A new complex systems approach to road trauma: applying systems thinking to the fatal five

Summary of Findings

Paul M. Salmon, Gemma J. M. Read, Scott McLean

Centre for Human Factors and Sociotechnical Systems
University of the Sunshine Coast
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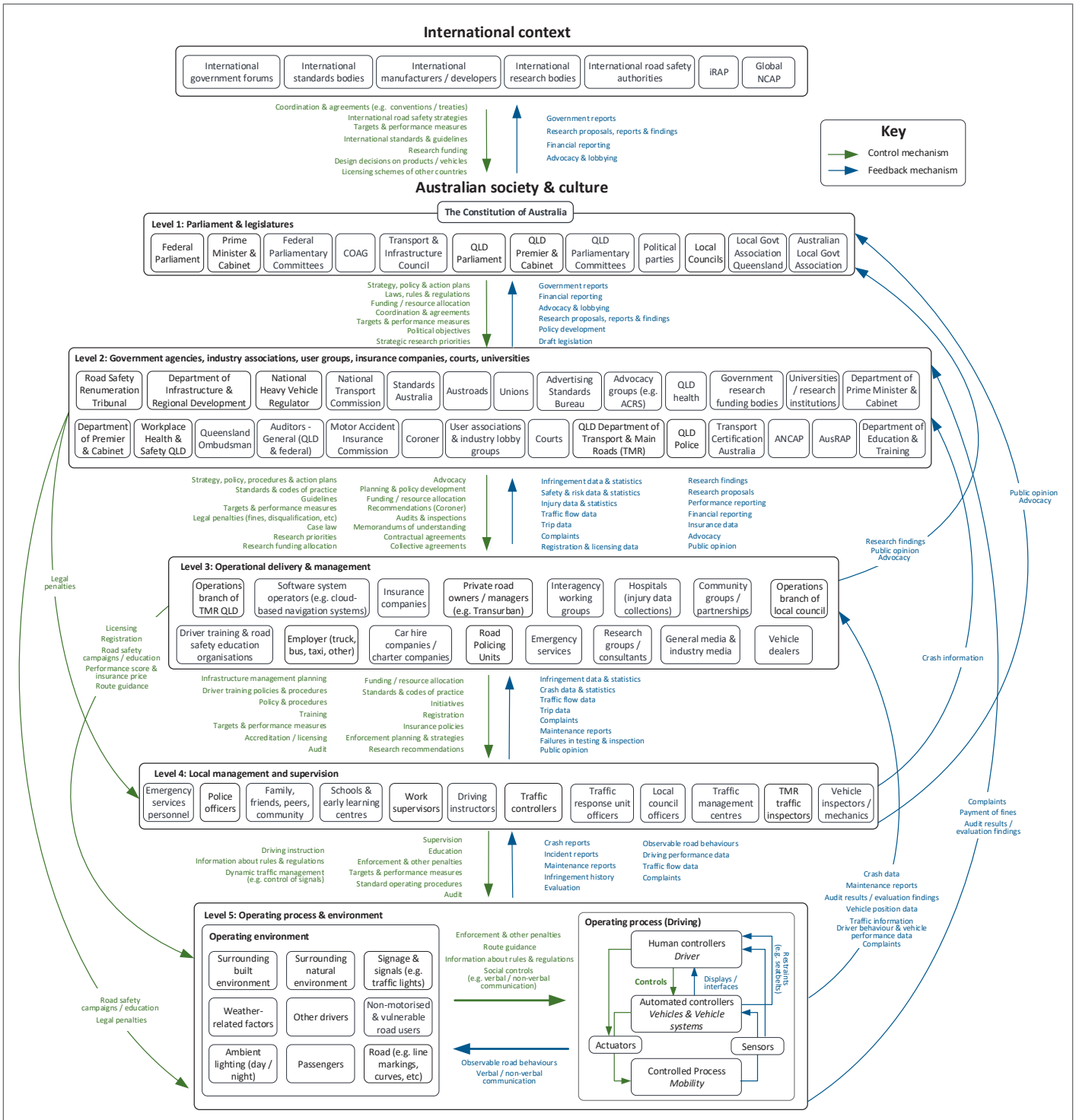
Road transport as a complex system

