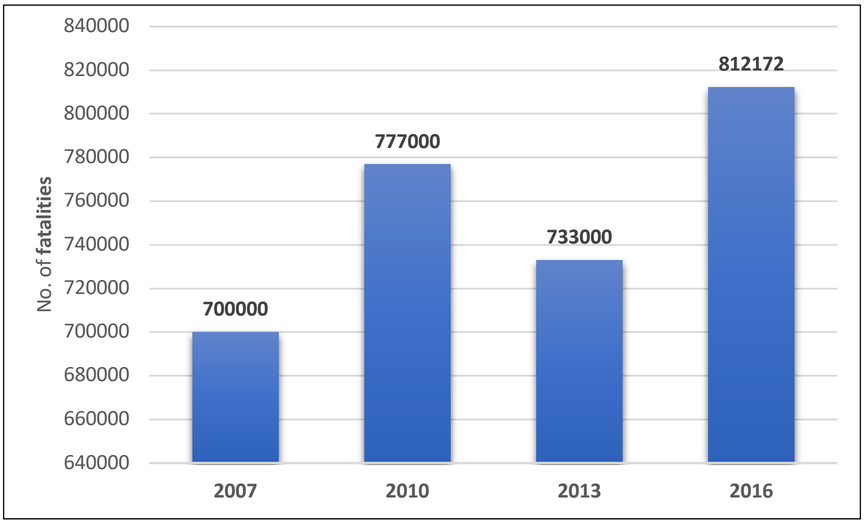

Figure 2: Fatalities from road crashes (Sources: WHO reports 2009, 2013, 2015 and 2018)

[1] National Capacity Building Workshop on Road Safety, 19-22 March 2019, Kathmandu

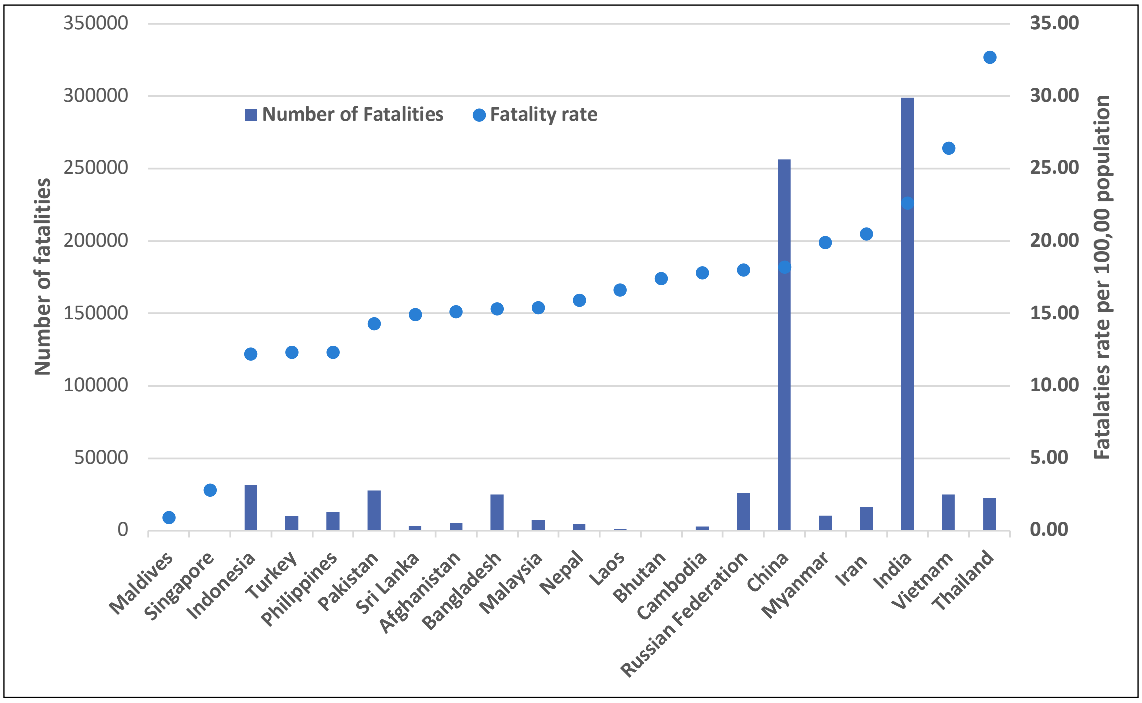

Figure: 3: Estimated road fatalities in Asian countries (Source: WHO, 2018)

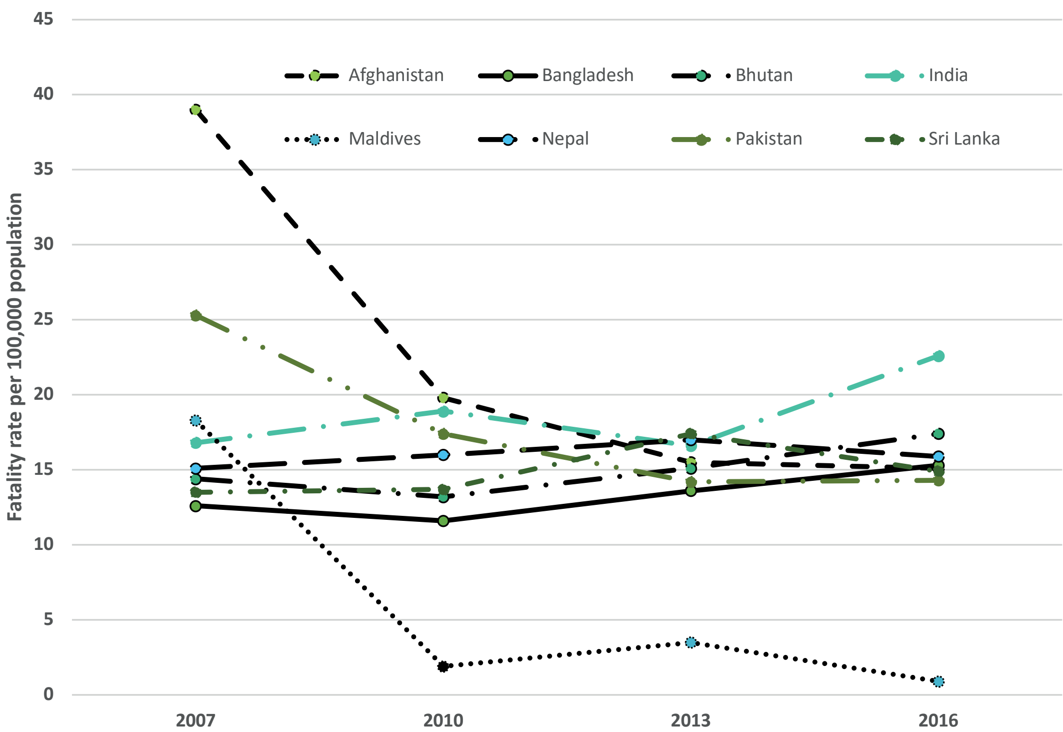

Figure 4: Road fatality trend in South Asia (Sources: WHO reports, 2009, 2013, 2015 & 2018)

New Delhi[2], and Bangkok[3]. Based on the analysis, policy suggestions are made to improve road safety.

Road Safety Situation in Asia

The Asia-Pacific region accounts for more than 60% of 1.35 million estimated global fatalities from road crashes (WHO, 2018). The fatalities per 100,000 inhabitants for the region is 18.35, which is slightly higher than the global average (18.14). Road safety presents a large challenge to Asian countries which are paying a high price for it (Wismans et al., 2016). In the majority of road crashes, fatalities and serious injuries are preventable by reducing the risk factors.

Figure 1 shows estimated fatality rates for 2013 and 2016. It shows some reduction of these rates in East and North-East Asia, North and Central Asia and South-East Asia. But the fatality rate has increased globally, in the Asia-Pacific region, as well as in South and South-West Asia. South and South-West Asia and South-East Asia subregions had high fatality rates of 20.3 and 17.8 respectively for 2016.

Figure 2 shows the fatalities from road crashes from 2007 to 2016 in the Asia-Pacific region. The trend is uneven. While there was some progress in the reduction of road fatalities between 2010 and 2013, fatalities increased by 10.8% from 2013 to 2016.

Figure 3 shows the estimated fatalities and fatality rate per 100,000 population for selected Asian countries in 2016. The fatality rate is very high for Thailand (32.7), Vietnam (26.6), India (22.6), Myanmar (19.9) and China (18.2). Pakistan's fatality rate is moderate, but it faces additional safety and security challenges due to the ongoing effects of the war on terror (Nazir et al, 2016). In terms of aggregate numbers, the number of fatalities is very high in India (299,091) and China (256,180).

Figure 4 shows the trends of fatality rates from road crashes in South Asian countries. There are some recent downward trends in Afghanistan, Maldives, Nepal, and Sri Lanka. For other countries, the fatality rate has an upward trend.

This high number of fatalities in Asian countries calls for a lot more focused and targeted polices and actions at the national level to improve road safety.

Results

Ideally no one should be killed in a road crash. Some developed countries are pursuing ambitious safety plan and policies of vision zero (Kristianssen et. al, 2018). The assessment of road safety in Asia revealed that instead of decreasing, road fatalities are increasing in many countries. The following sections present a broad analysis with respect to progress, road safety policies and practices, vulnerable road users, road safety in urban areas, data, and investment and governance.

Table 1: Comparison of number of fatalities in selected countries

Countries	Number of Fatalities in 2010	Number of Fatalities in 2016	Difference
Afghanistan	6,209	5,230	-16%
Bangladesh	17,289	24,954	44%
Bhutan	96	139	45%
India	231,027	299,091	29%
Maldives	6	4	-33%
Nepal	4,787	4,622	-3%
Pakistan	30,131	27,582	-8%
Sri Lanka	2,854	3,096	8%
Sub-total South-Asia	**292,399**	**364,718**	**25%**
Cambodia	2,431	2,803	15%
Indonesia	42,434	31,726	-25%
Laos	1,266	1,120	-12%
Malaysia	7,085	7,374	4%
Myanmar	7,177	10,540	47%
Philippines	8,499	12,690	49%
Singapore	259	155	-40%
Thailand	26,316	22,491	-15%
Vietnam	21,651	24,970	15%
Sub-total South-East Asia	**117,118**	**113,869**	**-3%**
Total	**409,517**	**478,587**	**17%**

(Source: WHO, 2013 and 2018)

Assessment of Progress

Table 1 shows the comparison of fatalities for Asian countries for the year 2010 and 2016. Only Maldives, Indonesia and Singapore showed meaningful reductions. However, the overall fatalities increased by 25% in South-Asia with only a reduction of 3% in South-East Asia. The number of fatalities increased significantly in the Philippines, Myanmar, Bhutan, and Bangladesh. Brunei

[2] Conference on Safe Mobility and Regional Connectivity, 20 22 January 2020, New Delhi
[3] ATRANS Conference, 4 December 2020, Bangkok

also made substantial progress in reducing fatalities, from 47 to 13 from 2011 to 2019, a reduction of 72% (The Star, 2020). Despite the high number of fatalities in India, road safety has not received priority attention, and thus requires more political attention and commitment (Singh, 2017).

Road Safety Polices and Practices

Asian countries have been implementing subregional frameworks (e.g. ASEAN Secretariat, 2016) and national road safety polices and action plans (e.g. MORTH, 2010, MOPTM, 2013). Most of these national policies, and action plans are aligned with the five safety pillars of the global plan for the Decade: (i) road safety management; (ii) safer vehicles; (iii) safer users; (iv) safer roads; and (v) post-crash care (WHO, 2011). However, while it is good to have national strategies and policies, their implementation, monitoring and follow-up has been lacking in many cases.

It is evident[4] that many Asian countries have been implementing similar activities and projects to improve road safety. Most national level activities focused on developing policies and strategies, improving black spots, capacity building, road safety campaigns and awareness raising, adding safety features to infrastructure, and developing regulations and guidelines. It is promising to see the comprehensive list of national road safety activities implemented, but these efforts have not led to a substantial reduction in the number of crashes and fatalities. But it can be argued that these road safety activities have helped to slow down the rate of crashes and fatalities in some countries. Consequently, in absence of these road safety policies and activities, the number of crashes and resulting fatalities could have been much higher.

Drink driving and speeding are two major causes for crashes in many countries, limiting speed, placing speed breakers in dangerous areas, strict enforcement of drink driving, and social engagement appear to be effective. For example, Kathmandu implemented a successful “Anti Drink Driving Campaign”, whereby traffic police were provided incentives to enforce the law and received 25% of the penalty charged to the offenders. The programme was very effective in reducing crashes, serious injuries and fatalities and received positive feedback resulting in its continuance (Chand, 2015). To support this initiative some restaurants in Kathmandu have now started arranging drivers for their drinking patrons. Common now is that one person in the group of friends would volunteer not to drink, i.e. designated driver. Drink driving offenders also need to attend a road safety course at the traffic office.

Brunei adopted a comprehensive safe system approach and has managed to tackle road safety challenges (Haque and Haque, 2018). Its fatality rate indicates that it now the leader in South-East Asia and is now rapidly approaching Australia’s rate. Furthermore, there is a proposal to use a road safety development index (Chen et al., 2017) to track progress towards road safety goals in South-East Asia. Singapore is also taking a safe system approach.

Thailand has made some progress in reducing the number of fatalities, but the fatality rate of 32.7 per 100,000 population is the highest in Asia. Most of the fatalities relate to two major cultural events in Thailand – the Thai New Year (April) and the Gregorian calendar New Year (January). Data indicates that speed, drink, and careless driving were the main causes of road crashes during these festive periods. There was an increase of 9% in fatalities during the New Year holiday period in 2021 compared to 2020 (Bangkok Post, 2020). A recent review of 12 of the WHO voluntary road safety targets in Thailand recommended the creation of strong leadership and high-level support for road safety improvements, formation of a more effective lead agency for road safety, a much stronger focus on implementation, development of intermediate indicators to help achieve targets and the establishment of an effective capacity-building framework (WHO, 2020).

Due to the lack of strict enforcement of traffic laws of unauthorised use of footpaths by motorcycles, vendors, street food stalls, such use is a common sight in many Asian cities such as Dhaka, Bangkok, Jakarta, and Kathmandu. These activities obstruct the use of footpaths by pedestrians and pose safety risks when pedestrians have to use the road with other motorised traffic. Advocacy and awareness campaigns targeting road users and drivers with smart policing and innovative enforcement of traffic rules related to the use of seat belts, child restraints and helmets, drug use, mobile phone use, speeding, and drink driving can enhance road safety (Kuo and Lord, 2019).

One of the common concerns in countries which have hilly and mountainous terrain like Nepal is the high number of casualties per crash. The authorities sometimes heed to the pressure of politicians and open new stretches of road still under construction, risking the lives of potential users. Proper safety audit of roads in remote hilly terrain, implementation of safety features such as road barriers, regular safety inspection of vehicles, enhanced driver training, advocacy and enforcement of traffic rules can help improve safety in these types of terrains.

Effective post-crash care can save lives. Tamil Nadu State, India focused on improving post-crash care and reducing response time when there is a crash injury. The response time for an ambulance to reach the crash site was reduced to 10 minutes. A network of trauma centres provide primary care to stabilise the victim and refer victims to nearby or other hospitals (Balasubramanian, 2020).

Influencing the behaviour of Vulnerable Road Users (VRUs) and young driver’s through education and awareness campaigns can help reduce crashes and

[4] Presentations by national road safety experts at the New Delhi Conference.

fatalities. The “Our Road Our Lives” community engagement campaign in Madhya Pradesh, India targets VRUs and young drivers to encourage safe behaviour (Sanghi, 2020). The programme demonstrated that continuous community engagement, road safety awareness campaigns at schools and in communities can improve pedestrian behaviours, such as making them more aware and thus careful while crossing roads and using pedestrian foot paths. Another important risk factor is the fatigue of long-haul drivers on major trunk routes. One community in Madhya Pradesh, India invited heavy truck drivers to take a short break and offered them refreshment, which reduced fatigue and contributed to a substantial reduction of crashes involving trucks and thus fatalities along that stretch of the road that implemented the program.

Vulnerable Road Users

In recent years, road safety experts have highlighted the need to target safety measures which protect Vulnerable Road Users (VRUs). VRUs include pedestrians, cyclists and powered 2 and 3 wheelers. Powered-two-wheelers offer a low-cost mobility option for many citizens in South Asia and South-East Asia. Their popularity is partly due to economic prosperity, the lack of accessible public transport and their ability to slip through congested streets. Table 2 shows the total vehicle fleet and number of powered two and three wheelers. It shows that the share of powered two and three wheelers range from 54% to 93% in Asian countries. Its share is 93% in Vietnam, 84% in Myanmar, 83% in Indonesia, 80% in Maldives and 73% in India. The share of two wheelers is low in Afghanistan, Bhutan, and Singapore.

Table 3 shows the share of road traffic deaths by user types. VRUs account for 54.8% of fatalities in the Asia-Pacific region and 75.2% of fatalities in South-East Asia.

Given the high percentage of powered two- and three-wheelers in Asian countries and the high share of fatalities among VRUs, road safety in cities can be substantially improved by accommodating the infrastructure needs of VRUs and providing adequate space for non-motorised transport (NMT) modes (Mohan et al., 2020). While there has been greater focus on the enforcement of helmet use for riders and pillion riders, it is also important that the helmet meets a quality standard. But many Asian countries do not have specified helmet standards as well as a lack of regulation and enforcement of helmet use. It is equally important to address other risk factors related to infrastructure and their integration into policies.
For example, some Asian cities have banned the use of motorcycles in cities (Yangon), and exclusive lanes for two-wheelers have been developed and planned in Malaysia. Vietnam provides a good example of the use of helmets where the compliance of helmet use soared to 92.5% after the introduction of a mandatory helmet law (Nguyen et al., 2013). However, there are questions about the standards and quality of helmets available in markets in Vietnam as

Table 2: Share of 2 and 3 wheelers in vehicle fleet, 2016

		Powered 2- and 3-wheelers	
Countries	**Total number of vehicle fleet**	**Number**	**Share**
Afghanistan	655,357	68,090	10.39%
Bangladesh	2,879,708	1,980,246	68.77%
Bhutan	86,981	9,786	11.25%
India	210,023,289	154,297,746	73.47%
Maldives	92,983	75,053	80.72%
Nepal	2,339,169	1,547,312	66.15%
Pakistan	18,352,500	13,538,200	73.77%
Sri Lanka	6,795,469	4,815,617	70.87%
Sub -total South Asia	**241,225,456**	**176,332,050**	**73.10%**
Cambodia	3,751,715	2,714,193	72.35%
Indonesia	128,398,594	106,570,833	83.00%
Laos	1,850,020	1,422,869	76.91%
Malaysia	27,613,120	12,677,041	45.91%
Myanmar	6,381,136	5,391,505	84.49%
Philippines	9,251,565	5,329,770	57.61%
Singapore	933,534	142,439	15.26%
Thailand	37,338,139	20,407,296	54.66%
Vietnam	50,666,855	47,131,928	93.02%
Sub-total South-East Asia	**266,184,678**	**201,787,874**	**75.81%**
Total	**507,410,134**	**378,119,924**	**74.52%**

Source: WHO, 2018

Table 3: Share of fatalities by type of users, 2016

Type	**Global**	**Asia-Pacific**	**South-East Asia**
4-wheeled vehicles	25.3%	20.2%	7.1%
Others/unspecifies	21.5%	24.9%	17.8%
Pedestrians	20.6%	13.5%	10.7%
Cyclists	2.7%	2.1%	2.8%
Powered 2 and 3 wheelers	29.3%	39.2%	61.7%
Total for VRUs	52.6%	54.8%	75.2%

Source: WHO, 2018

well as other Asian countries.

Additional efforts are required to reduce risk to VRUs as these modes constitute the highest share of urban travel and a high percentage of fatalities (Larson and Henning, 2013; Mohan, 2011; Houque et al., 2008; Gutierrez and Mohan, 2020). Yet specific issues related to VRUs are not part of the WHO's 12 voluntary road safety targets (Van den Berghe et. al., 2020). Addressing the safety of VRUs presents an opportunity to substantially reduce fatalities and is also a relatively low-cost option.

