



The driver, the road, the rules . . . and the rest? A systems-based approach to young driver road safety



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ABSTRACT

The persistent overrepresentation of young drivers in road crashes is universally recognised. A multitude of factors influencing their behaviour and safety have been identified through methods including crash analyses, simulated and naturalistic driving studies, and self-report measures. Across the globe numerous, diverse, countermeasures have been implemented; the design of the vast majority of these has been informed by a driver-centric approach. An alternative approach gaining popularity in transport safety is the *systems* approach which considers not only the characteristics of the individual, but also the decisions and actions of other actors within the road transport system, along with the interactions amongst them. This paper argues that for substantial improvements to be made in young driver road safety, what has been learnt from driver-centric research needs to be integrated into a systems approach, thus providing a holistic appraisal of the young driver road safety problem. Only then will more effective opportunities and avenues for intervention be realised.

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1. Introduction

Young drivers are universally recognised as a major public health and injury prevention problem due to their persistent overrepresentation in road crashes. Young driver safety continues to be a significant global concern despite an abundance of research and significant investment in crash-prevention and other intervention programs. Current Australian countermeasure examples include: free driving lessons offered to learner drivers by organisations such as the Royal Automobile Club of Queensland; outreach programs provided to secondary students by advocates of the Spinal Injuries Association; and television advertising campaigns featuring young drivers, their passengers and other road users targeting speeding and other risky driving behaviours, to name a few.

The continued overrepresentation of young drivers in road crash statistics, however, suggests that existing approaches are limited in their capacity to fully address the problem of young driver crashes. Notably the interventions described above are all targeted at the young drivers in an attempt to ‘fix’ them in a way that leads to improved driving performance. This is in direct contradiction with

alternative contemporary ‘systems thinking’ inspired models of accident causation, widely used in other safety critical domains, that argue that attempting to fix individual behaviour or specific components in response to accidents is inappropriate (e.g., Dekker et al., 2011). Rather, the system itself should be the focus of accident countermeasure development.

The systems approach is a long-established philosophy that first emerged in the early 1900s (e.g., Heinrich, 1931) and has since evolved through a number of accident causation models and analysis methods (e.g., Leveson, 2004; Perrow, 1984; Rasmussen, 1997; Reason, 1990). The approach centres on the notion that safety, and indeed accidents, are emergent properties arising from non-linear interactions between multiple components across complex sociotechnical systems (e.g., Leveson, 2004). The adoption of systems thinking is now widely accepted to be an appropriate approach for understanding and preventing accidents in most safety critical, complex, domains including aviation (e.g., Debrincat et al., 2010; Li et al., 2008) and rail (e.g., Read et al., 2013), and is currently the dominant paradigm in accident research (Underwood and Waterson, in press). Although contemporary road safety strategies contain elements of systems thinking (such as advocating a shared responsibility for road safety), and a systems approach to road safety generally was first touted in the early 1990s (e.g., Zaidel, 1992), applications underpinned by systems thinking-based models and methods in road transport remain sparse (e.g., Larsson et al.,

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2010; Salmon et al., 2012a), particularly within the context of young driver road safety.

This paper argues that the prevailing driver-centric approach, although having produced significant reductions in young driver fatalities and injuries, is no longer appropriate for directing young driver safety interventions. Rather, it is argued that a *systems* approach is required in which the role of the overall road transport system in young driver crashes is clarified and system reforms rather than further driver-centric interventions are pursued. The aim of this paper is to demonstrate the utility of using accident causation and analysis frameworks underpinned by systems thinking to initiate such an approach to young driver safety. In doing so, we first contrast the prevailing driver-centric approach with a systems approach to young driver road safety. In order to provide a holistic appraisal of the young driver problem, a description of the actors within the road transport 'system' is then presented and previous research on young driver safety is integrated into a systems framework. Based on these findings, the directions for future research are identified.