The fatal five are a set of behaviours known to play a direct causal role in road crashes and road trauma. They include driving under the influence of alcohol and drugs, driving while distracted, driving while fatigued, speeding, and driving without restraints. Most efforts to understand and prevent the fatal five have focused on drivers. From a systems thinking perspective, however, the fatal five are emergent properties of the overall road transport system. This means that, in order to understand what creates the fatal five behaviours, we first need to understand who contributes to road transport operation and how.

The diagram below shows the actors and organisations within the Queensland road transport system that share the responsibility for road safety. The figure also shows the controls (e.g. actions used to prevent the fatal five) and feedback mechanisms (e.g. information channels used to understand the status of the system) that are currently used to manage road user behaviour and safety. Whilst many controls are enacted, the reach and impact of some controls is questionable and there is scope to introduce system wide reforms designed to prevent the fatal five behaviours.

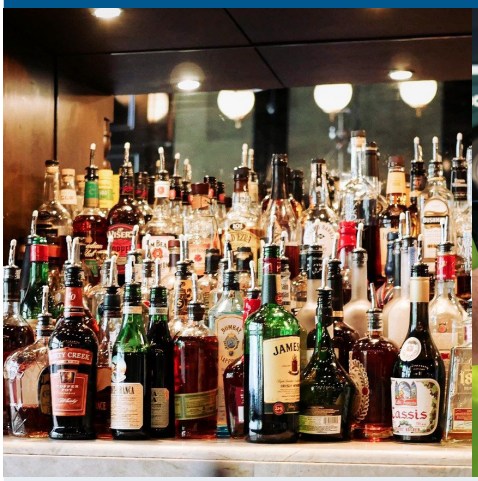


Queensland road transport system control structure (adapted from Salmon et al., 2016).

Factors influencing drivers' engagement in the fatal five

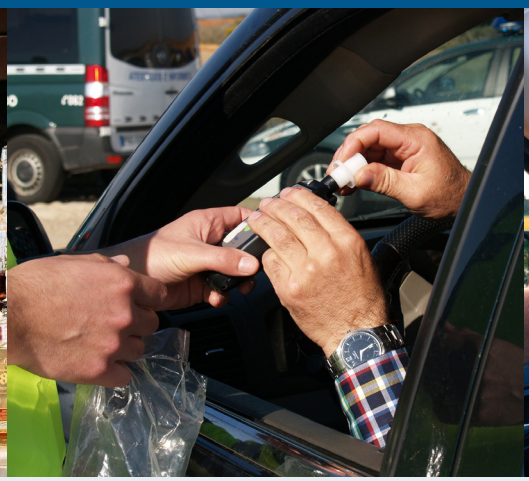
Once we understood the road transport system, we wanted to find out what factors influence driver behaviour. A survey of Queensland drivers and an expert workshop revealed that there are a wide range of factors that influence drivers' engagement in the fatal five. Whilst many of these factors reside within the road transport system, it was found that wider societal issues also have a strong influence on driver behaviour and road safety (Salmon et al., 2019a).

Societal factors



- Drug addiction
- Misuse of legal drugs
- Time poor life styles
- Increasing alcohol consumption levels
- Pressure to be connected
- Social media use
- Lack of viable public transport
- Work pressures
- Low-density urban form
- Failure to acknowledge road safety issues