Road Safety in Urban Areas

Safety is one of the indicators of the Sustainable Urban Transport Index (SUTI) (Gudmundsson and Regmi, 2017). The assessment of safety of urban mobility in selected cities (Regmi, 2020) and their comparison with their respective national road fatality rates is shown in Table 4. For most of the cities the fatality rates from road crashes are better than the national road fatality rate. This could be partly due to the concentration of population in cities[5], slower vehicle speed resulting from traffic congestion, strict enforcement of traffic rules, and awareness of traffic rules among urban residents. However, the fatality rates in Dhaka, Greater Jakarta, and Khulna, are surprisingly low and suggest the possibility of under-reporting.

Transport policies need to embrace the tenets of safe and sustainable mobility by prioritising public transport and discouraging personal mobility (Stevenson and Bhalla, 2020). In many Indian cities fatalities are 30% higher than the national average (Mohan et al., 2020). One of the options for improving road safety in cities is to enhance accessibility of public transport systems and integrating with facilities for NMT (Duduta et al., 2014, Mohan et al., 2020). This is useful in the current context of COVD-19 to maintain physical distance as well as to reduce number of private vehicles in streets which can contribute to reducing the number road crashes. Informal (unregulated smaller vehicle) transport is prevalent in many Asian cities and complement public transport. However, quality of service and safety is also a major concern (Phun and Yai, 2016). For countries with lower fatality rates in cities, there may be a need to be prioritisation and implementation of safety measures for roads in remote areas and rural roads.

Table 4: Fatality rate per 100,000 population in cities and their respective country

City, Country	Fatality rate, city	National fatality rate
Tehran, Iran	7.4	20.5
Colombo, Sri Lanka	8.3	14.9
Kathmandu, Nepal	7	15.9
Surat, India	4.6	22.6
Bhopal, India	9	22.6
Thimphu, Bhutan	8	17.4
Dhaka, Bangladesh	1.6	15.3
Khulna, Bangladesh	1.9	15.3
Bangkok, Thailand	10.3	32.7
Greater Jakarta, Indonesia	1.9	12.2
Yangon, Myanmar	8.6	19.9
Hanoi, Vietnam	6	26.4
Ho Chi Minh, Vietnam	8	26.4
Bandung, Indonesia	4.3	12.2
Surabaya, Indonesia	6.4	12.2
Ulaanbaatar, Mongolia	9.7	16.9

(Source ESCAP city assessment reports and WHO, 2018)

Road Safety Data

The availability of periodic and accurate road safety data greatly assists with implementing evidence based polices and monitoring progress. But there are often discrepancies among the road safety data and underreporting of crashes, injuries and fatalities is frequent. Country data is modelled in WHO reports which takes into consideration the possibility of underreporting. Table 5 shows reported and estimated fatality data for some Asian countries. The difference between reported and estimated data ranges from 1.5 to 10 times multiplier. For example, the estimated fatalities is almost double the reported number of fatalities in India and Myanmar, almost three times that officially reported in Vietnam, more than three times that officially reported in Afghanistan, more than six times that officially reported in Pakistan and more than 10 times that officially reported in Bangladesh (WHO, 2018). Police and hospitals are usually the primary sources of national road safety data.

The most current fatality data available in 2021 is presently provided in the 2018 WHO report[6] which in turn is based on the analysis of 2016 data. This is a data lag of 4 years. Furthermore, there is often a discrepancy between date sources reporting fatalities for the lower and middle income countries (LMICs). It is worth noting that fatality data presented by LMICs at recent road safety meetings are often different than that reported and estimated in the WHO reports. In the absence of accurate data, the planning and monitoring of progress becomes difficult. WHO reports are widely used and referred to by researchers, regional and international organisations.

5 Fatality figure divided by population in city gives a low fatality rate.
6 WHO issues global status report on road safety every two year.

Table 5: Difference between reported and modelled fatality data, 2016

Countries	Reported number of fatalities	Estimated number of fatalities	Ratio of estimated to reported fatalities
Afghanistan	1,565	5,230	3.34
Bangladesh	2,376	24,954	10.50
India	150,785	299,091	1.98
Nepal	2,006	4,622	2.30
Pakistan	4,448	27,582	6.20
Cambodia	1,852	2,803	1.51
Myanmar	4,887	10,540	2.16
Vietnam	8,417	24,970	2.97

Source: WHO, 2018

The importance of accurate crash and fatality data has been discussed on many occasions and at many fora, but it is still a persistent issue. Some researchers have questioned the quality of road safety data in Asia in WHO reports and stressed the need to harmonise road traffic fatality data (Phathai, 2019, Mohan, 2011). Additional efforts and resources are necessary to ensure availability of accurate and up-to-date road safety data. This can ensure development of evidence-based national road safety polices and plans based on accurate data.

Investment for Road Safety and Governance

Many researchers had called for increased institutional capacity and scaled up implementation and investment for improving road safety (Bliss and Breen, 2017). Recent reports on road safety set high investment needs for delivering road safety (World Bank, 2020a, 2020b, 2020c, 2020d and 2020e). To reducing the road crash fatalities by half by 2030 in Bangladesh, Bhutan, India, and Nepal the estimated investment needs are US$118 billion. The majority of investment is targeted at facilitating transport along major highway corridors and for four-wheeled vehicles. It is worth noting that four-wheelers only account for 20% of fatalities in the Asia-Pacific region and just 7% in South-East Asia. On the other hand, the share of VRUs fatality is 55% in the Asia-Pacific region and 75% in South-Asia. Low-cost measures can be employed to address fatalities from road crashes involving VRUs in most Asian countries. In the current context of COVID-19, there have been calls to give more emphasis to active mobility in order to facilitate social distancing. Improving infrastructure and facilities for pedestrians, cyclists, and motorcyclists can provide low-cost mobility solutions in cities and reduce significant numbers of fatalities (Leather et al., 2011, Mohan, 2011).

Most of the support provided by development partners focus on soft issues such as the development of national polices, strategies and action plans to improve road safety in LMICs (Pedan and Puvanachandra, 2019). Most road safety projects are either a component of larger infrastructure projects or soft capacity building projects. Comprehensive result oriented standalone road safety projects can be more effective. The United Nations partnered with local stakeholders in Nepal and organised a national workshop to develop a new road safety action plan for 2021-2030 (MOPIT, 2020). Governments need to commit resources for the implementation of action plans. It is usually observed that some countries lack adequate implementation and absorptive capacity, as seen from ratio of actual expenditure against allocated budget. For example, a recent report from Nepal suggested that only 14% of development funds on road safety were expended during a period of six months (Ratopati, 2020). Therefore, in addition to the funding, strengthening implementation capacity of national road safety institutions would be necessary.

To translate high-level commitment to road safety into actions and monitor progress, Bangladesh, Myanmar, Nepal and Sri Lanka have established National Road Safety Councils (Ashrafuzzaman et al., 2020; Khin, 2020). But the results of councils' actions are yet to be seen. In many cases these high-level safety councils do not meet frequently, and it takes considerable time to translate the decisions into actions in the field. Therefore, these high-level institutions need to be supported by strengthened institutional arrangements to pursue national policies into actions in the field.

Road safety involves many national and local level government institutions such as transport, police, hospitals, and schools. Lack of a lead road safety agency at the national level in many countries adds to governance, coordination and accountability challenges for road safety planning and management (Eusofe and Evdorides, 2017). This calls for a strong national safety leadership and cross-sector collaboration. Further, networking and collaboration among countries and safety research institutes with shared projects funding can ensure implementation of the safe systems approach in Asia (Abdelhamid et. al., 2018, World Bank, 2019).

Key Findings

This paper identified the following major safety issues in Asian countries:

- The number of road crash fatalities is increasing in many Asian countries.
- A lack of periodic and accurate road safety data and data analysis for focused and targeted road safety planning.

- The share of fatalities among VRUs, NMT, and long-haul trucks along trunk routes is high and which includes a high share of powered 2 and 3 wheelers in vehicle fleets.
- A lack of effective implementation of polices and activities to improve road safety and thus there needs to be more focus on development of effective policies and planning to reduce road fatalities.
- A lack of systemic investment in low-cost solutions such as tackling the issues of VRUs and NMT as well as a lack of advocacy, awareness campaigns and enforcement of safety rules and regulations.
- A lack of national lead safety agencies with strong leadership, accountability and cross- sector collaboration.
- Availability of many best practice successful demonstration road safety projects within Asia thus providing opportunities for other Asian neighbouring countries to learn from the experiences of the country carrying out the project.

Discussion

The track record of road safety efforts in Asia is mixed, with some countries making a little progress against a background of increasing road fatalities. The core question is how can Asian countries improve road safety? Do the countries need to plan and implement road safety activities differently?

Most of the national road safety policies and action plans of Asian countries were aligned with the recommended five safety pillars. It was evident that countries were implementing road safety policies and activities, but without substantial reduction in the number of road crashes and fatalities. In some cases, the response seems to be reactive to one or two major crashes. It is now critical for countries to shift the focus on refining policies and plans with emphasis on achieving results. The availability of accurate road safety data and their analysis is essential for evidence-based planning. By focusing on critical risk areas and taking both holistic top-down and bottom-up approaches, Asian countries need to plan and implement activities differently to achieve results. Development of robust monitoring framework can help track results.

The onus on planning and implementing holistic and comprehensive road safety policies and strategies rests with national road safety authorities and institutions. From the results of the last Decade, it is clear that there is no room for complacency. The new plan of action being developed for the second Decade continue to focus on the safe system approach that needs high level political support and good governance. Countries and stakeholders can utilise available guidelines (ADB, 2012; Small and Runji, 2014; WHO-ROSEA, 2015; and Van den Berghe, 2020) and frameworks (ESCAP, 2019a and ESCAP, 2020) to refine national polices and strategies for improving road safety. Some of the frameworks provide guidance on specific challenges such as institutional issues (Small and Runji, 2014), impaired driving (ESCAP, 2019b), managing speed (ESCAP, 2019c), safe road infrastructure (UNRSC, 2020) and targeting the five risk factors for improving road safety (Hyder et al., 2017, WHO-ROSEA, 2015, Pedan and Puvanachandra, 2019). Countries could also consider new approaches in enforcing seat belt use, speed management, and their relationship in tackling road safety (Mwebesa et al., 2018, Gupta et al., 2017) and exploring the interactions between road safety risk and influencing factors (Shah et al., 2018).

While it is difficult to prescribe a one-fit-all strategy, this review suggests that future national plans should include elements of data, address the issues of VRUs and urban safety, improve coordination, governance and accountability of road safety institutions, consider low-cost innovative solutions such as improved enforcement of traffic rules (related to use of seat belt, child restraint and helmets, drug use, mobile phone use, speeding, drink driving), advocacy, education and awareness training, changing road users behaviours, use of technology, and post-crash care.

Conclusions

A review of road safety in Asian countries was presented. Implementation of road safety policies and action plans in most countries have not led to an overall reduction in fatalities from road crashes. Many Asian countries like Thailand, Vietnam, India, Myanmar and China continue to have high fatality rates. Compared with 2010, the number of fatalities from road crashes increased by 25% in South Asia and only reduced 3% in South-East Asia. Countries such as Singapore, Maldives and Indonesia have managed to reduce fatalities, but fatalities increased in the Philippines, Myanmar, Bhutan, and Bangladesh.

Some of the distinct characteristics of the road safety problem in Asia are a high share of powered two- and three- wheeler vehicles in their vehicle fleets, more fatalities among VRUs, high number of fatalities per crashes in countries with mountainous terrain, high number of crashes involving truck drivers on major trunk routes, high speed and careless driving during festive seasons and lack of accurate and timely road safety data. In many cases, countries also lack a systematic and holistic approach to tackle these road safety issues.

The new Decade of Action for Road Safety (2021-2030), with the target to reduce fatalities and serious injury from road crashes by 50% by 2030, provides new opportunity for countries to translate their commitments to results. The target translates to a 7.5% annual reduction for the next 10 years. Only the effective implementation of comprehensive national road safety strategies taking a safe system approach, reducing risk factors, and addressing the distinct characteristics identified in this paper can contribute to the reduction of serious injuries, and fatalities. Some good practices from Asia discussed in the paper are: success of a comprehensive safe system approach in Brunei, helmet use compliance in Vietnam; success of “Anti Drink and Drive Campaign” in Kathmandu, Nepal, reduction of response time of emergency care in Tamil Nadu, India and enforcing rest time for long route truck drivers in India. There are ample benefits of learning from these good practices and other successful demonstration projects in Asian countries. Replication of good practices can be one of the effective ways to address road safety challenges.

An empowered and accountable road safety lead agency at the national level supported by road safety stakeholders and with a focus on low-cost strategies such as advocacy and education of users and drivers, enforcement of traffic rules, focus on VRUs, prioritising safety in remote and rural areas, and the provision of safe infrastructure for NMT and public transport, can help make up for lost opportunities during the last decade.

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Governance and Effective Management: Speed Management Demonstration Project, in the Islamic Republic of Iran

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Abstract

The Government of the Islamic Republic of Iran (Iran) has embarked on a challenging project aiming to demonstrate how to make road travel safer through speed management measures based on Safe System Approach (SSA) and Result Based Management (RBM). This follows from mounting concern in curbing a high death rate from motor vehicle crashes in recent years. However, despite the Government's commitment to address this problem, there have been setbacks owing to the challenges of putting in place a strong collaborative framework involving all the agencies charged with responsibilities for road engineering, traffic law enforcement and public education. Iran has established a National Road Safety Commission (NRSC) to lead and coordinate actions. In implementing a demonstration project, specific partnership arrangements have been established at national and provincial levels, as well as pillar-based project teams in 3 provinces. This paper examines the governance structure and opportunities to strengthen the collaborative management of the project and how similar programs can be established and executed in other countries to improve road safety based on SSA and RBM.

Keywords

Governance, Speed Management, Demonstration Project, Road Safety, Results-Based Management, Safe System Approach

Glossary

EMRO – WHO Regional Office for the Eastern Mediterranean
EMR – Eastern Mediterranean Region
LMO – Iranian Legal Medicine Organization
MOU – Memorandum of Understanding
MRUD- Ministry of Road and Urban Development
NGO – Non-Government Organization
NRSC – National Road Safety Commission
RBM – Results-based management
RMTO – Road Maintenance and Transportation Organization
SME – surveillance, monitoring and evaluation
SSA – Safe System Approach
UNDG – United Nations Development Group
UNGA – United Nations General Assembly
WHO – World Health Organisation

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Introduction

Most countries that actively pursue road safety objectives through government actions and policies have a number of agencies that act to make roads, road users and vehicles safer. There are also central and local governments that play their part in this endeavour. Some of the most successful jurisdictions are those that have good cooperation between agencies and levels of government, a common aim and effective leadership of the overall program of road safety. They may be said to have good *governance*.

This paper presents the research on what is considered *good governance* and its practical application in a speed management demonstration project in Iran. It provides a unique insight into the strengths and challenges identified as the project is developed to the implementation phase. The project aims to demonstrate how to implement speed management interventions to reduce road trauma in selected road corridors in three Iranian provinces. As such it is vital that a systematic process of evalation is defined and carried out. This evaluation will inform other juridictions seeking to improve road safety. The approach undertaken, the model developed and the lessons learned are presented as an example that other countries may follow, particularly as it applies to the governance regime.

This paper aims to demonstrate the importance of setting a firm base of action through governance and management structures and practices can contribute to effective partnership arrangements for road safety projects."

Background - Iran's Road Safety Situation

In Iran, road traffic crashes are one of the leading causes of fatalities and injuries. According to WHO Global Status Report on Road Safety, the average road crash fatality rate in Iran is 20.5 per 100,000 population, which is higher than the rate for the Eastern Meditteranean Region (17.9) (WHO, 2018).

Between 2004 and 2016, road fatalities had reduced substantially from 27,755 per annum (40.5 per 100,000 population) to 16,201 per annum (21.1 per 100,000 population). The interventions contributing to this reduction included the introduction of fixed and mobile speed cameras, laser speed detection devices, the introduction of demerit points, revisions to the Iranian Driving Act and engineering solutions such as traffic calming measures.

From 2014-2015, the trend in road fatalities flattened then started to rise again in 2017-2018. This is an unacceptably high rate and number of road fatalities each year requiring strategic intervention. Iranian Traffic Police data suggests that around 25% of injury and fatal crashes have involved speeding. The NRSC has provided evidence on the importance of speed as a risk factor in Iran and its role in mortality and severe injury crashes.

In response to this road safety situation, the Government of Iran, in partnership with the WHO, identified the need for strategic reform which manifested into the development of Safety Model Corridors as a demonstration project. In the development of this project, a governance framework was determined as critical foundation to ensure effective management and to achieve defined results. The Results-Based Management (RBM) approach and Safe System Approach (SSA) were adopted as key components with the requirement to fully understand and maximise all aspects of good governance.

Defining Governance in Road Safety

There are many definitions and interpretations of the term governance. In the context of local government decision-making, "Governance is the formal and informal framework within which decisions are made" (Wilmoth 2017). Historically, *governance* was simply another word for government or public administration. With the evolving complexity of government bureaucracies and dispersion of power and authority between government departments and levels of government, *governance* must also be about managing policy networks and inter-agency relations (Kjaer, 2004). In public sector endeavours, such as road safety, policy networks are characterised by:

- *Interdependence – network participants are mutually dependent on each other's resources in order to realise their objectives;*
- *Coordination – network participants need to act jointly in order to realise shared objectives; and*
- *Pluralism – networks are relatively autonomous vis-à-vis other networks and the state.* (Bevir, 2011).

The first recommendation of the World Report on Road Traffic Injury Prevention was to: *Identify a lead agency in government to guide the national road traffic safety effort* (WHO, 2004). A lead agency can take various forms. It can be a stand-alone bureau, a committee representing several government agencies, or be part of a larger transport organisation. The Report stresses that this lead agency should have adequate finances and should be publicly accountable for its actions. The National Road Safety Commission (NRSC) in Iran has adopted this role of the lead agency. In this case, the NRSC is chaired by the Ministry of Roads and Urban Development. The full list of members is provided in Appendix A.

Figure 1. Project governance elements (Source: NRSC)

Bliss and Breen (2009) extended this message and prepared guidelines for effective implementation of the World Report emphasising the importance of management capacity, stressing a systematic approach with a focus on clear institutional management functions, results-focused interventions, and a strong lead agency. They provided a practical checklist for measuring the effectiveness of the road safety management system.

Governance Framework

The key elements considered by this project to constitute good practice governance are shown in Figure 1.

In expansion of this model, the Government of Iran, in partnership with the WHO, has recognised that governance and effective management of the demonstration project must have 2 primary components; an end-to-end framework for defining, measuring and evaluating the project results, and a proven holistic approach to reducing road trauma. Those primary components adopted for the demonstration project are respectively the RBM approach (UNDG, 2011) and the SSA .