2. Understanding young driver road safety

2.1. The current approach: driver-centric

Traditionally a driver-centric approach has been applied to understanding not only young driver road safety, but road safety in general. That is, a strong focus has been on identifying the specific individual components which contribute to the increased risk experienced by all young drivers', with a particular emphasis on their driving behaviour. For example, much research has focussed on young drivers driving skills, such as hazard perception (e.g., Boufous et al., 2011) and situation awareness (e.g., Whelan et al., 2004); and risky behaviours such as speeding (e.g., Mitchell-Taverner et al., 2003) and driving under the influence of alcohol (e.g., Peck et al., 2008). Frequently the contributing factors are investigated in isolation (e.g., seat belt use, Calisir and Lehto, 2002) or in combination with a handful of other influential variables (e.g., age and gender, Rhodes and Pivik, 2011). The overarching focus then has been the young drivers themselves. Crucially, this research has helped delineate the breadth of driver behaviours and characteristics contributing to young driver crash risks, thus informing countermeasure development. To illustrate this point, the increased risk for all drivers at night simply due to reduced visibility, the greater likelihood of alcohol consumption at night (e.g., Vaez and Laflamme, 2005) and the negative influence of multiple peer passengers (e.g., Doherty et al., 1998) who are likely to be carried by the young driver at night, means that most graduated driver licensing (GDL) programs incorporate a night passenger restriction (e.g., in Queensland, young drivers are allowed to carry one peer passenger only between 11 pm and 5 am), and zero blood alcohol concentration for novice drivers (Queensland Transport, 2007).

Whilst the driver centric approach has had significant success in reducing young driver crash involvement, what appears to be missing is a comprehensive understanding of the system in which young drivers operate. That is, what is the breadth of factors – and most importantly, the relationships between the factors – which are influential in young driver road safety *within* the scope of the young driver road 'system'? How, for example, might other factors such as the behaviour of parents and peers, driver education and training, vehicle and road design, road rules, media coverage, advertising, and high insurance costs interact and influence young driver behaviour?

Moreover, driver-centric research is predominantly atheoretical, and the prevalent theme within the road safety literature focuses upon 'fixing the driver' (Larsson et al., 2010), while largely

ignoring the complex interacting system of factors which influence their behaviour. For example, limitations within the public transport system mean that young drivers are likely to be carrying passengers between 11:00 pm and 5:00 am on a Saturday. A systems approach which more fully considers the factors influential in young driver road safety, and the interactions between these factors, is vital if more effective countermeasures are to be developed.

2.2. An alternative systems approach

A systems approach to understanding any complex safety-critical environment, including the road, is characterised by

- (1) "top-down systems thinking that recognises safety as an emergent system property rather than a bottom-up summation of reliable components and actions;
- (2) focus on the integrated socio-technical system as a whole and the relationships between the technical, organizational, and social aspects; and
- (3) focus on providing ways to model, analyse, and design specific organizational safety structures rather than trying to specify general principles that apply to all organisations" (Leveson et al., 2009, p. 241).

As such, road safety is conceptualised as emerging from an interactive and dynamic system influenced by the actions of, and interactions between, a multitude of social, organisational and technical components (Salmon et al., 2012b). This is in contrast to the implicit philosophy inherent within the traditional driver-centric approach that road safety emerges from the driver and their immediate driving environment. An exemplar of what a systems approach can offer to road safety is provided by Salmon et al. (2012c). In this instance, a systems analysis method was applied to the 2007 Kerang rail level crossing incident in Victoria; a crash between a semitrailer and a passenger train which resulted in 11 deaths and 15 people seriously injured. The approach provided a context for understanding how system-wide factors (e.g., road design, trees in close proximity to the crossing, delayed loading of the truck, limited rail level crossing risk assessment process, rail level crossing design financial constraints) created the system in which the incident was allowed to happen.

It is noteworthy at this juncture, however, that a system approach is not synonymous with the road safety 'safe systems' philosophy "which holds that people will continue to make mistakes and that roads, vehicles and speeds should be designed to reduce the risk of crashes and to protect people in the event of a crash" (Australian Transport Council, 2011, p. vii). Whilst there are similarities between the two (such as the notion that safety is the shared responsibility of actors across the system), the safe systems philosophy is still heavily focussed on road user behaviour and the use of infrastructure and vehicle design to *tolerate* the outcomes of these behaviours. In contrast, a systems approach also considers factors outside the immediate environment, and identifies the need to understand the interaction of factors across the system that *influence* the behaviour of humans (i.e., road users) at the 'sharp-end' (i.e., on the road). Rather than strive for a system that is tolerant of adverse behaviours the aim is to address or mitigate the factors and interactions that create the adverse behaviours. For example, one Australian state is considering introducing a scheme whereby parents continue to supervise young novice drivers as much as possible throughout the earliest months of independent driving. Furthermore, the perpetual struggle between mobility and safety in the context of the young driver system also merits consideration within the broader systems approach (e.g., see Bates et al., 2010).