Road transport system factors



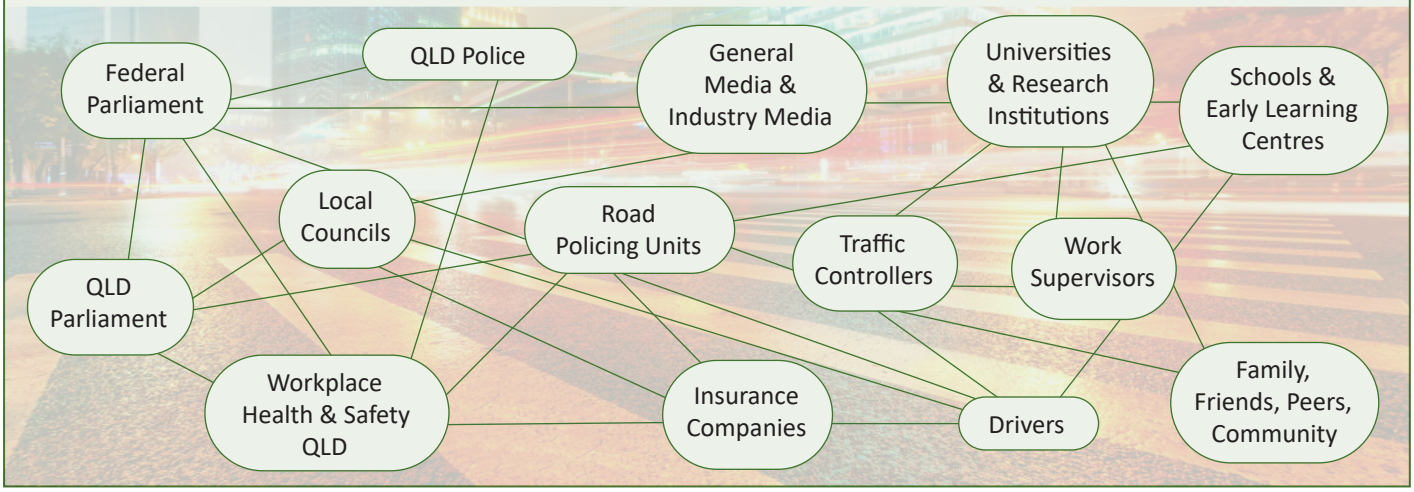
- Prioritisation of certain road safety issues over others
- Vehicle design
- Road rules & regulations
- Absence of testing for certain issues
- Standards and design guidelines
- Budgetary constraints
- Media & social media
- Public transport & necessity of driving
- Enforcement
- Work-related driving
- New technologies
- Road environment & infrastructure
- Behaviour of other road users

Driver-centric factors

- Personality
- Knowledge & experience
- Psychological state
- Stupidity & ignorance
- Emotions & stress
- Understanding of risks
- Impairment
- Complacency
- Optimism bias
- Laziness
- Addiction
- Economic pressures
- Time pressures

BREAKING DOWN SILOS

The findings above emphasise the need for road safety stakeholders to work together to develop multiple integrated interventions to tackle the societal, road system and driver-centric factors.



The complexity of road crash causation

Next, we wanted to explore each fatal five behaviour in-depth. We used causal loop diagrams (CLDs) to identify what variables interact to influence drivers' engagement in the fatal five behaviours and to help identify where interventions could have a positive impact on driver behaviour and road crash and trauma rates. We used the input from road safety experts to transform a simplistic CLD (diagram 1) into a generic CLD (diagram 2) describing the broader influences on driver behaviour, crash rates and road trauma. Specific CLDs (diagram 3) describing the factors that interact to create each fatal five behaviour were then developed. The CLDs demonstrate that there are key leverage points in the road transport system where small interventions can potentially have large effects.

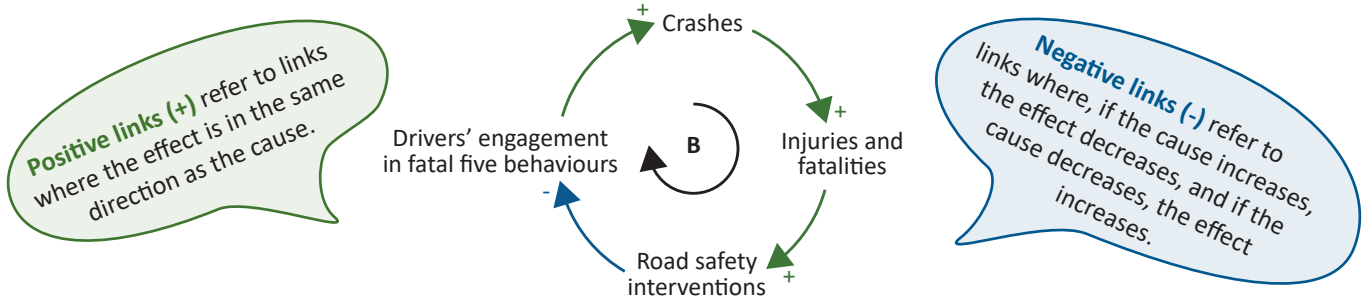


Diagram 1: Simple road trauma CLD.