The RBM approach has been adopted by many United Nations organisations, including the WHO as a proven tool that can be used to manage and monitor a road safety program. The key steps in the usage of this tool are:

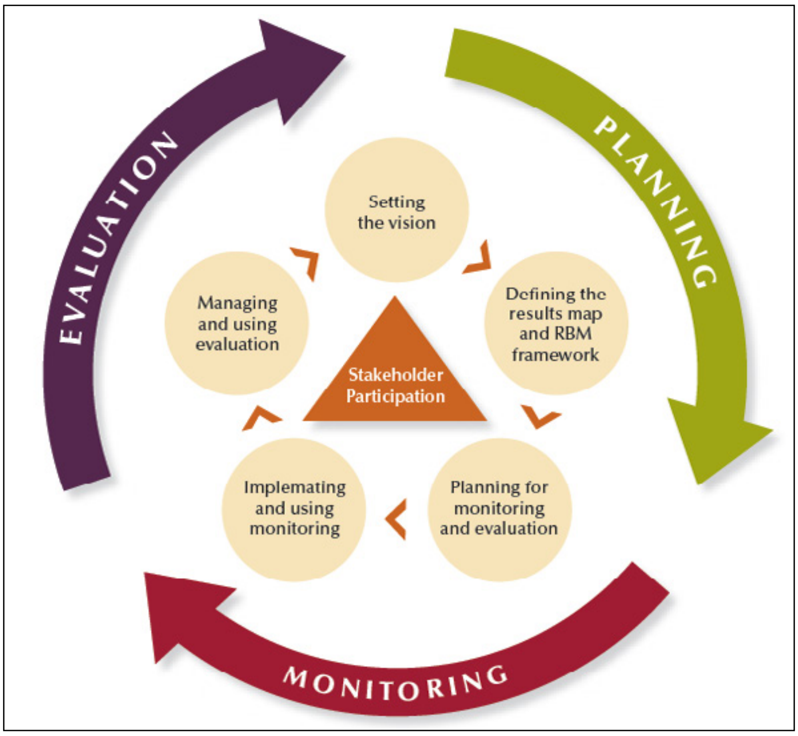
Step 1. Understand the situation
Step 2. Prioritise issues for action
Step 3. Devise a theory of change
Step 4. Define desired results
Step 5. Align results, strategies and funding
Step 6. Assess assumptions and risks
Step 7. Draw it all together in a results frame- work and a theory of change narrative
Step 8. Develop a monitoring plan
Step 9. Assess the evaluability of the programme (UNICEF, 2017)

Figure 2 depicts a model management process based on RBM as devised by the United Nations Development Group (UNDG).

The initial RBM steps allow a shared vision of the desired outcomes in the form of a results framework and a change narrative that is based on a clear understanding of the underlying situation. The concluding RBM steps involve measuring and monitoring the defined indicators of success to determine the ultimate impact, change outcomes, observable outputs, actions undertaken and resources that were applied.

Moreover, a chain of results of the project can be defined and outcome and impact indicators can be presented. The evaluation process focuses on identifying and measuring inputs, activities, outputs, outcomes and impacts. This is defined in the RMB Handbook as a Results Chain as shown in Figure 3.

These principles are embodied in the speed management demonstration corridors project. The chain of results approach calls for each element of the project to be defined, and for outcome and impact indicators to be presented



Source: UNDP, Handbook on Planning, MOnitoring and Evaluating for Development Results, 2009

Figure 2. Project management process devised by the UNDG

The Role of the SSA in Governance

The SSA has been pioneered in the Swedish Vision Zero policy and in the Dutch Sustainable Safety strategy, and is founded on the ethics of developing a sustainable road traffic system that preserves human life by eliminating serious road injury. In 2010 the SSA was adopted by the United Nations General Assembly (UNGA) to underpin the global plan for the first Decade of Action for Road Safety. This principle has been carried over with an enhanced focus on speed management in a Resolution adopted on August 2020 calling for a second Decade of Action[1]. In August 2020 the UNGA adopted resolution 74/299 improving global road safety, proclaiming the second Decade of Action for Road Safety 2021-2030, with the ambitious target of preventing at least 50% of road traffic deaths and injuries by 2030. SSA has been acknowledged in the resolution and in the Stockholm Declaration Third Global Ministerial Conference on Road Safety: Achieving Global Goals 2030 as well.

The explicit aim of the SSA is to eliminate serious and fatal road injuries through proactive road and traffic safety management in recognition that human road users are physically vulnerable, risk prone and fallible. System management measures must proactively eliminate unsafe road conditions, unsafe vehicles, unsafe behaviours and unsafe speeds under the management of a leadership agency. Prerequisites to managing a safe system include:

- effective leadership and capability;
- legislation and enforcement;
- ambition and innovation;
- understanding of crash types and crash/injury risk; and
- management of access to the system by regulating vehicles and drivers/riders.

Notably, the management of driving speeds is a pivotal factor in the SSA. This is because, not only does speed increase the risk of crashes occurring, it also increases the severity of injury whenever crashes do occur.

Using the international experience of SSA and RBM, a general governance framework was developed to ensure oversighting, commitment, partnership, coordination, implementation and surveillance, monitoring and evaluation (SME). The governance model for the Speed Demonstration project, as depicted in Figure 3, was developed by the NRSC.

The engineering component will ensure the identification and segmentation of the selected corridors for treatment, speed limit setting, traffic calming and risk reduction interventions based on national protocols and are to be clearly defined.

Law enforcement is to be addressed through enhancements to legislation, active and visible enforcement, deployment and detection, infringement processing and fines

[1] https://documents-dds-ny.un.org/doc/UNDOC/GEN/N20/226/30/PDF/N2022630.pdf?OpenElement

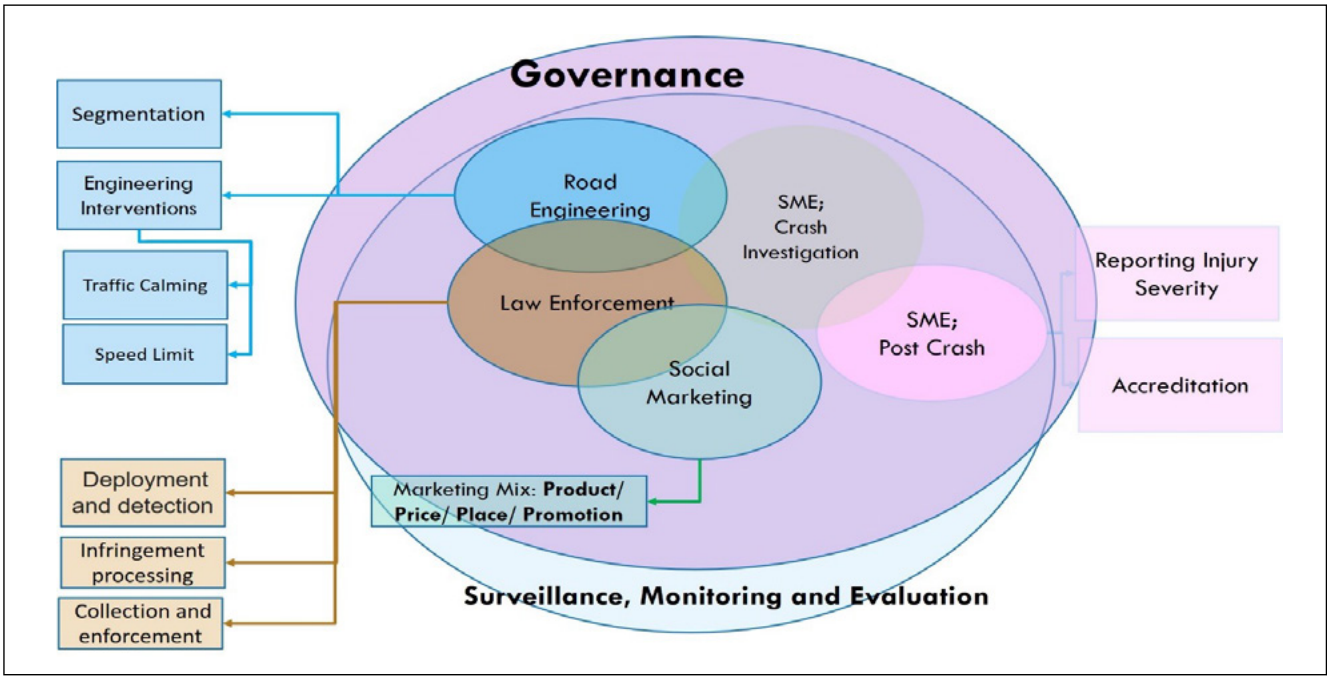


Figure 3. The Governance Framework devised by the NRSC for the demonstration Project

collection. The main tasks are to be assigned to action leaders with the responsibility to review procedures and develop protocols.

Social marketing is to be subjected to qualitative and formative research to best appeal for project target groups and the overall scope to develop and implement educational interventions to enhance road user compliance within the speed limit.

Crash investigation processes and protocols are to be reviewed as well as post-crash emergency response and care being addressed with continuous quality improvement.

A key attribute to the framework is the SME process. The anticipated results are the reduction of traumatic injuries and deaths in the demonstration project. The suite of initiatives in the disciplined governance structure are expected to be a model for others to follow.

In order to reinforce the importance of good governance, project details are now provided.

Enhanced Safety Model Corridors Demonstration Project

Following the SSA model, Iran has recognised that optimal and sustainable road safety outcomes cannot be achieved just through regulation and enforcement. Hence the demonstratation project integrates those elements with improvements in good governance, leadership and capability, education and information and road safety engineering.

To accelerate efforts towards enhancement of road safety in the country, NRSC, in its leadership role, initiated a series of technical missions in 2018-19 facilitated by WHO. The missions focused on implementing the demonstration project to deliver road safety improvements through speed management strategy with participation of national and international road safety specialists in the areas of governance, enforcement, social marketing and road safety engineering.

The international consultant missions carried out a situational analysis and reported on deficiencies and recommended solutions to manage speeds and road safety in the country. They also facilitated capacity building workshops. Based on the mission recommendations to accelerate efforts towards enhancement of road safety in the country and to make progress to achieve the intended national target of 20% reduction in road fatalities by 2025, the SSA was adopted by the Government to underpin its efforts to improve speed management.

To facilitate formulation of SSA in the national road safety system of member states, WHO Regional Office for the Eastern Mediterranean (EMRO) has developed the “Road Safety System framework for the Eastern Mediterranean Region” and Iran has been nominated to demonstrate an applicable model of SSA in EMRO. Therefore, with EMRO support, a project was launched jointly by WHO country office and NRSC in collaboration with national partners to demonstrate enhanced Safety Model Corridors focusing on speed management based on SSA/RBM.

The project aims to offer a workable model for EMRO member states commencing with a focus on the speed management component however will extend gradually to other SSA pillars to ensure an inclusive and comprehensive approach to road safety.The SSA is a completely new concept to Iran, there being no similar experience within the country. In addition, the RBM has not been fully formulated in road safety programs and one of the main objectives of this project is to institutionalise these two approaches in the Iranian road safety system.

MISSION: *Demonstrate that by applying a 'safe systems and collaborative approach' to road safety interventions, substantial reductions in road trauma will be achieved within a 12-month period (and ongoing).*

Objective 1: Reduce average (mean) vehicle speed in demonstration sites by 5km/h, within 6 months, sustained over 1 year;

Objective 2: Increase speed limit compliance by 30% within 6 months and by 50% within 1 year;

Objective 3: Reduce road fatalities by 30% within 6 months, sustained over 12 months;

Objective 4: Reduce serious injuries caused by road crashes by 20% within 6 months, sustained over 12 months;

Objective 5: Achieve greater community acceptance of speed limits and speed enforcement by 20% within 6 months and 50% within 1 year;

Objective 6: Achieve increased community satisfaction with the road and traffic environment by 20% within 6 months and 50% within 1 year;

Objective 7: Establish ongoing collaborative working groups (including Traffic Police, Road Maintenance and Transportation Organization (RMTO), local government, NGOs, Health) to continually improve road safety; and

Objective 8: Gain commitments by other jurisdictions in Iran and throughout the Region to implement speed management programs based on results of the Demonstration Project.

The Governance Regime within the Demonstration Project

To finalise the project implementation plan with defined benefits, a ***Speed Management Demonstration Project*** was approved in the meeting of NRSC, aiming to prepare the way for effective speed management in Iran.

The lead agency for road safety was confirmed as the NRSC with the secretariate being hosted by the Ministry of Roads and Urban Development. Given the scope of the project, key stakeholders at National and Provincial levels were invited to participate. Therefore, the establishment of an effective governance mechanism was identified as crucial to ensure a successful outcome for the project. NRSC brought all the stakeholders together to gain their contribution and support in implementing the demonstration project.

Coordination, advocacy, accountability and resource mobilisation were considered essential components. A road safety partnership was therefore formed within the NRSC to facilitate implementation of the project including:

- RMTO,
- Road Traffic Police,
- Ministry of Interior (Transportation and Traffic Department),
- Ministry of Health and Medical Education (National Emergency Management Organization)
- WHO Country Office

Led by NRSC and WHO country office, multiple taskforces were formed for the project, at both national and provincial levels. National Taskforces were established to coordinate stakeholders based on their internal structure, so that they could participate actively and maintain their ongoing processes. Provincial Taskforces were established to take charge of implementing different project steps, such as conducting baseline surveys, and implementing designed interventions. These Task Forces are set up to provide:

- *Coordinating mechanism:* To ensure good coordination of the project, a multisectoral mechanism has been set up with participation of various, stakeholders. A coordination body was established at national level and in each of the three selected provinces. The provincial coordinating body is led by the governor as the highest authority. In addition, to the design of evidence-based interventions, a technical group has been established at national level with the involvement of key technical staff from the provincial level. The WHO is supporting the technical working group.
- *Advocacy:* Before starting the project, some of high-ranking authorities of road safety at national and provincial levels contradicted the message about the impact of speed management in reduction of road mortality. This challenge was addressed through advocacy actions and sharing scientific evidence and figures from the country.

The Project planning phase

In the first step, in consultation with partners, three provinces were selected with consideration of their potential strengths to implement the project. The criteria for selection of the pilot sites included:

- Crash rates, especially speed related;
- Crash injury numbers and severity;
- Capabilities of local responsible agencies;

Figure 4. Locations of the demonstration road corridors

- Representative of road functions, geometric designs;
- Road user behaviours throughout the country;
- Degree of non-compliance to speed limits a major problem;
- Traffic and speed monitoring capability;
- Availability of traffic enforcement resources;
- Diversity of land use and environmental conditions; and
- Important road transportation links.

In consultation with the three provincial governments, segments of roads were selected for applying speed management interventions. This involved nominations by the provinces and negotiations about the lengths that could be covered with existing resources to implement changes and to measure and evaluate the results.

Based on selection criteria, local capabilities, capacity and resources, six corridors of duplicated, primarily rural, freeways/highways were selected in three provinces (Figure 4):

- **Isfahan:** MoorcheKhort-Meimeh-Delijan (125 km), Najafabad-Tiran-Daran (100 km)
- **Markazi:** Saveh-Tehran Freeway (77 km), Arak-Salafchegan (67 km)
- **Khorasan:** Kahak-Sabzevar-Neyshaboor (190 km), Chenaran-Ghoochan-Farooj (65 km)

A total of 1,250 kilometres of road length have been selected for the interventions.

The project is currently underway with two distinct phases, preparation and implementation. These phases are described in Figure 5.

Project Management Protocols

NRSC is the lead agency of road safety in Iran. The project was approved by the NRSC and a national task force was formed after an NRSC meeting chaired by the Minister of Roads and Urban Development. The NRSC's secretariat is responsible for managing and following up the implementation and progress of the project. Stakeholders of the project (members of the NRSC) nominated

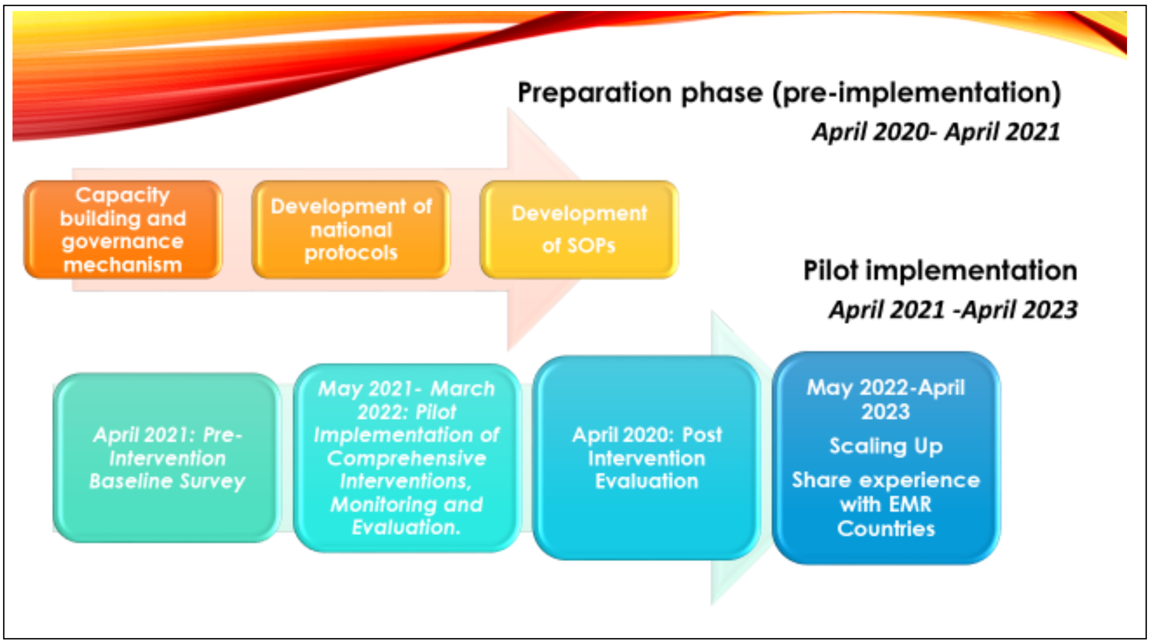


Figure 5 Speed Management Demonstration Project Phases

Figure 6. Photos of the Workshops in the three provinces

representatives to the national task force. Representatives report to the secretariat and follow up the progress of the project in their organization according to the interventions designed and report to the NRSC's secretariat as the project manager.

In the same way, provincial authorities (in three selected provinces- sub organization of RMTO in cooperation with Traffic Police) as the executive part of the project report the progress of interventions implementation of the project to the secretariat.

Efforts to build collaborative agreements were seen as crucial to the success of the project. Workshops were conducted in the three selected provinces with the attendance of national and provincial authorities to advocate and seek support of local stakeholders as well as to introduce and discuss the project components. Figures 6 and 7 show photos from these workshops and boards that record the commitments of high dignitaries representing their respective organizations. These ceremonies were covered by social media.

A detailed project plan was prepared with:

- elements and action areas/strategies;
- tasks;
- suggested performance indicators;
- responsible or lead agency;
- other stakeholders involved in each action;
- determining the top three priorities
- location of implementation (local/national); and
- timeline.

(Note: The original timeline required amendments given setbacks due to COVID-19 and other reasons. Also, the Progress reported in this paper are as at 1 August, 2021.)

The plan is structured under five focus areas.

Focus area A is Problem Definition with the objective of selecting and approving the demonstration and control sites. The actions include:

- Defining a mechanism for publishing and reporting speeding-related data in a timely fashion.