There are a number of systems-based models and associated analytical techniques, such as STAMP (Systems-Theoretic Accident Model and Processes, [Leveson, 2004](#)), HFACS (The Human Factors Analysis and Classification System, [Wiegman and Shappell, 2003](#)) and [Rasmussen's \(1997\)](#) Risk Management Framework (RMF); however, applications that are specific to the road transport context are sparse. In general these approaches share qualities such as being suitable for investigating complex sociotechnical phenomena, with (albeit diverse) theoretical underpinnings ([Salmon et al., 2012a](#)), Rasmussen's RMF is a particularly useful approach. Rasmussen's RMF is domain-generic, provides a framework for constructing a holistic picture of the factors impacting safety in the domain of interest, and can be readily modified to suit the domain of interest. In addition, the complex, safety-critical domain – young driver road safety – is conceptualised as comprising six socio-technical levels which have been adapted to describe the domain of young driver road safety:

Level 1: Government policy and budgeting: Decisions and actions regarding young driver road safety, including the development of behaviour-regulating laws and legislation, such as GDL and general road rules; provision of funding for interventions; and policy development.

Level 2: Regulatory bodies and associations: Conversion and informing of young driver legislation by regulatory bodies, research organisations and others with financial interest in young driver road safety (such as police and motor vehicle insurers).

Level 3: Local area government, planning, budgeting: Government policy including GDL and general road rules are integrated into driving. Parents are perceived as operating as the 'local government' of their young novice driver child by virtue of the dynamics of intra-familial power and authority.

Level 4: Technical and operational management: Other influential and authoritative bodies and organisations with a direct influence on young driver behaviour and decision-making.

Level 5: Physical processes and actor activities: the young drivers themselves, the psychosocial influences upon their driving behaviour, and their actual driving behaviour (i.e., 'the sharp end').

Level 6: Equipment and surroundings: The actual physical environment and surroundings in which the young person drives, including the motor vehicle.

In order for the system to maintain safety, decisions made at the higher levels (i.e., Local area government, Regulatory and Government) should influence actions at the lower levels, while information about the current state of affairs (i.e., driver behaviour and accidents) should transmit up the hierarchy and shape decision making at the higher levels; a process known as vertical integration ([Rasmussen, 1997](#); [Svedung and Rasmussen, 2002](#)). Thus a systems approach to road safety ultimately results in responsibility for road safety that is shared amongst a broad group of actors whose decisions and actions interact and impact upon each other. This is in contrast to the predominant theme of 'fix the driver', which primarily attributes blame to the young drivers themselves ([Larsson et al., 2010](#)).

Rasmussen's RMF is associated with the AcciMap technique which is an accident analysis framework that provides a figurative representation of the causal factors and interrelationships; in this context identifying the multitude of potential decisions and events that combine to result in a young driver road crash. Elucidation of these factors and relationships therefore allows identification of potential avenues of intervention to prevent future critical incidents ([Watersen and Jenkins, 2011](#)). The focus here is on removing factors upstream from the accident rather than the immediate causal factors at the sharp end. Part of the AcciMap process involves

constructing an Actor Map which provides a representation of the actors (such as motoring organisations, passengers and government departments) residing within the system under analysis. AcciMaps and Actor Maps have provided unique insight into the contributing actors and decisions in critical incidents in various areas, such as gas plant explosions ([Hopkins, 2000](#)), police firearm mishaps ([Jenkins et al., 2010](#)), space travel ([Johnson and Muniz de Almeida, 2008](#)), and public health incidents ([Cassano-Piche et al., 2009](#); [Vicente and Christoffersen, 2006](#)).

A systems approach to young driver road safety will therefore consider not only the individual factors contributing to road safety; it will also consider other key persons and technology within the road transport system, and the multitude of interactions amongst each of these actors. A systems approach also recognises that the young driver road safety "system is more than the sum of its elements" ([Rasmussen, 1997, p. 284](#)). Perhaps most importantly, a systems approach can integrate driver-centric research findings to provide a more holistic understanding of the young driver road safety problem. To initiate this, the following sections first identify the actors important in young driver road safety through presentation of an Actor Map. They then illustrate how the factors identified in previous young driver research align with Rasmussen's framework, commencing with contributing factors in young driver crashes, followed by young driver road safety countermeasures.