This CLD shows how, as more drivers engage in fatal five behaviours, crashes and fatalities increase which leads to an increase in road safety effort. This creates a reduction in crashes and fatalities, but these improvements eventually lead to a reduction in road safety effort. As a result, engagement in the fatal five behaviours and crashes and fatalities rise again. This dynamic prevents large reductions in road trauma as the number of crashes and fatalities oscillates over time.

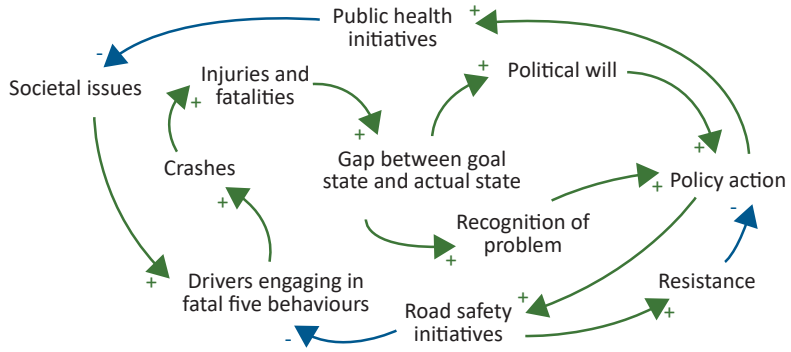
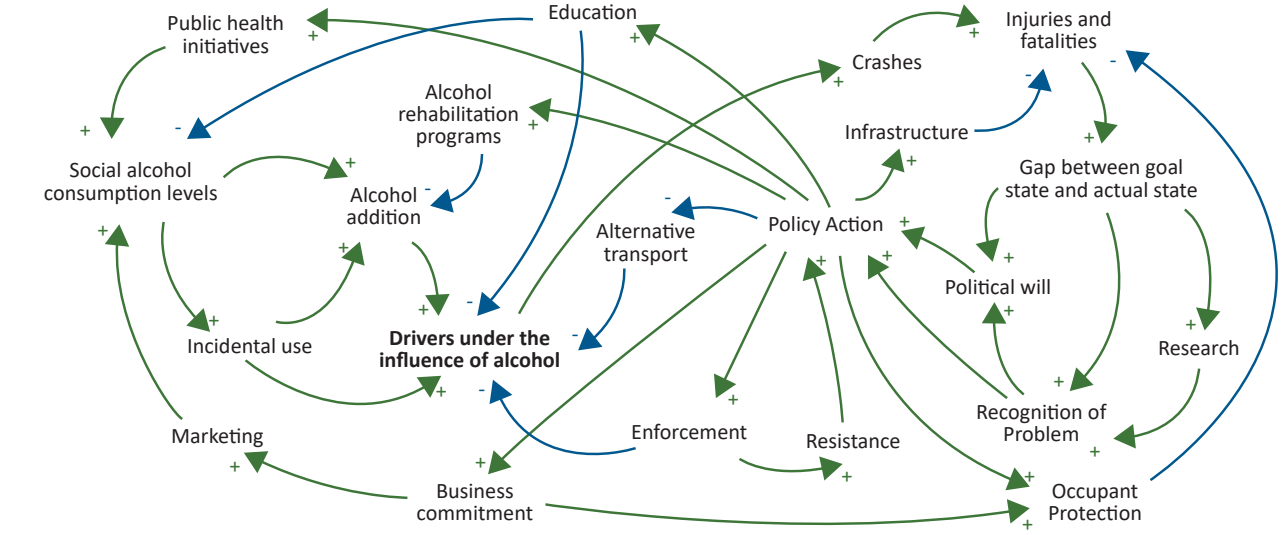


Diagram 2: A generic CLD that describes the broader influences on crash rates and road trauma (adapted from Salmon et al., 2019b, 2020).