Progress: *Baseline data has been collected and reviewed, intervention and control sites have been selected. However, the mechanism for timely data reporting is still under development in consultation with Traffic Police. Requirements include the need for a total monitoring and collation of all segregated data from all speed detection sources, traffic monitoring, enforcement activity, speed surveys and surveys canvassing public attitudes to speeding.*

Focus area B is Working Groups with the objective of establishing a working group for the demonstration sites

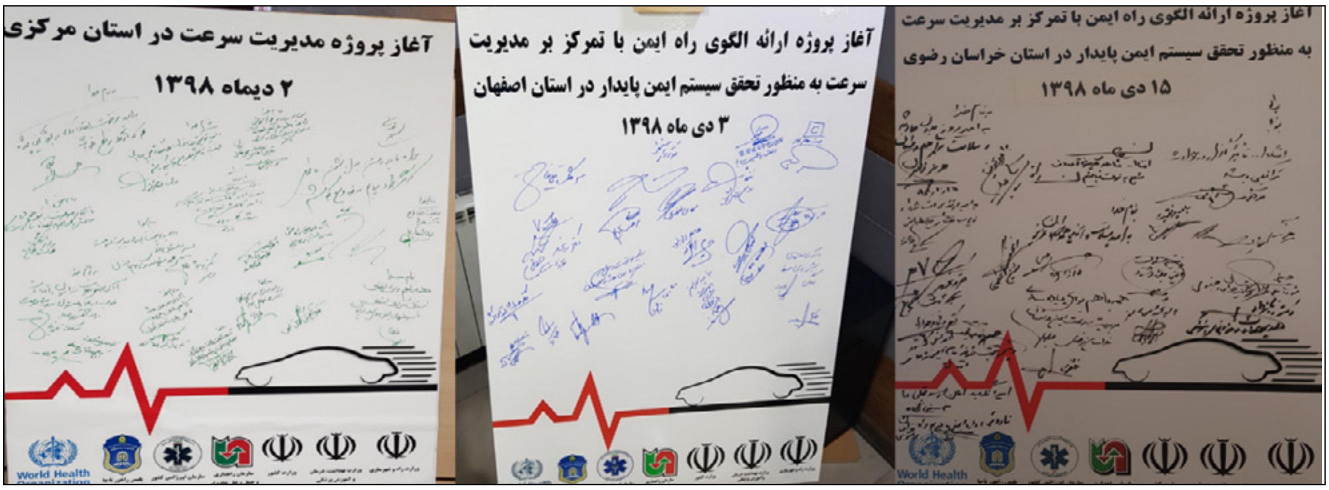


Figure 7. Logos and signatures of agreement by high level officials in three Provinces

by developing a pattern for a comprehensive multi-sectoral mechanism for speed management. The actions include:

- Securing commitment of all key stakeholders;
- Ensuring clear leadership, responsibilities and accountability mechanisms are in place; and,
- Establishing memoranda of understanding (MOUs)

Progress: The project was divided into 6 pillars focused on the key technical aspects. Pillar 1 is the Road Engineering Pillar. Pillar 2 is Surveillance, monitoring and evaluation. Pillar 3 is Crash investigation and Governance. Pillar 4 is Law enforcement. Pillar 5 is Social Marketing. and Pillar 6 is Post-crash Services. These groups are also advised by national and international consultants. High level agreements have been formally signed off at national and provincial/local levels. The rationale is to ensure participatory ownership, commitment and continued contribution to the project objectives.

Focus area C is Speed Management Plan based on SSA Principles with the objectives of promoting speed limit setting based on the SSA in demonstration sites, and developing a national and regional education and communications strategy. Actions include:

- Demonstration pilot engineers (specifically RMTO and Police experts) should identify and train in safe system speed management practices;
- Arrange for intensive training on speed limit setting with the use of the guidelines based on the SSA and low-cost engineering countermeasures that can be implemented in a short timeframe;
- Conduct training (on public education and communications) for decision-makers and/or practitioners; and,
- Develop a program of public education and social marketing on speed risk.

Progress: A National SSA-based guide for speed management has been prepared and RMTO and some Police experts have been trained in safe system speed management practices, however, more Police need to be trained. Training on public education and social marketing has been provided to decision-makers. A social marketing strategy has been prepared. It is considered imperative that all participants are informed, trained and attuned to the SSA so that an holistic to ensure a coordinated approach.

Focus area D is Speed management implementation of the Project plan. Actions include:

- Implementation of infrastructure modifications, speed limit setting according to safe system audit guidelines, monitoring, evaluation strategies and reporting;
- Road policing strategic planning aligned with the overall speed management plan complemented by the implementation of effective speed management law enforcement interventions; and
- Implementation of speeding-related public education programs to promote community acceptance of speed management interventions and changes to the road and traffic environment.

Progress: The implementation phase commenced with a high profile Government launch on 27 April, 2021.

Focus area E is Surveillance, Monitoring and Evaluation with the objectives of securing broad community understanding and support, increasing speed limit compliance and reduce average speeds travelled, reduce fatal and injury crashes, and document and promote demonstration project results. Actions include:

- Conduct locally representative surveys of drivers to monitor trends and collect information on attitudes regarding speeding and safety interventions and road user satisfaction with the road and traffic environment;
- Monitor and evaluate the effectiveness of speed enforcement, traffic calming interventions and speed reduction;
- Measure the crash and trauma outcomes of speed management interventions;
- Assess the impact of pilot speed management countermeasures, including traffic calming and low cost perceptual countermeasures; and
- Conduct comparative evaluation against baseline studies and report results to all key stakeholders.

Progress: Specific performance indicators for each segment of the project plan have been identified and baseline studies and data collection have been undertaken.

Pillars of the project

The project is based on six main pillars of safety.

1. Road safety engineering
2. Surveillance, monitoring and evaluation
3. Governance or management
4. Law enforcement (efficient and effective interventions)
5. Social marketing
6. Post crash services

Establishing baselines and resourcing

This section explains how the project has progressed discussing the leadership structure, baseline research, capacity building, guidelines, protocols and technology.

Project leadership

The newly formed Road Safety Partnership is to oversight and facilitate implementation of the project including the outcomes from the following organisations:

- RMTO,
- Road Traffic Police,
- Ministry of Interior (Transportation and Traffic Department),
- Ministry of Health and Medical Education, National Emergency Management Organization
- WHO Country Office

Baseline studies

As it is a demonstration project, baseline data about the selected road segments and traffic behaviour and performance both require a baseline for pre- and post-evaluation and to determine the type and nature of interventions that are likely to yield positive results. The data collected included traffic volumes, crashes, injuries, fatalities, free mean speeds, speed variance, 85th percentile speeds, speed violations, and percentage of heavy vehicles[2]. In addition, an examination of specific road features of demonstration lengths was performed by the national consultants, who shared the observations via geo-marked photographs[3]. This information is being used to determine how to segment the corridors and what interventions should be implemented.

Separately, research was carried out to understand community and road user knowledge and attitudes regarding speed limits, speeding, speed enforcement, speed behaviour, and speed deterrence factors. This involved a literature review, examination of crash and violation data, as well as qualitative and quantitative community attitudes studies.

Capacity building and Guidelines

Over three missions to Iran, international consultants conducted workshops at a national level covering the SSA, road safety management, institutional strengthening, road safety engineering and traffic calming, setting safe speed limits, public education, community involvement, traffic law enforcement, and offender processing. Later, through internet conferencing, additional courses were conducted, covering crash investigation, offender processing, road engineering and 2+1 road design. Also, a national consultant led a workshop covering a review of road engineering studies applicable to this region. Project and operational protocols are being developed for each part of the project.

Guidelines for SSA-based speed limit setting were prepared by an international engineering consultant assisted by a national consultant.

Technology and resourcing

Iran has established a substantial national traffic and speed monitoring system. When a vehicle is detected by a speed camera, the owner is instantly sent a text message to advise the detection. However, while this is good practice, the speed cameras are often not in use due to being damaged or inoperable. In addition, the back-office infringement processing system is not efficient in issuing, tracking and enforcing infringement notices, diluting the deterent impact of speed enforcement initiatives.

Iran has also developed a system for real-time monitoring of buses that monitors and provides driver feedback on safe driving behaviours. There is potential to expand this system to other classes of vehicles and professional drivers.

Lessons learned in the Practical Application of Good Governance

To implement the project, NRSC, as the lead agency of road safety, approved the project as a national project in the meeting in the presence of the all memebers. The NRSC implemented the following structures and actions to carry out the project:

- Establishment of task forces;
- Holding experts' meetings with partipation of delegates of NRSC members;
- Holding workshops at national and provincial level; and
- Conducting site visits.

The establishment and controls of the NRSC, the road safety lead agency, proved to be highly beneficial in being both a guiding and authoritative body to inform, and coordinate the front-line agencies in this demonstration project. This has been important from a National perspective as the provincial authorities are seeking guidance and support in a progressive application of road safety reform. However, barriers and restrictions have been identified with coordination across the three provinces, expectations that increased funding will flow and the difficulty in ensuring agency level cooperation in data collection and information exchange in the provinces.

Adopting a project plan and a Road Safety Partnership has been instrumental in gaining ownership and commitment

[2] Note that speed data collection was conducted with a variety of tools to ensure efficacy of the measurement of actual vehicle speeds. These included traffic detectors, overt and covert speed cameras – static and point to point.

[3] Note that the original plan of site visits by the international road safety engineering expert could not be possible due to COVID-19 related travel restrictions.

from the contributing agencies. The identification of leadership groups has devolved accountability to those agencies in a way that can be monitored through performance indicators within the overall plan. This has been a strategic direction to reduce the tendency for the *silo* phenoma present in a number of agencies.

The establishment of 6 working groups under the framework of the pillars with a designated leader has secured the commitment of key stakeholders to accept accountability and responsibility for productive outcomes. In some cases, these have required an MOU to secure a commitment.

Other lessons include:

- Road Safety Governance is enhanced by strengthening the role and function of the NRSC;
- The establishment of working groups with specific responsibilities and performance indicators assists in building capacity;
- Having a time-bound plan and technical support that was provided through national and international technical expert groups strengthens the project; and
- Advocacy, communication with key authorities at national and subnational level, capacity building of technical staff using robust scientific evidence are very important and effective.
- Information collecting and information sharing helps to build cohesiveness in road safety agencies;
- It is critical for all agencies to work collaboratively to achieve common objectives;
- It is important and practical to build partnerships and establish good governance at and between National, Provincial and local levels.

Conclusion

This challenging speed management demonstration project has been initiated in 3 provinces in Iran with the intent of ensuring safer travel through speed management measures. In order to carry out the project, commitment of the safety stakeholders and NRSC is an important issue. Therefore, in the first instance, the project was approved in the NRSC meeting. The initial phase has required a strong governance framework under the auspices of the NRSC. So, NRSC formed a task force to plan and monitor the execution and progress of the project through partnership and cooperation of the stakeholders.

This has ensured effective governance through a partnership of the major stakeholders, pillars of responsibility have been identified. working groups at national and provincial levels with clear terms of reference and clear agendas wereestablished and have strengthened the resource capacity of the project. The focus on setting clear performance indicators and surveillance and monitoring plans is assuring effective evaluation. This disciplined approach has identified some resistance and weaknesses in the silo mentality which will require constant monitoring. Instead the project is demonstrating the benefits of accountabilities and responsiveness. Information collecting and sharing is identified as a measure to build a collaborative approach to achieve the common objectives of saving lives. The insights provided on governance are intended as a model for other countries to adopt in addressing speed management and road trauma.

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The AAA Approach to Crash Investigation Reform – The Perspective from Road Policing Practitioners.

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Key Findings

- The crash investigating reporting process is convoluted in its complexity and in need of a complete overhaul to ensure it is *fit for purpose;*
- Crash data analysis must be based on accurate, timely and meaningful data entry elements;
- The AAA approach combines the core components of traditional 3 E's and the contemporary Safe Systems Approach
- The AAA approach to crash investigation provides a simple and practical approach to data and analysis as a foundation to road safety reform;
- Requiring the investigator to focus on contributory factors and preventative actions has the potential to change the paradigm of crash investigation from reactive to pre-emptive reform.

Abstract

Professional road crash investigation, complemented by intelligent analysis and dynamic actions provide the foundation for road safety reform. However, to date, the real potential resulting from police investigative findings have not been fully realised due to the lack of streamlined connectivity from the crash scene to the reform process. Such deficiencies include inadequate investigations, inadequate data management, convoluted processes, system delays, inadequate analysis and limited immediate and mid-term actions which should be generated following thorough and efficient investigations. A review of processes across high, medium and low-income countries has identified a more effective approach to achieving results in road safety reform across all road safety disciplines. The simple AAA framework to '*Acquire, Analyse and Action*' is presented as a contemporary model to ensure an evidence-based foundation drives road safety reform to identify root cause analysis locally, nationally and globally. This provides structure, discipline and purpose as well as technical skill and competence to achieve practical recommendations as preventative measures for crash reduction. A multi-disciplined expert review team to validate/assess/modify these recommendations in serious crashes ensures constructive countermeasures are prioritised and actioned. This facilitates a paradigm shift in thinking and analysis to achieve a continuous improvement process designed to reduce road trauma and save lives.

Keywords

Crash investigation; Road Policing; AAA; Acquire, Analyse, Action; Road Safety Reform;

Acronyms

AAA – Acquire, Analyse, Action
EDR – Event Data Recorder
ERT – Expert Review Team
LMICs – Low and middle-income countries
SSA – Safe Systems Approach
UK – United Kingdom
USA – United States of America
WHO – World Health Organisation
3 E's – Enforcement, Education and Engineering
24/7 – Operational response: 24 hours a day, 7 days a week

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Introduction

Road crashes, injuries and deaths are a serious cost and humanitarian concern internationally. They result in tragedy for many families, pain and suffering for many individuals and are a huge resource cost to police and other emergency services in attending motor vehicle collisions, extracting the dead and injured and follow-up aftercare, reports, and investigation.

Achieving road trauma reduction is a complex challenge involving the interrelationship between road users, vehicles, road infrastructure and emergency rescue. Road crash investigation is a vital means of identifying causality and initiating action for reform in all these disciplines, ultimately to provide safer travel and reduce casualties. The United Kingdom (UK) police policy decrees that road deaths be approached with the same investigative standard of thoroughness, impartiality and effectiveness as unlawful killings until the contrary is proven (ACPO 2001).

Crash investigation has traditionally been vested with traffic police having a 24/7 emergency response capability. Outcomes generally focus on identifying offences or offenders as a basis for criminal and civil litigation. The broader and more purposeful approach is to maximise the value of crash investigations and proactively impact reform across all road safety disciplines. However, this reform is inhibited by the inadequacies of the investigative process, the complexity of data capture and extensive delays in data analysis. Key stakeholders in the use of this data must appreciate that the value of detailed investigations and analysis will enhance the integrity of countermeasures and reform.

Technical advice, training manuals and crash reporting practices ignore a prime remedial rationale for investigations as considered by the International Civil Aviation Organisation in aircraft crash investigations i.e. to determine *why the accident happened and how similar events might be avoided in the future* (https://www.icao.int/Pages/default.aspx). Here, the immediate actions address system faults and provide continuous training for the pilot(s). Similarly, engaging the road crash investigator in this process ensures a commitment to identify *real causes* with ownership of potential solutions through active involvement in road safety reform.

The paper emphasises the need for a *mindset* change for investigators to *prevention focused* analysis and a *mindset* systems' refresh to focus on preventative strategies rather than merely collection and analysis. Improving these foundational aspects will drive more purposeful and timely *action reform*.

A simple, practical, and targeted model is presented to achieve this action-based reform. Through effective training in this disciplined approach, the skills of police crash investigators will be highly valued and meaningful in achieving productive outcomes in road safety interventions globally.

Methodology

This paper examines the process of road crash investigation, data recording and analysis to determine its current contributory effectiveness in road safety reform. The discussion follows to identify a more practical crash investigation perspective to achieve more focused and timely outcomes across all road safety sectors.

The perspective is presented from two road safety and road policing specialists, practically and professionally experienced in over 25 low and middle-income countries (LMICs) over 20 years, as well as veteran policing experience in Australia and other high-income countries. This perspective is enhanced through direct crash investigation experience and providing training and guidelines as crash investigation specialists internationally. Deeper insights are obtained working with crash investigation practitioners, understanding the environment, living within the communities and specifically as participant observers and assessors of police investigations and operations.

The limitations of this conceptual approach recognise organisational reluctance to readily change the status quo, particularly if it involves additional responsibility, training, strategic planning, and decision making for themselves and their operatives. This particularly applies to the recommended expert review process involving leadership to identify crash causes and implement remedial action. Additionally, the prevention foci is a constructive add-on to current investigations. This concept appreciates the potential that police and the legal systems may view identified *system* weaknesses as a mitigation against legal culpability. These aspects should not prevent implementation and be addressed through *evaluation and continuous improvement*.

To achieve positive outcomes, organisations must firstly acknowledge inefficiencies in their current policies and practices and be prepared to train operatives to achieve road safety outcomes. The process will dramatically streamline the feedback loop from crash to reform to ultimately save lives.

Background

The original conceptual framework of countermeasures for road trauma was consolidated by Julien H Harvey in 1923 with the 3 E's triangle being Engineering, Education, and Enforcement (Damon 1958). These three elements have maintained currency in strategic and modelling crash risk interventions. Systems' analysis of road trauma progressively gained impetus following the Haddon

Matrix general injury prevention model (Haddon 1972) with variations of the construct of the 3 E's being adopted (Donaldson, 2002), (Derakhshani, 2019). More recently, the Safe Systems Approach (SSA) has become the primary model for reducing traffic crash fatalities and serious injuries (OECD/ITF 2008).

The SSA seeks to understand crashes and risk and apply system reforms through safer roads and roadsides, safer vehicles, safer road users and safer travel speeds and create a road transport system in which human mistakes do not result in serious injury or fatality (Jurewicz, 2010, Steinmetz, 2015, Doecke, 2018). While engineering, education and enforcement are key contributors to this approach, albeit under a broader framework, the focus is to acknowledge human errors as failings and address systemic system solutions.

Over decades, most fatality crashes have been attributed to human factors frequently referred to as errors and ranging from 71% to +/- 90% (Treat 1980, McDonald 1985, PIARC 2003, Stander 2005, Shinar 2007, Shuey 2013). This operator failure (the human factor) remains the single greatest obstacle to safety in vehicular travel (Mawson 2014). These deliberate or careless actions include high-risk road user behaviours such as dangerous driving, speeding, drink and drug driving, fatigue, and distracted driver behaviours. Failure to comply with the basic safety precautions such as occupant restraints and motorcycle helmets also contribute as human failings.

James Reason described errors as skills-based, rule-based, and knowledge-based, acknowledging these may frequently occur without consequences. However, he describes the *trajectory of accident opportunity penetrating the defensive systems* as the collectively failures of latent errors aligning with system inadequacies (Reason 1990). This is a window of opportunity, colloquially referenced in later reports as the *swiss cheese* effect when the holes align in crash potential or accident sequence (Reason 2000, Peltomaa 2012). These errors may also be considered as levels of driver performance not being adequately skilled as a novice or importantly not having safety ingrained as attitude, behaviour, and culture (Shuey 2013).

The complexity of these errors with their differing interpretations in road safety provides a challenge to eliminate the collective failures of individuals or strive towards error-tolerant design infrastructure to be forgiving of human errors as applied in the SSA. However, strategists, reformists and scholars shy away from trying to eliminate the human errors and draw a distinction between errors and pre-meditated deliberate civil disobedience to the rule of law creating a high-risk situation. Whether deliberate or careless, the consequences bear the same impact. It is therefore critical to accurately and timely identify the real crash causes and minimise speculation so that effective remedies can be implemented. *The foundation for this is the integrity of the crash investigation and the timeliness from the crash to any action, reform or countermeasure.*

Data collection

Accurate data collection and efficient analysis provides the basis of well-founded road safety strategies. These enable the underlying causes of crashes to be identified and road safety exposures treated (Shuey 2013). The quality of this data is fundamental for the accuracy of crash analyses, and consequently the design of effective countermeasures as well as an intelligent crash reporting system (Imprialou and Quddus 2019). Further, crash data provides basic information for effective highway safety efforts at any level of government, however, the lack of uniformity among countries and among different jurisdictions in the same country is prevalent (Montella, 2019).

Universally, police reports provide the primary data source for analysis and commentary by road safety management, researchers, and reformists. These reports provide a broader database than those in-depth multi-discipline and forensic specialists assessing a small proportion of crashes meeting a set criteria (Larson, 2004). It is therefore incumbent to ensure this process adds value to road safety reform. However, over time, the data capture requirement has gradually increased in complexity to satisfy the statistical agency *needs* while omitting critical issues required of a reform agenda. Convoluted collision reporting procedures range from detailed hand-written reports and manual completion of proforma templates, to direct entry into sophisticated data systems.

Mandated data requirements ensure officers consider and assess numerous categories, classifications, data elements and values, tick boxes and alternatives varying from up to 200 data entry considerations in Australia, UK and United States of America (USA) to 14 pages of information in the Kingdom of Saudi Arabia.

These requirements include detailed measurements, photographs, a crash narrative, offender interviews, victim, and witness statements, and will complement the data requirements as evidential briefs for penalty assessment, administration, legal liability, or financial compensation. Recently, *dynamic data elements* have been introduced to record any automated system(s) present (NHTSA 2017). Police data is therefore useful for general analysis, but often lacks the fidelity to understand crashes through the identification of *contributing factors* (Doecke 2020).