3. Actors influencing young driver road safety

Before examining the knowledge base on young driver crash contributing factors and the interventions designed to enhance young driver behaviour and safety, a description of the actors within the road transport system is required. That is, in the young driver context, who comprises the system and where in the system do they reside? For this purpose, an Actor Map (see [Fig. 1](#)) was produced in which those playing a role in young driver safety in Queensland, Australia (the jurisdiction in which the authors reside), were identified from the extant literature, associated websites and professional expertise and placed across the six system levels described earlier.

[Fig. 1](#) has some important features. First, actors are present across all levels of the system, confirming that a systems approach is required in this context. Second, multiple actors are present, indicating that the young driver crash problem is far more complex than is currently considered by the literature. Whilst it is reasonable to surmise that there is some sharing of responsibility between some actors, for example, between courts, licensing authorities, and police as regulators and enforcers of road rules and licensing provisions, there appears to be limited vertical integration of the various actors' actions, with a focus upon top-down rather than merely bottom-up processing and instruction. For instance, notwithstanding the opportunity for parents and the young driver to participate in a number of community forums in the period before the introduction of the enhanced GDL in Queensland in July 2007, there has been limited opportunity for parents and the young driver to be integrated within the young driver road safety system and to 'feed back' regarding actions, practices, and policies of actors at higher levels as depicted in [Fig. 1](#).

Such limitations are evidenced in research (e.g., [Toole et al., 2013](#)) framed within a safe systems philosophy which targets vehicles and infrastructure (level one in Rasmussen's RMF) and emphasises the need for stakeholders to collaborate and 'road agencies' to take the recommendations on board (conceivably those actors in level six of Rasmussen's RMF), rather than a systemic approach which crosses all six levels of the young driver road safety system. An important line of inquiry now is to establish what is known regarding the role of the different actors in young driver safety.