This CLD goes further to show the complex set of variables which interact to prevent large reductions in road trauma, in this case relating to crashes involving drivers driving under the influence of alcohol. The CLD suggests that, because many factors external to the driver play a role in drink-driving related crashes, interventions beyond enforcement, education and engineering are required.

Diagram 3: Drink driving casual loop diagram showing the factors that create drink driving-related crashes (adapted from Salmon et al., 2019b, 2020).

Using system dynamics to evaluate road safety interventions

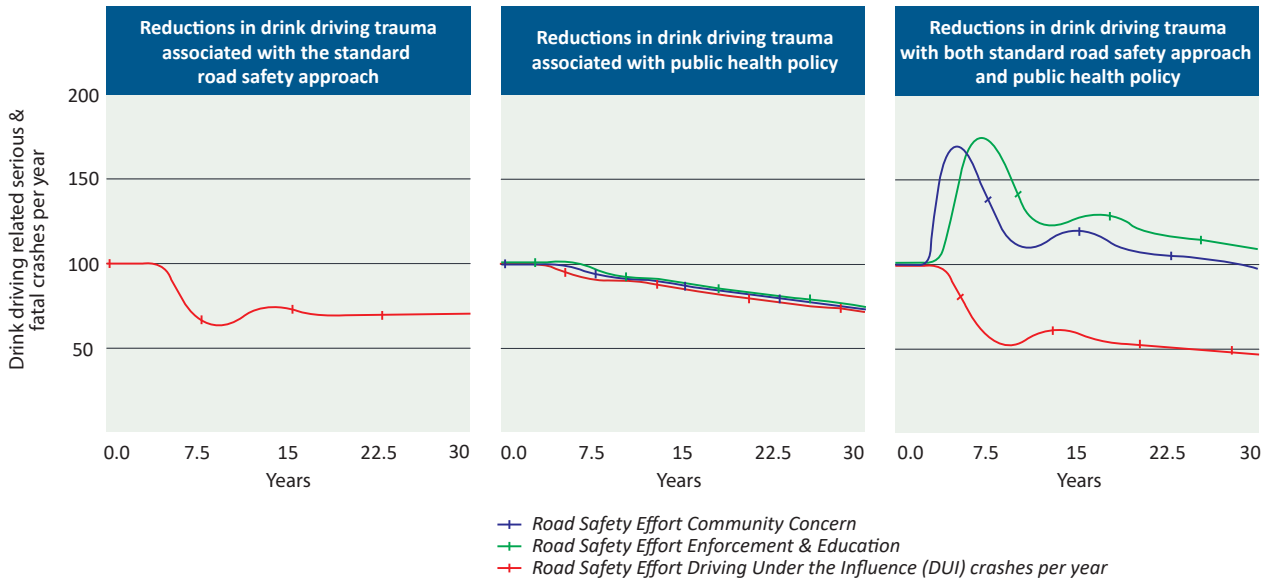
As shown by the CLDs, a clear message of this research is that interventions beyond enforcement, education and engineering are required to prevent the fatal five. To develop such interventions, we held a series of road safety expert participatory design workshops. As a result we created eight interventions relating to road safety policy, work, urban design, in-vehicle monitoring, gamification and incentivisation, and safety ratings.

Evaluation of the interventions via a survey of road transport stakeholders revealed positive ratings for a number of them; however, we wanted to understand the likely impacts in terms of a reduction in crashes and road trauma. To achieve this we used system dynamics, which is a computational modelling method that provides dynamic simulations of system behaviour over time.