Accurate data collection globally is hindered by the lack of universal adoption of the WHO standard fatality definition of death within 30 days of a crash and the variation of interpretation of serious injuries. Further, under-reporting of both fatalities and serious injuries, especially of vulnerable road users, combined with extensive delays and/or the unavailability of serious injury data and causation restricts real-time or effective reform in the 3E's or SSA.

The under-reporting of crash numbers deprives road safety reformists with the opportunity to fully appraise the real magnitute of countermeasures and seek commensurate funding to address the gravity of the problem. The International Transport Forum on the road safety performance of 42 member and observer countries claims that police data significantly understates the number and seriousness of crash injuries (ITF Road Safety Annual Report 2020).

Effective reform requires timely, accurate and meaningful data at the point of entry.

> *The government is very keen on amassing statistics – they collect them, add them, raise them to the n^{th} power, take the cubed root and prepare wonderful diagrams. But what you must never forget is that every one of those figures comes in the first instance from the village watchman, who just puts down what he damn pleases.* (Sir Joseph Stamp, 1929)

While this historic quotation draws attention to data quality, a critical issue is the lack of timely analysis to action strategic reform. Normal *acceptable* lapses are twelve months to consolidate actions from the fatality database to more than two years for the broader serious injury database.

Data analysis

From initial information, data is coded, computerised, collated and analysed. Validation criteria and quality controls apply in some jurisdictions for vehicle and personal identification as well as linking to hospital and insurance surveillance. Following this array of different processes, analysts and researchers extract data for the purpose of identifying countermeasures and strategic reform.

Identifying, collating and consolidating crash causes is traditionally a longitudinal process undertaken through analysis of a substantial database of fatal crashes and trends. Serious injury data bases, *if maintained*, are rarely considered in this analysis. Australian states separately collect and analyse statistics complemented by data, recording and analysis by the Office of Road Safety in its National Road Safety Data Hub.

Further, crash causes can be a matter of interpretation. The clinical approach examines events, behaviours and conditions, while the epidemiological/statistical approach examines factors and variables divergent from the normal driving population. The emerging naturalistic approach examines all behaviours, events and conditions available in an objective data format (Shinar 2007). *Whatever approach is used to examine causes, it is substantially reliant on the biases and inefficiencies of the foundational data collection.*

The quality of the crash investigation

The quality of crash investigation varies globally from poorly trained traffic police undertaking basic investigation to identify fault or compensation liability to highly qualified forensic analysts. Multi-fatality investigations may be undertaken by multi-disciplined police crash investigation specialists on 24/7 call-out such as Victoria and New South Wales police. Some jurisdictions operate with a formal multi-discipline response capability for multi-fatality or set criteria call out of a multi-discipline response team usually with hi-tech and forensic capability. However, while fatality and serious injury rates remain high, the ability of these hi-tech investigative bodies to attend all serious crashes is not possible. Further, notwithstanding, the in-depth analysis of these bodies, the immediacy of reform is rarely actioned.

Concerns have been raised about the quality and reliability of *analysed* police data which is simplified and standardised without any meaningful appreciation of behavioural issues leading to the crashes (Larson 2004). In Queensland, the reliance on police data for the counting of road crash injuries can be problematic when compared to hospital data where it was found around two thirds not linking to any record of police data (Watson 2015). Similar results of under-reporting were found in New Zealand with less than two thirds of all hospitalised road crash casualties recorded in police data (Alsop 2001). An accurate representation of the road crash injury problem is essential for prioritising funding and resources as well as targeting and evaluating road safety interventions. (Watson 2015).

Crash statistics are often less useful in determining the actual cause of the crash as the data collected often only reflects the information obtained at the crash scene and not the events that preceded the crash (Oskarbski, 2020). What must be acknowledged is that in most cases, more than one cause contributes to a crash. These issues need to be searched for, scrutinised and analysed at the time of the crash. Contributory factors are considered as those, if removed, the crash would not have occurred (Shinar 2007). Statements espoused 60 years ago hold credence today.

> *No official traffic safety program can be fully effective without an adequate accident reporting and records system. Only with good accident facts, properly analyzed and intelligently used, can enforcement be properly directed, educational effort be effectively aimed, and traffic and highway engineering be scientifically applied (Damon 1958).*

Current research identifies subjective reasoning attributed to misrepresenting causes and the complexity of crash reports inviting commentary under *injudicious actions*. Some categories such as *driver inexperience* or *aggressive driving* are ineffective in driving road safety reform unless some action follows. The trend in the UK is for contributory factors to be classified into coherent categories to maximise statistical clustering and minimise the risk of misinterpretation by police (Rolison 2020).

Crash investigation therefore, without initial robust root-cause analysis has the potential to bias the outcome and dilute the intervention. Positive and negative biases have been observed in some countries with police identifying infrastructure as a cause when they are responsible for speed management and conversely engineers blaming the lack of speed enforcement as the cause. While traditional roles are important, all disciplines should have a primary focus on identifying the *real causes* i.e. root cause analysis and contributory factors.

While police investigations are principally targeted towards prosecuting an offender, the research identifies the need for quality-based data collection processes to ensure the accurate identification of real causes.

Observational perspectives

Observational perspectives in both high-income and LMICs support the research commentary. Specifically:

- Initial investigations are deficient in identifying the real causes of crashes
- The priority of investigations is to determine fault
- Investigators require a higher level of skill and equipment
- The data collection process is complex, cumbersome and time consuming
- Traffic police often do not have the time and in many cases, the training needed to gather and record the required data
- Under-reporting, omissions and inaccuracies lead to misleading analysis
- The delays in reporting, collating and analysing data does not support timely reform
- Contributory factors need to be an automatic component of any recommendations
- Data sharing is deficient however, should be an essential outcome of any analysis.

Discussion – considering alternate approaches

Sweden and The Netherlands within their Vision Zero strategies, focus on prevention providing the foundation for the SSA in management and sustainable safety. Sweden's vision is to identify elements of a crash which determine fatality or survivability under OLA (**O**bjective data, **L**ist of solutions, and **A**ddressed action plans). High crash risks identified include run-off road crashes, head-on, intersectional side-impact, and vehicle-pedestrian crashes (OECD/ITF 2008).

In the UK, the lead police investigator has responsibility to debrief investigations to identify lessons learned, which contribute to preventative measures and referrals to partner agencies. Investigators should ensure that longer-term prevention, intelligence and enforcement opportunities are identified and shared with local neighbourhood policing teams. In Australia, road defects and infrastructure issues are likewise required to be notified to partner agencies. While road safety audits may be undertaken following some high-profile crashes, it is not the norm.

Independent crash investigation and reconstruction professionals may be engaged in court trials to support a prosecution or defend an accused, however, *rarely involved in preventative measures*. In LMICs the investigations are generally less rigorous for routine fatalities (such as pedestrian, motorcycle or 1-4 fatalities) although many countries have multi-discipline teams responding to high profile and multi-fatality crashes. In the USA, the National Highway Traffic Safety Administration (NHSTA) has implemented the Fatal Analysis Reporting System (FARS) which allows users to query the database of fatalities and extract information relating to the specifics of crashes and the cause of those crashes.

Similarly, the EU has, through the European Transport Safety Council (ERSC), developed a centralised repository for road crash trauma data including an Annual Road Safety Performance Index which details levels of road trauma on a country basis, however, it does not provide the detailed level of functional data investigation that the NHSTA provides. Australia has a National Transport Safety Bureau however, under the umbrella legislation of the Transport Safety Investigation Act 2003, their primary focus is on air, rail and marine transportation safety. Expanding the resource or functional roles of these bodies does not present as a viable alternative improve the road crash investigation process.

An avenue for reform is the coronial process, particularly in the UK and Australia, where it provides a critical role in exploring and identifying crash causes, for serial, clusters, systemic or multi-fatality crashes. Court hearings occur months or years after events and often recommendations must be extracted from lengthy findings. Inquests into *single vehicle run off road crashes*, while more frequently occurring on rural roads, do not receive the same rigorous investigative or *cluster* considerations and may only result in a *Chamber Finding.* Clarity of recommendations and preventative actions need a formalised process for road safety reform.

It is also acknowledged that Parliamentary Committees are established to canvass specific safety issues such as motorcycle safety, speed, pedestrians, drink driving, driver distractions or general increases in road fatalities. These committees accept submissions from interested parties and provide recommendations for legislative change or government initiatives. The time lapse from any issue being first raised to countermeasures or solution is frequently years.

The serious system delays in reform internationally is demonstrated in identifying and actioning education, legislation, enforcement, and remedial countermeasures for driver distractions in mobile phone use and drug driving, the emergence of which have now spanned two decades. A further clear example is the failure to acknowledge the importance of EDRs in assisting the identification of crash causes, which, while being stressed by specialist investigators, is not pursued at a strategic level. The critical issue is that the EDR on airbag deployment, captures time-series data in the last five seconds of speed, braking, acceleration, deceleration and evasive actions, as well as some post crash information. This data provides a better understanding of crash causes and safer vehicle designs.

USA has legislated endorsement under the Federal code for investigator access to the EDR data elements (NHTSA, DOT Part 365), the United Nations has a proposal under consideration (UN Reg No 160.00) and the ETSC is advising on refining specifications, now mandated in the EU from 2022. Endeavours to streamline data retrieval and maximise benefits, although having been discussed at the Australian and New Zealand Police Commissioners' Forum 18, 10-11 October 2019 has not been pursued for national reform of the Australian Design Rules.

It is noteworthy that much of the information obtained from these multi-disciplined teams, independent reviews and coronial inquests do not find their way into the official data systems for ultimate analysis. Some recommendations may be independently actioned. It is also relevant that while many jurisdictions have computerised data entry and contributory factor databases, the immediacy of data reform is not driven through crash investigation findings. *Critically, there are limited* ***formalised*** *preventative measures encouraged to be recommended by investigators.*

A catalyst for change – the need for a paradigm shift in thinking and processing

Continuing with the same processes year on year will inevitably achieve the same results. The research integrated with the observational perspectives highlights the need for accurate data to ensure productive countermeasures, enforcement and reform activities. It follows that if the foundational data is inaccurate, omitted, inefficient, or delayed, then any analysis or data mining is likely to have misleading or inaccurate outcomes. These ineffecincies directly impact the timeliness and framing of strategies.

This leads to a need for a *mindset change* for the investigator to be prevention focused in crash analysis and a similar *mindset system refresh* so that the system is directed towards reform. Currently, there is a vast amount of supressed evidence which can be harnessed to crash prevention strategies to saving lives.

The weakness in the current approach is the lack of a legitimate *voice* of the crash investigator. Considering the time, effort and expertise in attending crashes, taking photographs, measurements, checking environmental issues and interviewing witnesses, this presents as a untapped resource to address prevention as a key outcome. We trust the investigator to prepare a *prima facie* case for prosecution in all countries, why not trust those same skills (upgraded if necessary), to present a *prima facie* case for reform? This opinion/recommendation can then be presented to a multi-discipline *Expert Review Team* for comprehensive analysis.

By broadening the analysis to a holistic review *at the time of the investigation*, more meaningful and preventive measures can be identified. The voice of the investigator is important to assist this process.

The following model is a simple process which recognises and addresses the need for efficiency and effectiveness to be the basis of road safety reform. It is presented as the catalyst for change to instigate a paradigm shift in thinking and action and as a first step in converting road tragedies into prevention and reform.

The AAA Conceptual Approach

The AAA approach is a road safety perspective that recognises that road safety outcomes can only be achieved if road safety programs are based on relevant, accurate, timely and accessible data. While not discipline specific, it's three key components recognise the value of efficient and effective data management in a practical application to achieve results. The processs is applied directly to the crash investigation commencing at the scene and equally applicable in the strategic approach involving:

Acquire – Gather all relevant information, understand the real situation, understand the real causes of crashes, improve the collecting, recording and storage of basic crash data, improve the crash investigators' skills and identify, evaluate and expand data sources.

Analyse - Understand the patterns, trends, emerging issues and the management of that information. Identify the risk factors and understand the relationship between cause and outcome.

Action - Apply strategically-driven, evidence-based (evidence of effectiveness) and outcome-focused road safety interventions and then assess the effectiveness of those interventions.

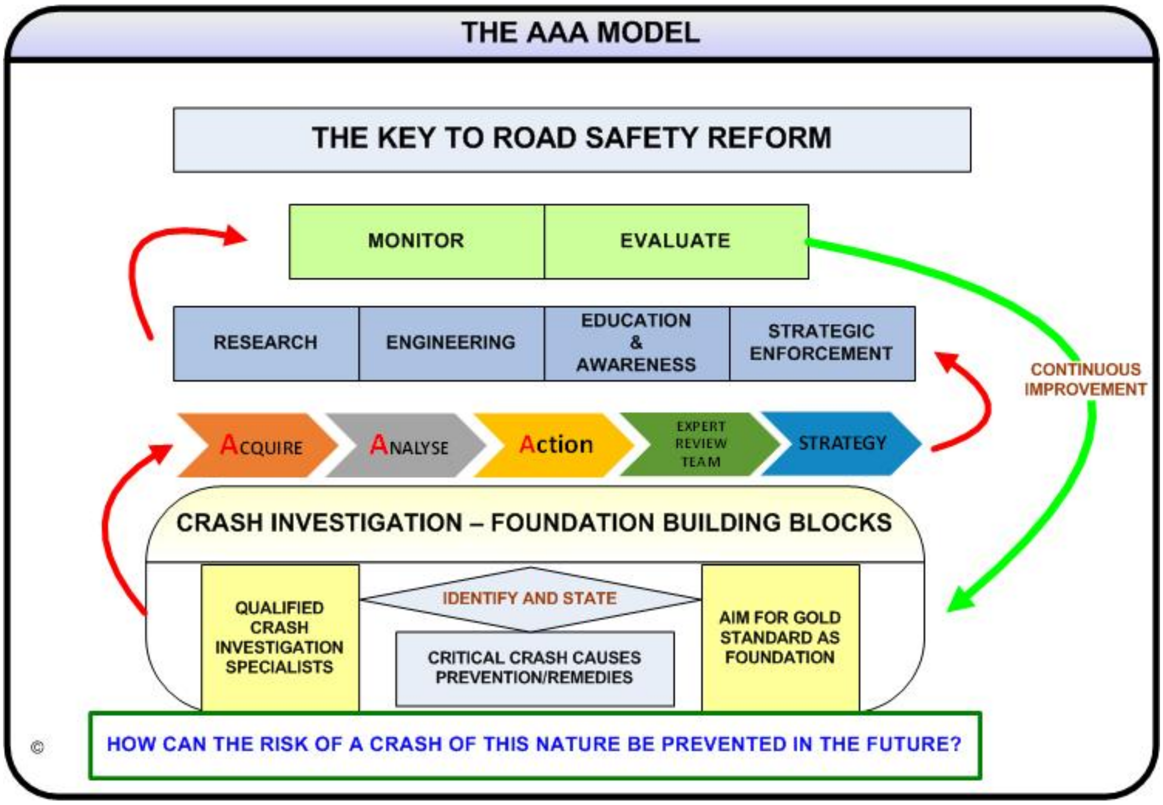

Figure 1. AAA Model of Crash Investigation

The foundation of the model is the thorough, professional and methodical investigation of crashes, undertaken by qualified crash investigation specialists, which result in meaningful and achievable *recommendations for the prevention of future crashes.*

The AAA model depicted in Figure 1, involves a process of continuous improvement that monitors and evaluates the overall process so as to ensure it remains relevant, timely and responsive.

This model is focussed on addressing the weaknesses identified in the current processes to develop road safety strategic, operational and tactical planning. It is designed to identify the real causes of road trauma and achieve real road safety outcomes. The model combines both historical and contemporary thinking in strategic road safety policy and action plan development by incorporating the Safe Systems and the traditional 3 E's approach.

It is noted that SSA in its current implementation is not achieving the significant outcomes anticipated especially in LMIC as the reform emphasis is on unaffordable infrastructure and technology with minimal attention to road user behavioural reform. The short to medium term answer is to make the road users safer through strategic road safety planning that involves implementation of effective enforcement and education/awareness programs.

By compelling the investigator to advise on prevention or remedial recommendations *in every crash,* it engenders a mindset change, develops credence in the investigator's opinion and voice and directly attributes to the reform agenda.

NB: As standard procedure in the AAA process, the chief police investigator is required to proceed with due process for any prosecutable actions or compensatory findings identified in the investigation and under the law of the country. Additionally, as part of the road safety reform process, there is a requirement to identify and state the primary, secondary and tertiary contributory factors and make a recommendation as to ***how can the risk of fatalities or serious injuries from a crash of this nature be prevented in the future.*** This is a critical opinion based on the evidence adduced from the investigation and required to instigate the reform process which is then contemporaneously addressed by an expert review team (ERT).

The Expert Review Team

To strengthen the recommendation of the initial crash investigator(s), the systems approach needs the power and authority to initiate action reform. It is appreciated that the investigating officer, however skilled, does not have the authority, wisdom and multi-disciplined experience to address all issues. The investigator's opinion/recommendation is the starting point from which to build evidence-based reform. This also ensures contributory ownership of the reform agenda for all involved.

The ERT should be convened within two weeks to review every fatal crash as a multi-discipline approach. This dynamic review is intended to raise the criticality of any fatality and the requirement for an action-oriented response, without usurping the role of any subsequent judicial process. The team should comprise a representative of the road safety council as chair with the following members:

- The investigating police expert
- A senior traffic police officer from the province/district
- A representative from the Road Traffic Authority with engineering experience
- A local government representative
- Community leader
- Other experts to be coopted as required depending upon the nature of the crash
    - Those with mechanical expertise
    - Medical or health service experts
    - Any party with a vested interest in the outcome (not victims)

In a number of countries, additional Forensic Crash Investigation is undertaken by independent and qualified investigative institutes to review the findings and recommendations of police crash investigators. Examples of these are:

- Pakistan - Automotive and Crashworthiness Research facility.
- Thailand - Traffic Accident Research Centre (TARC) for validation of police crash investigations.
- Malaysia - Malaysian Institute for Road Safety Research (MIROS) in a similar capacity.

The benefit of a multi-discipline analytical approach is that the collective skills and knowledge will identify real causes and preventative actions as a primary and unified focus. This then must be addressed practically according to legislation, resourcing and skills available.

This approach is action-focussed and partnership-based directed towards a reform agenda. It provides a structure to achieve a mindset change for the investigator and a system change directed towards the identification of real causes. The analyses focus for both the investigator and the ERT to prevent future crashes will require parallel training and guidelines.

This process operates as a formalised and action-oriented debriefing. It is complementary to strategic analysis of a broader jurisdictional database of fatalities, injuries and crashes over extended periods to address trends, clusters, blackspots, black lengths, and repetitive human behaviour failings. However, it is enacted as an immediate response to a tragedy and as a direct contribution to the reform agenda.

This focus presented is a mindset change to enable a voice for the investigator and the ERT in the immediacy of road safety reform. The cybernetics of continuous improvement within the model through evaluation, acknowledges there still may be inefficiencies which can be addressed through experience, skill and additional training. The ERT process is a model which should be implemented immediately in both high-income and LMICs.

Results

The research and practical experience from the practitioners have identified critical deficiencies in the current crash investigation processes with limited immediate value available for road safety reform. The research has not endeavoured to resolve all deficiencies raised. However, the AAA model introduces the first step in a mindset change for the investigator and a system mindset change for the overall process. Checks and balances are incorporated into the model to ensure continuous improvement. The following findings are presented:

- The crash investigating and reporting process is convoluted in its complexity and in need of a complete overhaul to ensure it is *fit for purpose;*
- Crash data analysis must be based on accurate, timely and meaningful data entry elements;
- The AAA approach to crash investigation provides a simple and practical approach to data and analysis as a foundation to road safety reform;
- The AAA approach combines the core components of both the traditional 3 E's and the contemporary SSA;
- Requiring the investigator to focus on contributory factors and preventative actions has the potential to change the paradigm of crash investigation from reactive to pre-emptive reform.

Conclusion

This paper has examined the processes of crash investigation from an operational and practical perspective, as well as drawing upon research, to identify critical deficiencies in the investigation, recording and analysis of road trauma. A simple AAA model is presented which enhances the role and *voice* of the crash investigator, supported by an Expert Review Team to identify and drive road safety reform. *This approach is designed to clearly identify three contributory factors as priority and then make a determination as to how the risk of this type of crash can be prevented in the future.* The benefit of this paradigm shift in thinking and action is in the immediate identification of reform actions and interventions for short-term gains reinforced through tactical, operational, and strategic planning for long-term gains. The ultimate goal is saving lives locally, nationally and internationally.

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Road Safety Case Studies

M7 to M2 Pre-congestion Speed Management

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Key Findings

A pre-congestion speed limit management trial showed:

- Reduction in observed crashes
- Delayed on-set of congestion
- More gradual breakdown in speed
- Reduced congestion footprint

The trial has since become part of the day to day management strategy with a second trial at an additional location along the M7 corridor, set to commence mid-2021.

Abstract

This paper explores the development and implementation of the M7 to M2 pre-congestion speed limit management trial conducted on workdays between 26th June 2018 and 31st December 2018. This trial was the first of its kind in NSW and was implemented using a live loop reporting system utilising key trigger values (specific loop metrics) to identify the opportune time to reduce speed limits prior to flow breakdown. Through measuring the rate at which speeds dropped during flow breakdown, the heatmap footprint of congestion, and the instance of congestion related crashes it was established the trial was able to have a calming effect on traffic flow and reduce the overall footprint of congestion.

Keywords

Speed Management

Glossary

Westlink M7 (M7)
Northwestern Roads Group (NRG)
Transurban (TU)
Variable Speed Limit Sign (VSLS)
Variable Message Signs (VMS)
Operations and Management Control System (OMCS)
Digital Video Management System (DVMS)
Data Analytics Tool (DAT)
Inteligent Transport Systems (ITS)
Closed Circut Television (CCTV)
Transport for New South Wales (TfNSW)
The Department of Transport, Victoris (DoT)

Introduction

NRG, owner and operator of the M7 had observed consistent morning flow breakdown at the M2 motorway interface near the Abbott Road merge. Eastbound flow breakdown typically occurred at 5:50am creating queuing

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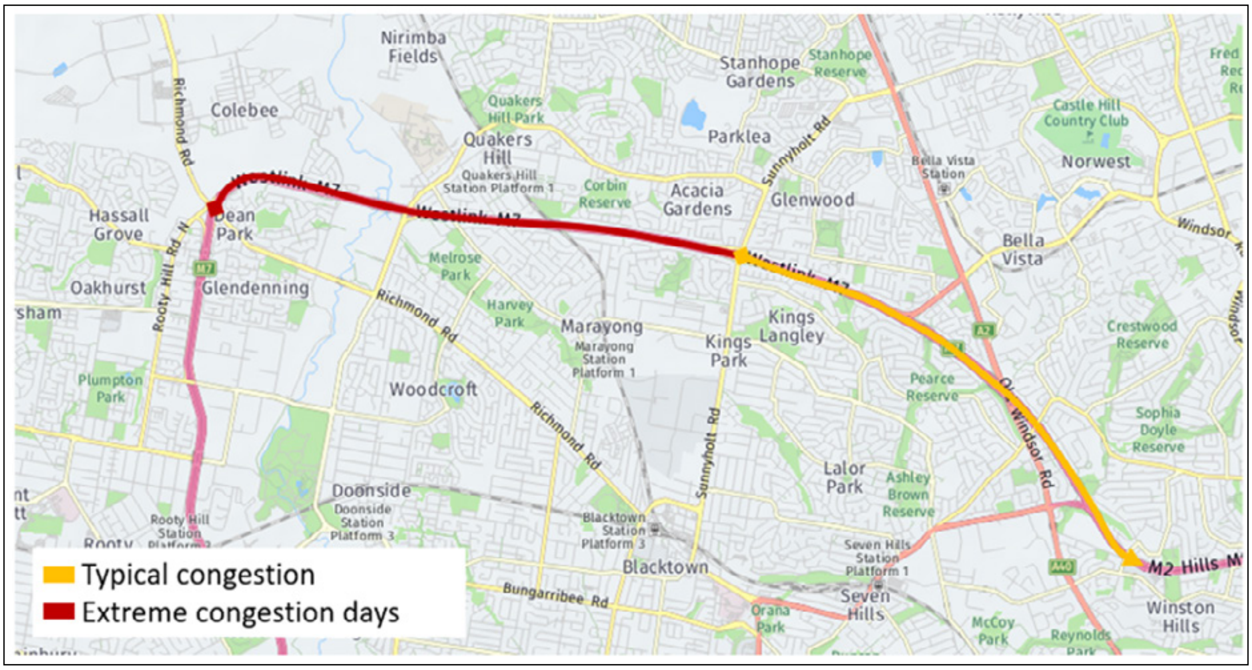

Figure 1 – Map of M7 observed congestion extents

that regularly extended back to Sunnyholt Road (5km), with extreme cases extending as far back as Richmond Rd (12km), see **Figure 1**.

Previously, under the original management plan, once flow breakdown had established the NRG operators would react to the prevailing conditions dropping the VSLS speed limits and provide advanced warning notification on the VMS in order to manage the risk of vehicles approaching the back of the queue.

Over the last 15 years, rather than 'react' to congestion, there has been a move to implemented 'proactive' speed management strategies in order to improve motorway flow, increase safety and delay the onset of flow breakdown. Recently in Australia, DoT in Victoria have completed a trial of 'proactive' VSLS speed limit control on the M80 in Melbourne and are now in the process of permanent implementation (iTnews, 2016). In NSW, the TfNSW operated M4 Smart Motorway uses variable speed limit signs to vary speed limits in response to heavy traffic and incidents to improve road safety, traffic flow and journey consistency (Roads and Maritime Services, 2017).

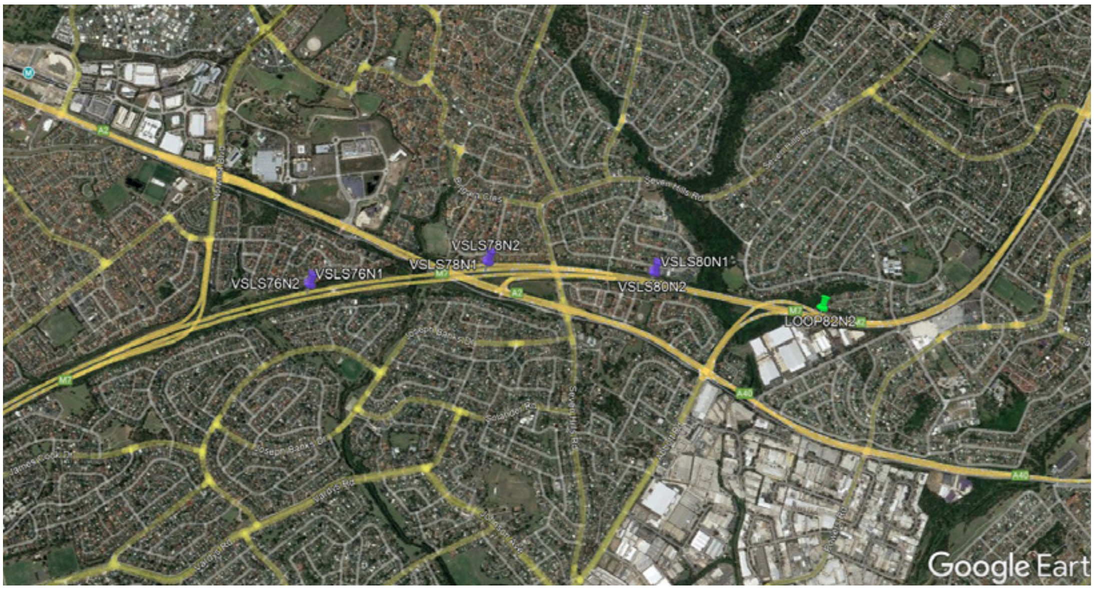

Figure 2. M7 Variable Speed Sign and Loop Locations

NRG under the guidance of TU recognised a key opportunity to leverage off this changing approach to speed limit management and conduct a trial of proactive speed limit control on a key section of the M7 within the existing functionality of the OMCS.

Methodology

The location of the study was identified by NRG, operators of the M7, as a region of the motorway that was experiencing repeated daily flow break down and identified as an opportunity to pilot a pre-emptive speed limit reduction trial. A trial scope was then outlined by NRG and TU in order to seek approval from TfNSW to alter the existing operation protocols related to speed limit changes on the M7. Previous protocols only permitted NRG from reducing speed limits on the M7 after congestion had already formed.

At the request of TfNSW in order to time the reduction in speed limit changes as to ensure optimal compliance, the dynamics of flow breakdown at the M7 M2 interface utilising loop data (LOOP82N1, see **Figure 2**) was analysed. This would ensure that the speed limit was reflective of current congestion conditions and would not be perceived as an arbitrary change. The analysis focused on data that could be analysed live using the M7 OMCS (see **Appendix**), with two key indicators, speed (measured) and count used to predict the onset of flow breakdown.

The trial was to run for 6 months with the aim to drop speeds limits approaching the M7 M2 interface approximately 10-12mins before flow breakdown occurred. Upon activation from within the M7 control room, speed limits would drop from 100km/h to 80km/h on the existing road side VSLS's (76N, 78N, 78M, 80N), shown in Figure 2. With the signs at 500m intervals this provided 2km of reduced speed approaching the point of congestion.

Speed limit drop trigger development

Figure 3 shows eastbound traffic volumes and speeds (30sec 2min rolling average) over the morning peak for each individual workday in March 2017 with the median value shown in bold (location of loops shown in **Figure 2**). Displaying volume and speed concurrently, the plot identifies the critical point where the onset of flow breakdown occurs. Demarcating the period "just before flow breakdown" and "after flow breakdown".

<u>Before Flow Breakdown (March 2017)</u>

At point A (**Figure 3**) around 5:30am approximately 10 minutes before flow breakdown, volumes above 9 veh/30s were steadily increasing at the merge. Concurrently driver speeds were below 92 km/h and continued to reduce. This marked the period where the merge was approaching capacity, but crucially just before flow breakdown. The minimal variation in all the individual working days showed this point occurred with consistent volumes and speed. The variation (standard deviation) between each of these values was 2 vehicles and 3.8km/h respectively, identifying the predictability of traffic just before flow breakdown period.

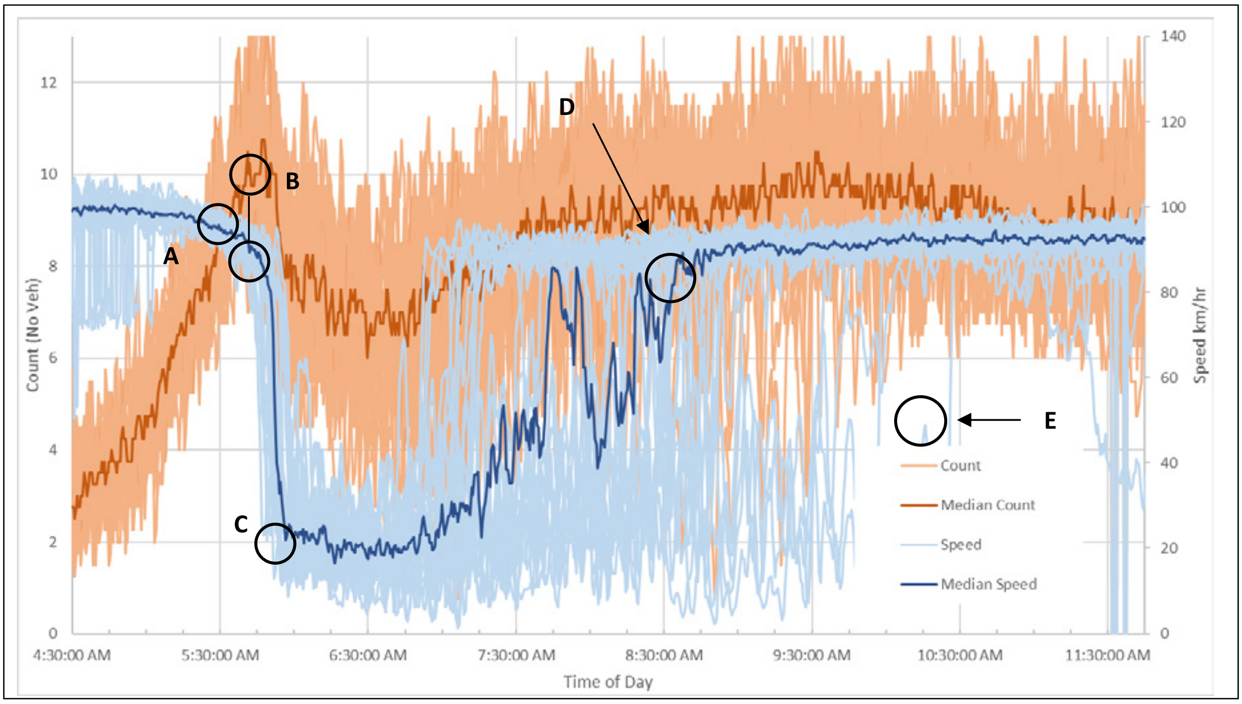

Figure 3. AM peak speeds & counts March 2017

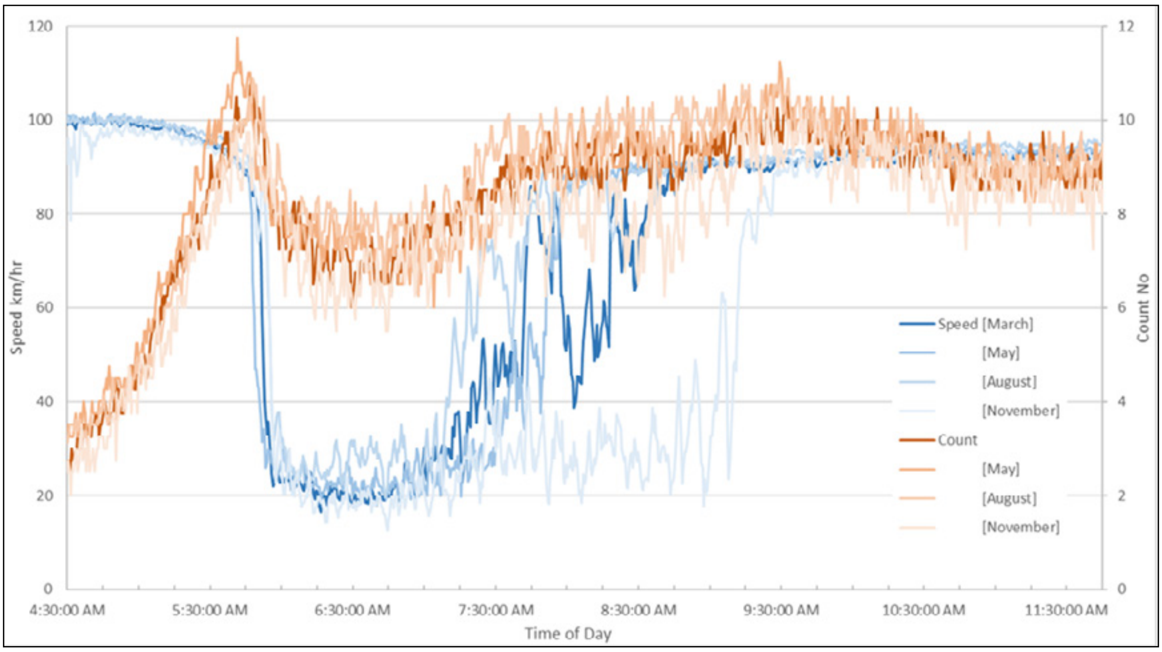

Figure 4. Speed Count Seasonality

At Flow Breakdown (March 2017)

Point B (**Figure 3)** at 5:43am, the increasing volumes were above 10.5 veh/30s reaching tipping point as speeds continued to drop. The capacity of the merge was reached and flow began to breakdown. At Point C (**Figure 3**), 5:53am, the combination of relatively high speeds and large volumes caused turbulence within the traffic stream resulting in emergency breaking and a sudden speed drop of over 60km/hr in 10 minutes to 24km/hr. Once flow break down has occurred, speeds do not typically recover for up to 3 hours, Point D, with some extreme daily cases not recovering until 10:15am, Point E (**Figure 3**).

Seasonality

Figure 4 shows the median values of workdays in March, May, August and November. The first 1hr of flow breakdown (5:50am-6:50am) occurred without seasonal differences. Furthermore, it is only the recovery period that exhibits any seasonal variability, likely as a result of decreasing demands at the end of the peak, however this was not the focus of the trial.

Applying Speed Limit Drop Triggers

To ensure the daily appropriateness of the speed limit drop activation in conjunction with M7 DAT alert capability (see **Appendix**), the trial used a two-step alert based activation of the speed limit drop. The first step, 'Alert One' warned

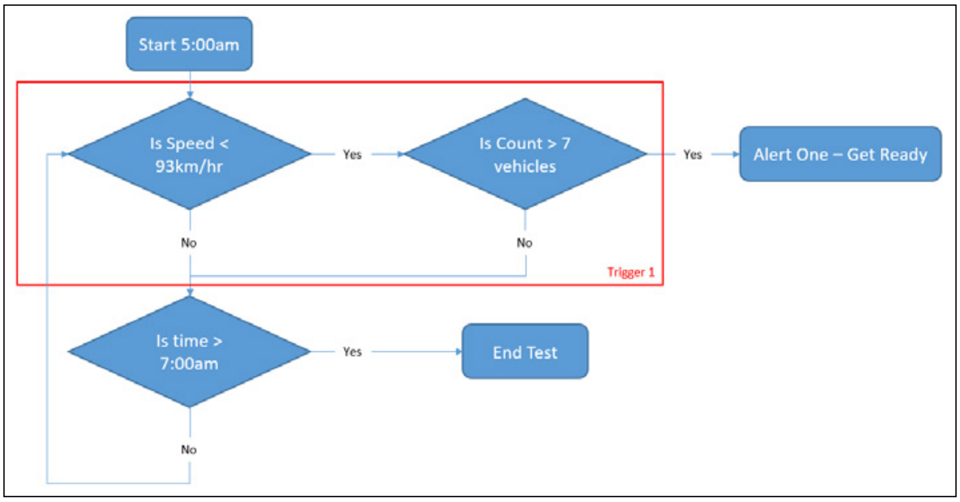

Figure 5. Alert One flow diagram

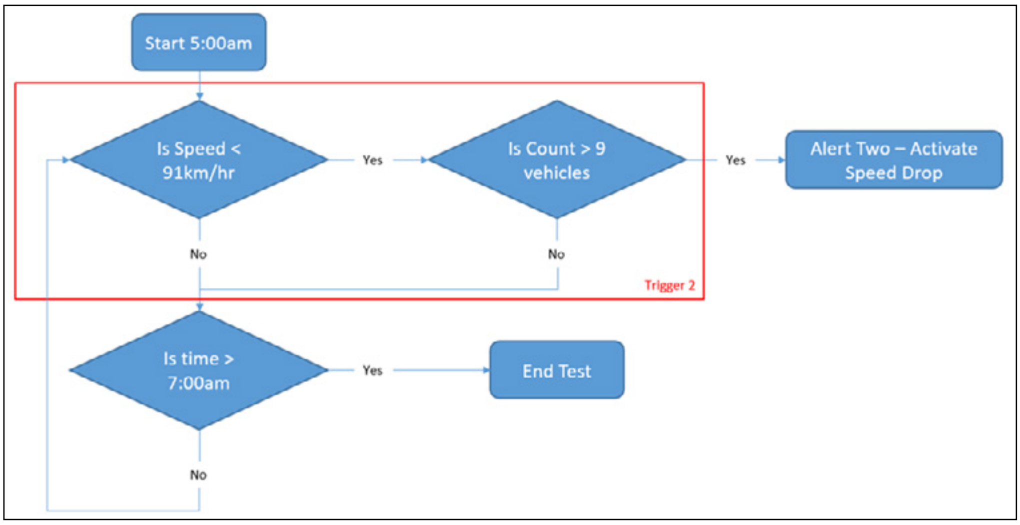

Figure 6. Alert Two flow diagram

the M7 control room that conditions were beginning to deteriorate, while 'Alert Two' confirmed flow breakdown indicating to the control room to activate the VSLS speed limit drop.