System dynamics was used to simulate the dynamics of drink driving-related trauma and is prevention. The model provides insight into what combination of interventions would have the greatest impact in terms of reducing drink driving-related crashes. Specifically we tested two types of policy intervention:

- Standard road safety approach. This included standard road safety interventions such as randomised breath testing and road user education campaigns.
- Public health policy. This policy aimed at reducing the population prevalence of alcohol misuse in the community through a set of public health measures such as taxation of alcohol, restriction of sales, improving responsible sales and serving, and increasing diagnoses and recovery programs for those experiencing alcohol addiction.

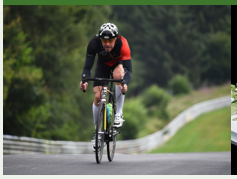
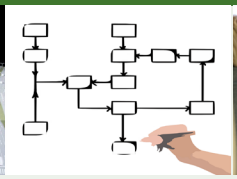
The analysis showed that the target of a 50% reduction in drink driving-related serious and fatal crashes over 30 years was only achieved by integrating the road safety and public health approaches and implementing them together as part of a coordinated approach.



Graphs showing the impact of different interventions over a 30 year period (adapted from Salmon et al., 2020).

LEVERAGE POINTS

Leverage points are areas within a complex system where small changes can potentially have large effects. Our analyses identified a series of leverage points in the road transport system where interventions could have large effects on the road toll. Example leverage points include:

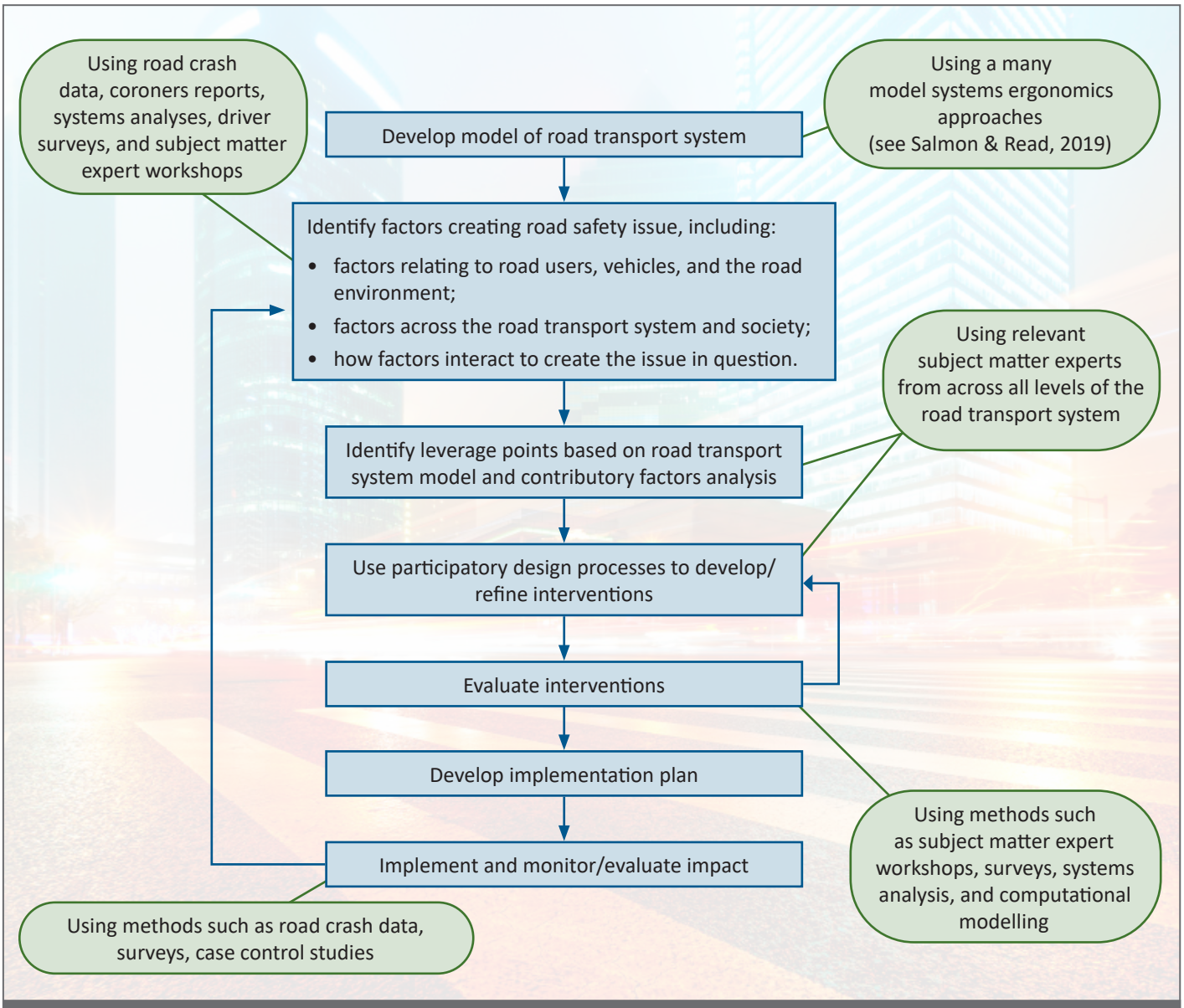
Modal shift	Land use planning and urban design	Standards, processes, certification	Employers	Road safety strategy & policy	Societal issues
					