Alert One – Warning

As conditions near the M7 M2 interface deteriorated rapidly, Alert One provided a warning that mainline traffic conditions were becoming heavier, drawing the situation to the attention of the control room operators. For the trial, an activation window of 5:00am to 7:00am on workdays was used as the process involved manual activation of the speed limit drop. The activation window would therefore remove the risk of unnecessary distraction outside of this timeframe.

Loop data from 81 individual workdays from 2017 was fed into an excel model where the most appropriate trigger values of volume and speed for Alert One were identified. The activation of Alert One is show in the flow diagram in **Figure** 5.

Alert Two - Confirmation

Alert two confirmed to the M7 control room that flow breakdown was imminent and activation of the speed limit drop would occur. As with Alert One, loop data from 81 individual workdays from 2017 was fed into an excel model where the most appropriate trigger values of volume and speed for Alert Two were identified. The activation of Alert Two is show in the flow diagram in **Figure 6**.

Results

Safety

Crash statistics were collected for the 6 months during the trial between Quakers Hill Parkway and the M2 between 5:30am and 7:00am. These crash statistics were then compared against the 6 months preceding the trial and to further historical values.

- Before the trial (between 26 June 2017 and 31 December 2017) there were 5 crashes along the eastbound corridor. 100% of these were 'nose to tail' or typical congestion related crashes, with 60% involving 3 or more vehicles.

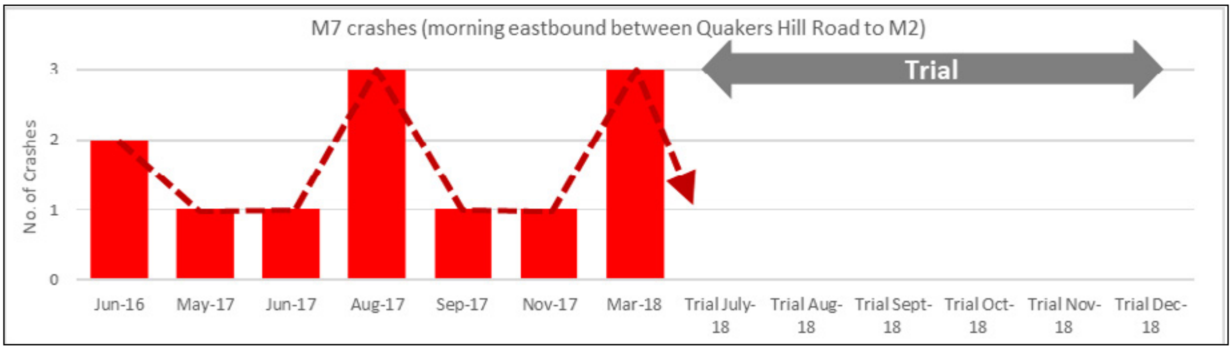

Figure 7. M7 crash performance before and during trial

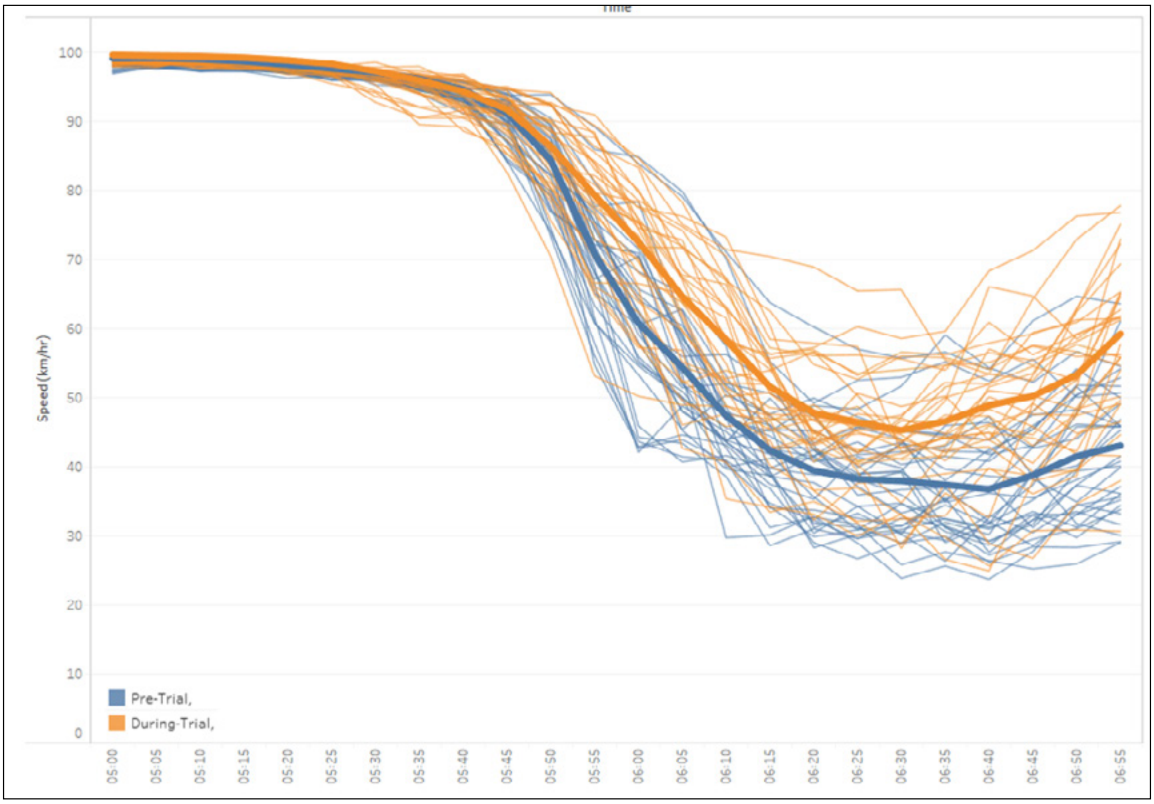

Figure 8. Eastbound speed profiles near M2 interface representative days

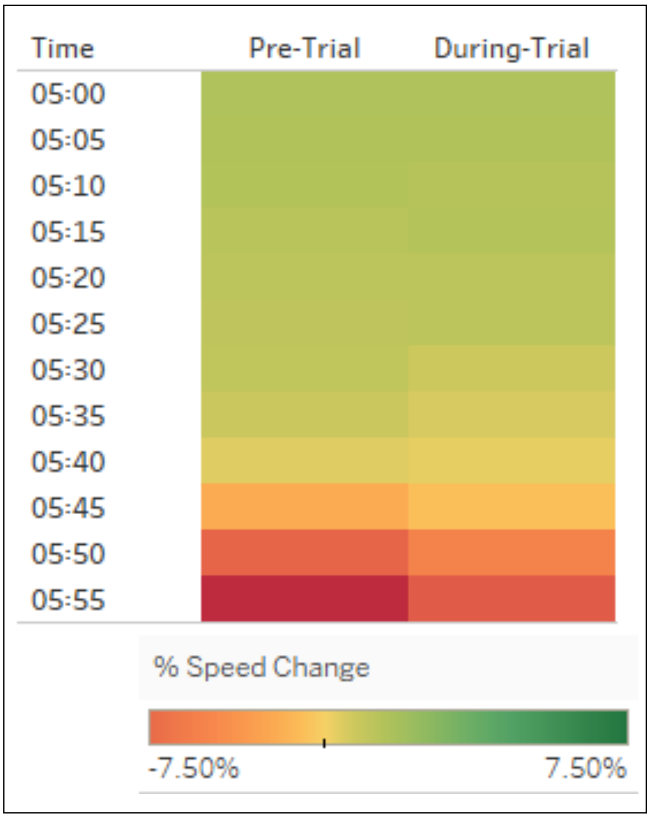

Figure 9. Comparison of 'rolling rate of speed change' March 17 (Pre-Trial) versus August 17 (During-Trial)

- During the trial (between 26 June 2018 and 31 December 2018) there were no crashes observed.

The analysis compared over 350,000 trips before the trial with 350,000 trips during the trial. As such there is good confidence in the exposure and relevance of the trial's benefit. Additionally, analysis revealed the 5 crashes before were not linked to rain events and were not linked to day light savings effects (the same yearly period).

A longer historical crash trend is shown in **Figure 7,** where 12 'nose to tail' congestion related crashes eastbound on the M7 corridor between Quakers Hill Road and M2 between 5:30am and 7:00am were identified, further illustrating the instance of congestion related crashes around this part of the network.

Impact to Traffic Flow

The traffic flow analysis focused on the same traffic loop (LOOP81N1) located at the source of congestion with the M2 interface. **Figure 8** compares all workdays in March 2017 (pre-trial) with all workdays in August 2017 (during trial) between the hours of 5:00am and 7:00am with the average speed profile shown in bold.

The comparison indicates the positive impact the pre-emptive speed limit reduction has had on traffic speeds with a more gradual reduction in speed decline, a key indicator of success, as was agreed to by TfNSW. Consistently higher speeds between 5:45am and 6:30am

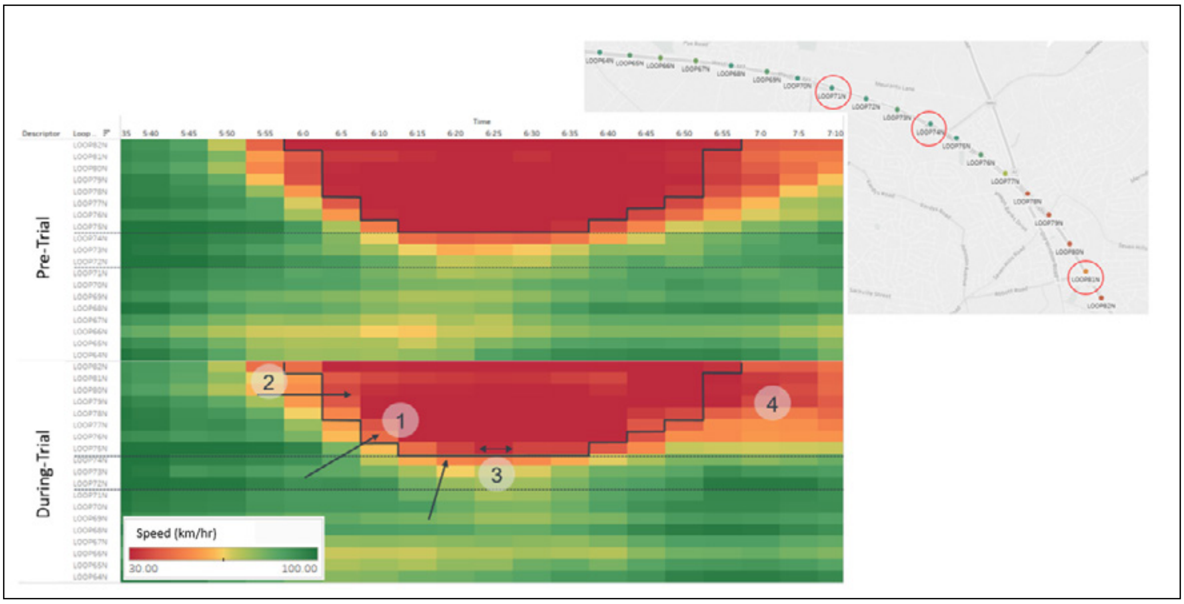

Figure 10. Speed comparison highlighting congestion footprint, back of queue, duration, and speed transition

have also been observed with the average indicating the greatest speed differential of 10km/hr occurring at 6:00am.

Figure 9 further illustrates the slowed rate of change with less intense speed reductions occurring during the trial and over a longer period, 25min compared to 15min. It is theorised that this may lead to a safer transition into congestion through a reduction in breaking intensity and could be the result of reduced number of crashes.

To analyse the extent of congestion, a speed heatmap (**Figure 10** March vs August) was developed. A black line was drawn around the core of the shock wave (where sub 30km/hr speeds were experienced) on the pre-trial heatmap. This line was then superimposed on the 'during trial' heatmap and the following observations were made:

1. Observed delayed on-set of congestion.
2. Smoother transition into flow breakdown with a more gradual decline in speed.
3. Reduced length and duration of back of queue, a reduction of 15min sub 30km/hr speeds (20min down to 5min).
4. There was some additional turbulence experienced towards the end of the peak. Further analysis indicated this to be caused by increased traffic growth (around 2%) in the later part of the peak.

Discussion

It was difficult to deduce much from the analysis of crash data given the limited sample size however zero observed incidents was promising. Prior to the trial it was hoped that better use of emerging near miss data would be utilised, however this was unavailable at the time. It is hoped, given a potential future trial recently available, near miss data will lead to more fruitful analysis.

What is understood from the analysis however, is that reducing the speed limit to match the prevailing road conditions slightly ahead of time has shown to have a calming effect on traffic. This is observed through the consistently extended period to which it takes speeds to drop from free flow conditions to congested, with higher speeds observed through much of the early peak. This has shown to potentially reduce congestion impacts both in extent and duration and it is theorised that this calming effect may lead to a reduction in harsh breaking and associated safety benefits.

Conclusions

The trial was conducted on workdays between 26 June 2018 and 31 December 2018. It has:

- Shown reduced crashes from 5 to 0 over the common time period.
- Smoothed traffic flow.
- Delayed the onset of congestion.
- Reduced shockwave intensity and congestion length.

Overall the low-cost safety benefits of the trial have resulted in the trial being incorporated permanently into business as usual operations with a second trial at a second location along the M7 currently being proposed.

Acknowledgements

I would like to thank our colleagues at Westlink M7 in particular Glen Archibald and Paul Hanna for their help though the M7 to M2 Pre-congestion Speed Management Trial.

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Appendix – Key M7 OMCS capabilities

The current M7 ITS infrastructure includes; 220 variable speed limit signs; 58 variable message signs; 88 CCTV cameras; loop detection every 500m and on every ramp; and an OMCS including a DVMS.

Additionally M7 created a tailored, add-on DAT that is able to provide real time and historic traffic data using outputs from the OMCS. Within this tool, alert parameters are able to be configured for real time vehicle speeds and vehicle counts averages (across user defined multiples of 30s intervals) and then displayed to the M7 control room using a GUI dashboard.

ACRS updates

From the President

It was a real pleasure joining so many of you at our conference. Like everyone, I missed some special personal connection that cannot be replicated or replaced, but the conference energised and renewed me just the same. The virtual environment will become a strength over time with its capacity to draw people together from a wide geographical spread across Australia and New Zealand. And of course it coincided with the inauguration of the International Outreach Chapter, an auspicious beginning to a new era in the life of the College.

It is an important time with the Australian Government close to publishing a national road safety strategy to 2030, and the United Nations about to publish the global plan for the decade. My hope is that the College can look back on our policy contribution having achieved some major wins for our community. Once we see what we have achieved in policy wins, I think we need to reset our policy agenda for the years ahead (which I expect to be useful as New Zealand enters its next round of planning for Road to Zero). Some of our existing policy asks will remain, such as providing information to the community about the safety of the roads we use – I can't see us getting close to our goal without infrastructure safety star ratings – but what else do we need to do?

I was therefore delighted with the release at the conference of the draft policy principles of the College by our Chief Executive Ingrid Johnston. All members were invited to contribute to these principles, which she drafted in concert with our Vice President Policy Narelle Haworth.

I encourage you all to review these draft policy principles. They are at once simple and straightforward, and have great meaning and intent. They open up some debates that we need to have, including what are widely referred to as principles of the safe system approach to road safety. I helped capture, document and shape a set of principles which characterise this approach as part of an OECD project at the beginning of the century. For some years since I have largely sat to one side, and listened as others have considered and applied them in their own way.

Overall, significant progress has been made in design philosophy and outcome ambition. Victim blaming is now easier to identify and harder to justify. Elimination is an accepted public policy goal. However, we must also recognise that how our approach to safety is being interpreted and delivered won't get us to where we want to be. Two examples of this relate to design and responsibility.

The now pervasive view that the design of the road traffic system should accommodate human error does not embrace a fundamental need to prevent that error in the first place. "Self-explaining roads" aren't the answer because roads and traffic authorities have spent so many decades conditioning drivers to breathtakingly dangerous speed limits that this risks mass confusion and, yes, victim blaming. That said, the design problem is real. We must think deeply about how human error can be prevented, and how our design philosophy can be strengthened to anticipate the human factor issues being confronted in much safer environments.

We also need to reconsider whether the word "shared" is useful for what will be required ahead. There is now a more widespread view that the road user is no longer solely responsible for their own safety, but it seems to be much more difficult for people to define the other actors who are responsible, except other users. We need to be much clearer about what organisations and professions are responsible for the safety of the road traffic system and what they can be expected to do about that.

We could start with government, and seek statutory backing for road traffic safety that reflects widespread government responsibilities for: charging road users; designing and operating road infrastructure; regulating vehicles, drivers, commercial transport operations, and workplaces; and the health of the community. We could become serious about public or private organisations which hold primary safety responsibilities, or generate injury risk in road traffic, having evidence-based management systems in place which can attain and maintain safe systems of travel.

The final example of our need for change is perhaps the most obvious one. We need to think much more deeply about what a systems approach to road safety is, how the elements and actors of the road traffic system interconnect and impact upon one another, and how deficiencies in the system can be significantly reduced and eliminated over time. This will be vital if we are to come close to realising our goal.

The conference started us on these paths, and I will be interested to see where they lead us. There is so much we can and must do now, and even more that we need to set ourselves up for in the future.

Martin Small
President, ACRS

From the CEO

The last few months have reinforced for me the dedication and passion of the members of the Australasian College of Road Safety. It's been a time of firsts for us – the first fully virtual Australasian Road Safety Conference, and the first committee formed for the new International Outreach Chapter. These are both important milestones for the College, made possible by the willingness of our members to give it a go. Thank you all.

Some highlights of the past few months have been:

Australasian Road Safety Conference, 28-30 September 2021

The first fully virtual ARSC was, by all accounts, an outstanding success. With over 650 delegates from 26 different countries, the opportunities provided be a virtual format were quickly and fully embraced. Engagement was consistently high, with great debates and discussions during sessions, connections made, video calls held, and lots of choosing from the a la carte menu of options, jumping between sessions, and catching up on content.

Plans are underway for next year's conference to be held on 28-30 September 2022, at the Te Pae Convention and Exhibition Centre in Ōtautahi Christchurch, Aotearoa New Zealand. Te Pae is brand new and has been designed as a gathering place. It's a key part of the regeneration of the city following the devastating earthquakes of 2011. This will be a hybrid event, capturing the best of both in person and virtual formats, and will be held in conjunction with Trafinz, the New Zealand Local Authority Traffic Institute. We look forward to being able to meet in person in New Zealand next year.

ACRS Policy Principles

The College does a lot of fantastic advocacy work, particularly in the Chapters. I am very keen to build on that foundation, and develop a strong policy platform for the College, so that it's easy for people to see who we are, what we stand for, and what policy changes we advocate for to achieve our vision of eliminating fatal and serious injuries on our roads. I am putting into place an inclusive and democratic process for developing a suite of policy position statements, allowing all members to have their say during the drafting of statements while will then be reviewed by the Executive Committee and formally endorsed at our Annual General Meetings.

It will take some time to build a suite of statements, but it will mean our advocacy work will be stronger, easier and more consistent. They will become valuable advocacy tools – concisely, clearly and transparently outlining particular policy issues, the principles guiding our response, and the latest evidence, leading to our key policy asks on the issue. Of course, there will always be instance where we don't have a statement to cover a particular niche policy issue. In the opening session of the conference, I released the draft set of Policy Principles for the College, to underpin the position taken by the College on policy issues in road safety. They draw inspiration from suggestions from our members, good practice in the safest countries and the safest industries and are designed to provide an overview of our fundamental values and form the foundation of our advocacy work.