Key findings

In summary, this program of research had a number of key findings, including:

- drivers' engagement in the fatal five is influenced by multiple factors from across road transport systems and society;
- wider road transport and societal issues play an important role in influencing drivers' engagement in the fatal five;
- societal issues which influence road safety outcomes include alcohol and drug misuse and addiction, a high reliance on technology and social media, increasingly time poor lifestyles, work pressures, and a reliance on the motor vehicle;
- road safety interventions are likely to be more effective if they target key leverage points and consider broader societal issues; and
- an integrated approach to public health, urban planning and transport safety is likely to achieve greater public health and road safety gains than a 'siloed' approach.

Overall, the strong message of this research is that interventions beyond the traditional road safety approaches of enforcement, education and engineering are required to initiate new reductions in road trauma. Such interventions can be identified and implemented through the following approach.



A systems approach to understanding and preventing road trauma.

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The work presented in this booklet is described in full in the following publications:

Salmon, P. M., Read, G. J. M., Stevens, N. (2016). Who is in control of road safety? A STAMP control structure analysis of the road transport system in Queensland, Australia. *Accident Analysis and Prevention*, 96, 140–151

Salmon, P. M., Read, G. J. M., Beanland, V., Thompson, J., Filtness, A., Hulme, A., McClure, R., Johnston, I. (2019a). Bad behaviour or societal failure? Perceptions of the factors contributing to drivers' engagement in the fatal five driving behaviours. *Applied Ergonomics*, 74, 162-171.

Salmon, P. M., McClure, R., Read, G. J. M., Hulme, A., Thompson, J., McLean, S. (2019b). Using Causal Loop Diagrams to Identify and Represent the Factors that Contribute to Road Trauma. Transportation Research Board 98th Annual Meeting, Washington DC, United States

Salmon, P. M., Read, G. J. M., Stevens, N. A., Walker, G. H., Beanland, V., McClure, R., Hughes, B.., Johnston, I., Stanton, N. A. (2019c). Using the abstraction hierarchy to identify how the purpose and structure of road transport systems contributes to road trauma. *Transportation Research Interdisciplinary Perspectives*. Vol 3, 1-9

Salmon, P. M., Read, G. J. M. (2019). Many-model thinking in systems ergonomics: a case study in road safety. *Ergonomics*, 62:5, 612-628

Salmon, P. M., Read, G. J. M., Thompson, J., McLean, S., McClure, R. (2020). Computational modelling and systems ergonomics: a system dynamics model of drink driving-related trauma prevention. *Ergonomics*, 1-17.

For further information, please contact:

Professor Paul Salmon
Director, Centre for Human Factors and Sociotechnical Systems
University of the Sunshine Coast
Email: psalmon@usc.edu.au
Web: http://www.usc.edu.au, https://www.hf-sts.com
Phone: +61 7 5456 5893