I look forward to working with all our members over the coming months to finalise this set of policy principles and draft the first of our policy position statements.

ACRS contribution to the Australian Joint Select Committee on Road Safety

On 13 September 2021, ACRS President Martin Small and I appeared as witnesses at the Australian Federal Parliamentary Joint Select Committee on Road Safety. This is essentially a continuation of the Joint Select Committee from 2020, we emphasised the importance of this becoming a Joint Standing Committee in the next term of Parliament to properly embed the issue of road safety as one worthy of ongoing Parliamentary oversight. This will be especially important to ensure the new National Road Safety Strategy 2021-2030 is fully implemented with transparent and strategic governance and evaluation.

International Outreach

The ACRS International Outreach Chapter (IOC) has reached an important milestone and entered a new phase. With the seed funding from the Australian Commonwealth Department Infrastructure, Transport, Regional Development and Communications having ended, the future sustainability of the of Chapter has now passed into the hands of the members. We are thrilled that from the more than 67 members across 23 countries, a Chapter Committee has been formed to steer the Chapter from here. Thank you to A/Professor Masria Mustafa, Mr Ali

Zayerzadeh, and A/Professor Teresa Senserrick for taking on the roles of Co-Chairs, along with Mr Youb Raj Bhatta (Secretary), Mr Galeboe Motlhajoe, Dr Rusdi Rusli and Mr Sovann Kong as Committee members.

We look forward to continued and growing engagement with the IOC, with more vibrant discussion, knowledge sharing and connections in future meetings.

Global Plan for the Decade of Action for Road Safety 2021-2030

As a member of the United Nations Road Safety Collaboration, the College helped to launch the Global Plan for the Decade of Action for Road Safety 2021-2030 with a webinar held on 28th October 2021.

The webinar featured the new Co-Chairs of the International Outreach Chapter, discussing the Global Plan and the role of the College in the Decade of Action.

The release of Australia's National Road Safety Strategy 2021-2030 and accompanying Action Plan is due imminently. Between this and the Global Plan for the Decade of Action, there is much to be done, as always, as we work together to eliminate fatal and serious injuries on our roads.

Dr Ingrid Johnston
Chief Executive Officer, ACRS

ACRS Chapter reports

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

Australian Capital Territory (ACT) and Region

Since our last report, the Chapter has taken a decision to meet on the third Thursday of each month to enable members to keep in contact and monitor more closely active projects. This has been successful with good numbers attending our online meetings.

The Chapter has also identified a number of projects to be given priority and others which for one reason or other are unable to be progressed at the moment. A summary is provided below.

Wildlife Project

This project has progressed to the point where it has been established that significant data exists to enable quantify the number and severity crashes involving wildlife in the ACT and surrounding region. It has also identified that much of the costs of these accidents is carried by government health services.

The next phase is to develop a project brief and fund significant research which will provide the information on which governments and other stakeholders can make decisions on what actions need to be introduced to address the research conclusions.

The Chapter is of the view that it is not in a position to lead this next stage. An organisation with suitable resources and supported by sufficient funding is required. Of course, the Chapter would be prepared to assist on an advisory basis with other support organisations.

Discussions on these issues with other stakeholders are planned for the immediate future.

Safety When Transport and Work merge

Local Government Chapter members from our Region have identified safety issues with trades people in their areas. Recently they have refined the essential problem to one involving work people driving to or from work rather than during working hours.

A project committee has commenced planning a workshop for Wednesday 6 April 2022 on the ACT/Queanbeyan border. This will enable the committee to consult with central parties well in advance and allow interested parties to lock in the date.

Other Projects

The proposed project promoting the National Road Safety Strategy and Action Plan is on hold at least until the National Road Safety Action Plan is agreed and released by all Australian governments.

Normally the Chapter and ACT Road Safety promote an annual ACT Road Safety Forum. Due to the Pandemic and other ACT priorities, the Forum will be delayed in mid-2022.

Consideration is to be given in 2022 to examining ways in which the Chapter can assist in achieving Zero Vision targets in the ACT in specific timeframes.

Thanks to the ACRS 2021 Conference organisers and participants

A number of ACT chapter members had the pleasure of attending and contributing to the ARSC held virtually from 28-30 September. They were overwhelmingly appreciative of the conference organisers for putting together an excellent program under very difficult conditions. Some of the delegates reluctantly had to forgo the pleasure of Melbourne coffee and the social benefits that come from physically attending a conference, but there were some compensations: Glitches in the online delivery were few and the sessions were kept to strict time. Switching from one parallel stream to another to attend a favoured talk was practically seamless.

The range of topics covered was, as usual, incredibly broad. Plenaries addressed issues such as the exciting potential of technology to address safety issues, with thoughtful caveats about its limitations and the need to address some of the misplaced assumptions about development paths.

A number of speakers reinforced the need to consider road safety across many elements of the complex system of systems that contribute to road safety outcomes. One such element is political and funding commitment. This in turn is influenced by our road safety community's ability to communicate research findings and engage broader community support for interventions to address things like speeding, which can generate loud opposition.

Many attendees at this conference, including Federal and State government representatives, articulated commitments to time specific targets for achieving Vision Zero and interim goals on that path. The ACT is undoubtedly going to continue its own strategic goal setting for Vision Zero supported by the work showcased at the conference.

Lastly, it was satisfying to note the work presented by ACT chapter members on local initiatives such as Joe The Rider, Log Book Runs, road audits and fleet driver initiatives across the ACT and neighbouring LGAs of Queanbeyan Palerang, Goulburn Mulwaree, and Eurobodalla. These programs make significant contributions to safety and community engagement.

ACT Chapter Chair & Secretary

Mr Eric Chalmers & Mr Keith Wheatley

South Australia (SA)

Community Road Safety Education – Wednesday 8 September 2021

Over 30 people attended either in-person or on-line to hear about the South Australian Royal Automobile Association's (RAA) programs in community road safety education, together with research in the area conducted by the Centre for Automotive Road Safety (CASR, University of Adelaide). It was a pleasure to hold the first in-person event by the South Australian Chapter since early 2020.

The seminar welcomed two very experienced presenters:

Ben Haythorpe - Senior Manager Community Engagement at RAA. Ben oversees many of RAA's school and community education programs, including the RAA drive school. Ben's team covers many areas of community education, educating in the areas of child restraints (and fitting), preschool, primary school and high school students, as well as several programs tailored to older drivers.

Ben gave an excellent overview of the various road safety education programs provided by the RAA. The Street Smart High program for secondary students has now been in operation for 10 years and its effectiveness has been supported by feedback from teachers. Ben also outlined Street Smart Primary along with a trial of Street Smart Preschool; all aimed at their respective age groups. Another youth oriented programs touched on was Keys2Drive. Other RAA programs were the Safety Centre, where parents receive training in child restraint installation; Years Ahead, aimed at the older demographic, and a trial of Senior Drivers Masterclass.

Trevor Bailey – After retiring from the South Australian Department for Infrastructure and Transport. Trevor has been working at the Centre for Automotive Road Safety on researching a wide range of behavioural factors relevant to road safety.

Trevor gave an engaging presentation on effective road safety messaging for children, teenagers and parents, emphasising evidence-based messaging. Research identified some good practices for children and teenagers as pedestrians, cyclists and passengers. Some lessons from past campaigns were presented, including some community campaigns from Word War 2, the 'Clunk-Click' restraint use campaigns from the UK, and the NSW 'Little Pinky' campaign, with some lessons learned.

The seminar is available on the ACRS Youtube Channel at https://www.youtube.com/watch?v=-GKHJ2S7_Nw.

Next Event: The Chapter is planning its next lunchtime seminar for mid – late November 2021.

SA Chapter Chair & Secretary

Jamie MacKenzie and Phil Blake

New South Wales (NSW)

The NSW Chapter Committee for 2021-22

Mr Duncan McRae (Chair)

Dr Prasannah Prabhakharan (Deputy Chair)

Dr Cassandra Gauld (Secretary)

Mr Mick Timms (Treasurer)

Dr Anna Chevalier (Seminar Coordinator)

Mr David McTiernan (Stakeholder Liaison)

Dr Liz de Rome (Committee Member)

Emeritus Professor Mike Regan (Fellow and Committee Member)

Mr Michael Rogers (Committee Member)

Dr Ralston Fernandes (NSW Centre for Road Safety Representative)

Strategic direction 2021-22

Since 2020, the NSW Chapter has focused on taking a more strategic approach to its activities.

Last year the Committee concentrated on stakeholder engagement, collaboration, and consultation. In recognition of this commitment, a new position of Stakeholder Liaison was established on the Committee. David McTiernan accepted the new role and has been actively building and fostering the Chapter's relationships with key stakeholders. Some of these relationships include, TfNSW, IPWEA, the Australian Driver Trainers Association (ADTA) and Local Government.

Throughout last year the Chapter continued to deliver the seminar series on key road safety issues and initiatives. When the COVID pandemic first emerged, the Chapter was quick to respond and moved the Seminar series to a fully online model. However, over recent times the number of online road safety forums has dramatically increased and it has become difficult for road safety professionals to attend all the sessions on offer.

In recognition of the changing landscape, the NSW Chapter decided to refocus its' resources and concentrate on identifying key areas where it could bring about practical change. The Committee is currently working on a range of ideas and will soon commence promotion of the first key area - enhancing understanding of speed.

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

Western Australia (WA)

Since a series of Committee member election processes earlier this year the Western Australian (WA) Chapter has established a programme of meetings, events and opportunities for WA members to participate and engage. The Committee meets monthly to plan, implement and review the programme of activities. This work has included conducting an online survey of members regarding how they would like the WA Chapter to operate and what they would like to occur in relation to events, mentoring and ways of communicating.

As a part of this, the Committee has planned and held a WA Chapter meeting each calendar quarter which is accompanied by an event such as guest speakers. Two workshops have been held to provide members with the opportunity to provide input into College submissions, including the WA draft Infrastructure Strategy. Feedback from participants has been very positive and the workshops have demonstrated there is a growing level of engagement amongst WA members.

A Book Club has been established. The Book Club meets every second month and each meeting discusses a particular article of research or publication. Attendees either join in person or online.

Corporate members are being very supportive through the provision of venues for meetings and events, and often arranging the guest speakers, for example the WA Centre for Road Safety Research (WACRSR) at the University of Western Australia (UWA). WACRSR also include articles and promotion of the WA Chapter's activities. This support is greatly appreciated.

The jewel of our latest activities is our WA Conference Hub. With the good luck WA has had enabling people to come together for events; GHD provided a venue, catering and administrative support for the WA Chapter to offer WA conference attendees with an 'in-person' experience for the second day of the conference. With the support of the College, WA attendees came together to access the on-line conference with different conference streams being made available in different rooms, networking taking place between sessions and open dialogue throughout the day. The day was well attended and the immediate feedback from various attendees was overwhelming positive. On behalf of the WA Chapter I would like to thank all those involved getting our Hub organised, but also the College for making the 2021 Conference happen.

Corporate member, Injury Matters, is our next quarterly host with an event prior to the end of the year. The Western Australian Local Government Association (WALGA) is hosting our next Book Club with an article focused on road safety within education and the Committee is considering various ideas about how to make more of the materials provided by the Conference, such as debriefing and sharing the 'take-aways'. The WA Chapter Committee is also planning for 2022 and how we can continue building momentum within the road safety community.

WA Chapter Chair
Ms Teresa Williams

ACRS News

2021 Australasian Road Safety Conference - What an amazing three days

What an incredible three days of learning and engaging the 2021 Australasian Road Safety Conference delivered. The virtual format of ARSC2021 was embraced by delegates for its flexibility, engagement opportunities, and the ability to access over 130 presentations, as well as the Plenary Sessions, symposiums, and the posters over the next 6 months.

Conference Feedback

We are still collecting delegate responses to the post-conference survey but these comments made during the closing session are a great reflection of the positive response received so far.

- Great connections, discussions and presentations during this conference.
- What a great conference - I am new to road safety, so this has been my first conference, but it has been informative, friendly and singularly focused on saving lives and reducing trauma. I can't wait for the next one! Thank you to all the organisers and presenters.
- Outstanding organisation and efforts all. The virtual interface has been more than I anticipated. Great to network with so many people. Looking forward to Christchurch.
- A fantastic conference, awesome job by the organisers so much work over two years. Congrats to all of the award winners, the poster development.
- This has been a great conference, despite challenging circumstances.
- Really enjoyed the three days - missed seeing people in person - but liked being able to take part in the online discussions
- Great conference. So many great presenters. Bring on NZ. Thanks to everyone involved.

As indicated by these comments many people were involved in the delivery of the conference. We extend special thanks to the Organising Committee co-chaired by Dr Jeff Potter and Mr Chris Brennan, the Scientific Sub-Committee chaired by Dr Marilyn Johnson, International Sub-committee chaired by Dr Ray Shuey, Social Sub-committee chaired by Ms Kathryn Collier and the Sponsorship Sub-committee chaired by Mr Shaun Lennard.

Conference Award Winners

We also extend our thanks to all conference abstract authors, presenters and contributors. The Conference Awards were presented during the conference closing session and acknowledge the most outstanding participants. Congratulations to the following Conference Award winners:

Peter Vulcan Award for Best Research Submission Winner: Max Cameron

Monash University Accident Research Centre
For the submission Increasing the effectiveness of mobile speed cameras on rural roads in Victoria based on crash reductions from operations in Queensland.
Sponsored by Transurban.

Best Road Safety Practitioners Submission Winner: Roisin Sweeney

For the submission: Development of a truck driver public health project: mental and physical safety (MaPS) on our roads.
Sponsored by Transurban.

Best New Researcher Submission Winner: Laura Mills

University of the Sunshine Coast
For the submission: Twelve years of roadside drug testing in Queensland: the extent and nature of recidivism.
Sponsored by Transurban.

Best Submission by a New Practitioner Award Winner: Jay Baththana

For the submission: Using community feedback to complement road safety risk metrics.
Sponsored by Transurban.

Conference Theme Submission Award Winner: Robbie Napper

For the submission: Design, the Law and Lego: an interdisciplinary approach to road safety.
This is awarded to the submission that best matched our theme which this year was – a fresh approach.
Sponsored by Transurban.

Best Paper with Implications for Improving Workplace Road Safety Award Winner: Daniel Brain

For the submission: Consignors of import containers play a critical role in preventing heavy vehicle rollover, but they're often unaware of their role.
Special mention: Roisin Sweeney, for the

submission: Development of a truck driver public health project: mental and physical safety (MaPS) on our roads. Sponsored by NRSPP.

Victoria Police Award Winner: Jenny Felsch

For the submission: Caravan Safety Awareness Project in northern NSW.
The award was announced after the conclusion of ARSC2021.
Sponsored by Victoria Police.

Tasmanian Road Safety Advisory Council Award Winner: Danilo Messias

For the submission: Developing a marketing strategy to increase Victorians' vehicle safety awareness and influence purchase decisions.
Sponsored by the Tasmanian Road Safety Council (RSAC).

Best Road Safety Poster Award Winner: Fritha Argus

From Main Roads WA
For the submission: Using road inventory data to produce AusRAP star ratings.
Sponsored by Transurban

People's Choice Poster Award Winner: Author of the submission is: Richard Cohen; Design: Marissa Hor; Art Direction: Warren Taylor

For the poster submission: The next frontier: Road safety in the workplace.

What's Next?

During the closing session the 2022 Australasian Road Safety Conference was announced with plans for a hybrid conference being delivered online and in-person in Christchurch, New Zealand from 28 - 30 September 2022 in conjunction with Trafinz. Many more details to come.

Road safety champion recognised with prestigious road safety Fellowship Award

Congratulations to inspirational road safety advocate Peter Frazer who was presented with the prestigious 2021 Australasian College of Road Safety (ACRS) Fellowship at the ACRS Award Ceremony held on Wednesday 29 September at the 2021 Australasian Road Safety Conference (ARSC 2021).

The award is deserved recognition of Peter Frazer's outstanding contribution to road safety throughout Australia, and internationally through policy development, community education, and advocacy work. Peter's dedication began with heartbreaking personal loss. On 15 February 2012 Peter's daughter Sarah was killed in a completely avoidable road crash after her car broke down on the Hume Freeway south of Sydney. The tow truck driver who had come to Sarah's assistance also lost his life.

The 2021 ACRS Fellowship Award honours Peter Frazer's tireless, passionate, brave, and courageous contribution to road safety in Australia. The Australasian College of Road Safety and members of the road safety community across Australasia congratulate Mr Frazer's outstanding contributions and 2021 ACRS Fellowship win.

Innovative workplace program takes out top road safety award

The 2021 3M-ACRS Diamond Road Safety Award has been awarded to an innovative program developed by Transport for NSW in response to the high number of workplace fatalities that occur on NSW roads every year. The government run program is a first in Australia, providing comprehensive, practical tools to support employers and workers who drive or ride while at work.

Transport for NSW developed the Road Safety in Your Workplace program in collaboration with the State Insurance Regulatory Authority (SIRA) and Insurance and Care NSW (icare) to help employers address their road safety risk and provide support and guidance to workers.

The project aim was to deliver effective information and support through new engagement tools and channels. These cost-effective tools are free for all employers and workers throughout NSW, and easily transferrable for implementation and roll-out across other jurisdictions.

The 3M-ACRS Diamond Road Safety Award was presented at the ACRS Award Ceremony held on Wednesday 29 September at the 2021 Australasian Road Safety Conference (ARSC 2021).

Two highly commended awards were also presented to:

City of Rockingham Strategic Road Safety Action Plan – Team Leader: Ryan Gibson, Coordinator Planning and Design;

- The development of a Strategic Road Safety Action Plan for the City of Rockingham is an important strategic step in working towards the reduction and elimination of serious injury and fatal crashes within the City. The Strategic Action Plan outlines several actions guided by the Safe System approach to achieve the goals of Western Australia's 'towards zero' strategy.

Road Safety Training Module for Food Delivery Riders – Team Leader: Tia Gaffney, National Leader Safe Mobility Outcomes, The Australian Road Research Board

- The program was developed by ARRB as a novel, bilingual training program for a major provider of food delivery services, in response to the Worksafe NSW set of guidelines released following the deaths of 5 food delivery riders within a period of two months in 2020. The program was built as a complete end-to-end solution for industry, intended to improve road safety for food industry delivery riders (FDRSs) by providing clear information about risk factors when operating 2-wheeled delivery vehicles.

International Outreach Chapter Update

A special International Outreach Chapter (IOC) meeting was held on 27 September - an ARSC 2021 Pre-conference event, sponsored by Towards Zero Foundation.

The establishment of the International Outreach Chapter was with the support of the Australian Government Department of Infrastructure, Transport, Regional Development and Communications. With the grant period ending, the Chapter members discussed how to continue the IOC. A fee structure was agreed to, and IOC Committee members approved. We welcome the new International Committee Members:

- Co-Chair - A/Professor Masria Mustafa, Malaysia
- Co-Chair - Mr Ali Zayerzadeh, Iran
- Co-Chair - A/Professor Teresa Senserrick, Australia
- Secretary - Mr Youb Raj Bhatta, Nepal
- General committee - Mr Galeboe Motlhajoe, Botswana
- General committee - Dr Rusdi Rusli, Malaysia
- General committee- Mr Sovann Kong, Cambodia

The International Outreach Chapter continues to welcome members from around the world with current participation from members in 23 countries including 19 LMICs. See updates on IOC meetings and other news here: https://acrs.org.au/chapters/international-outreach/

Diary

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

Launch of the Global Plan for the Decade of Action for Road Safety 2021-2030
28 Oct 2021

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

UN High-level Meeting on Road Safety
5 July 2022, New York, USA
https://undocs.org/en/A/RES/75/308

Australasian Road Safety Conference 2022
28-30 Sep, Christchurch, New Zealand
https://australasianroadsafetyconference.com.au/


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