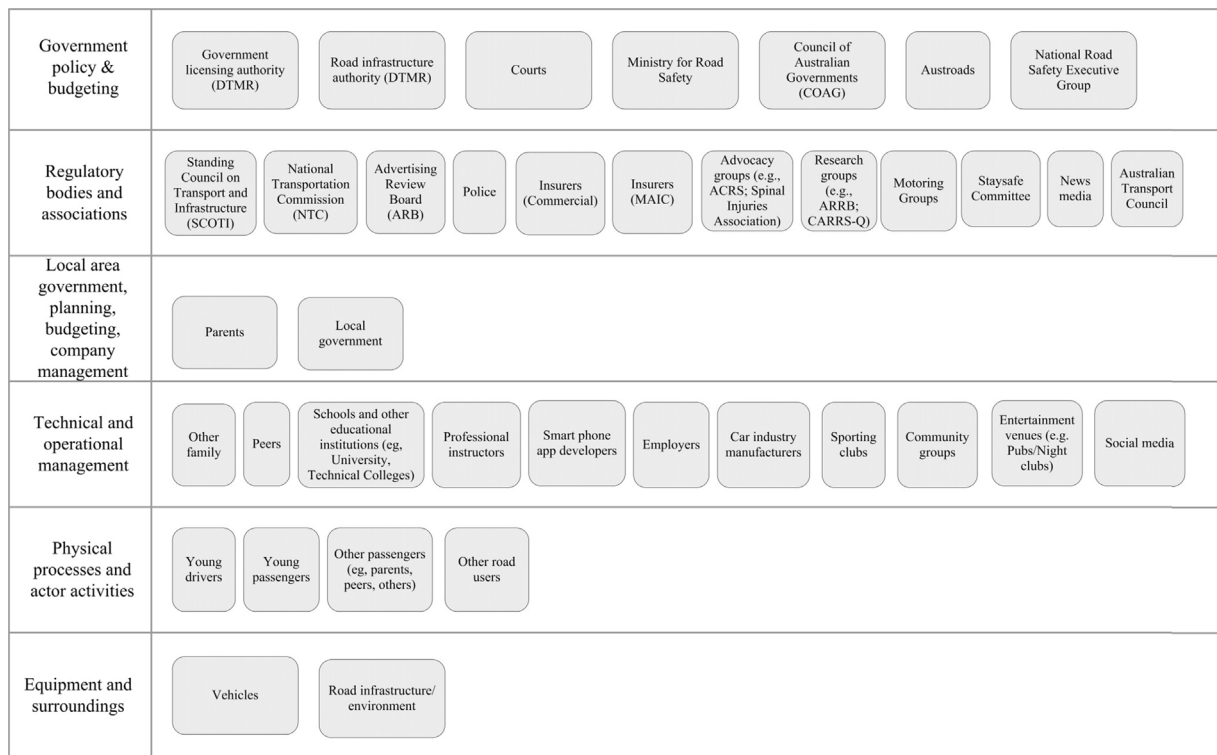


Fig. 1. Actor Map of young driver road safety in Queensland, Australia—key actors.

4. Contributing factors in young driver crashes

Research consistently demonstrates that young driver crashes and fatalities are associated with and influenced by a myriad of driver, journey, vehicle, and passenger characteristics and broader social factors. Fig. 2 presents an AcciMap representing the range and variety of contributing factors in young driver crashes that have been identified in previous research undertaken in motorised jurisdictions internationally.

Fig. 2 demonstrates that the majority of the literature on young driver crashes describes contributory factors related to the drivers themselves, or their vehicles. Whilst this is appropriate and has proven useful for guiding intervention development and application, it is likely that more contributory factors are present across the other levels. Whilst AcciMaps typically incorporate arrows indicating directionality of relationships, the extant literature has only investigated a portion of the potential influential relationships. Notwithstanding the paucity of research regarding the directionality of relationships, a multitude of variables across the three levels of technical and operational management, physical processes and actor activities, and equipment and surroundings level can be seen as potentially influencing the self-reported risky behaviour of young drivers.

It is likely that there are many interrelationships amongst the factors presented in Fig. 2 that remain unexplored. For example, it is likely that the 'number of passengers', 'age of passengers', and 'passenger gender' in relation to the driver, is influential in the 'journey purpose' and the nature of the 'driving exposure' undertaken in a vehicle of particular 'size', 'age', and 'ownership', which conversely may influence 'seat belt use' and 'driver inattention and distraction', 'driving intentions' and 'driver willingness' to be risky, particularly as passengers are frequently 'peers' and young drivers often observe the behaviour of 'other young drivers'. In turn, other factors such as education, training, rules and regulations, and enforcement will shape young drivers propensity to travel with multiple passengers and also the way in which the driver–passenger cohort

behaves in this context. Likewise, the extent to which education, training, rules and regulations, and enforcement shapes young driver behaviour in a positive manner will in turn be linked to factors surrounding policy, funding, research, political pressures and so on. However, the interrelationships require further delineation before a full understanding of passenger influence in young driver road safety is gained. Moreover, the need for different approaches to understanding, and therefore intervening in, risky driving behaviours such as speeding and drink driving (e.g., Fernandes et al., 2007) has also been recognised, however such approaches are rarely operationalised. This suggests that AcciMaps of contributing factors in young driver crashes may need to be developed for specific risky behaviours, such as those targeted in the Fatal Five (drink driving, speeding, fatigue, not wearing seatbelts and distraction, Queensland Police, 2013).

Furthermore, as Fig. 2 illustrates, the majority of relationships identified represent interactions at the physical processes level. For example, risky driving behaviour is associated with parents, peers, driver age and individual development, driver gender, driver drug and alcohol use, driver willingness, travelling speed, vehicle ownership, driving experience, punishment avoidance, driver personality, driver emotions, residential rurality, driver willingness and driving intentions (e.g., Catchpole et al., 1994). In contrast, fewer research studies examine the interactions between factors across the six levels, examining relationships between contributory factors such as vehicle ownership, travelling speed and driving exposure (Scott-Parker et al., 2011a), and parents and peers and driver expectancies (Scott-Parker et al., 2012b).

Perhaps most importantly, Fig. 2 shows a clear lack of knowledge on crash contributory factors at the higher levels of the road transport system, despite a number of actors present in the system at these higher levels (see Fig. 1). Whilst there is a plethora of knowledge on factors related to the drivers themselves, little is known regarding how other components in the system shape young driver behaviour and safety. For example, how political and funding issues at the higher levels shape road design in a way that

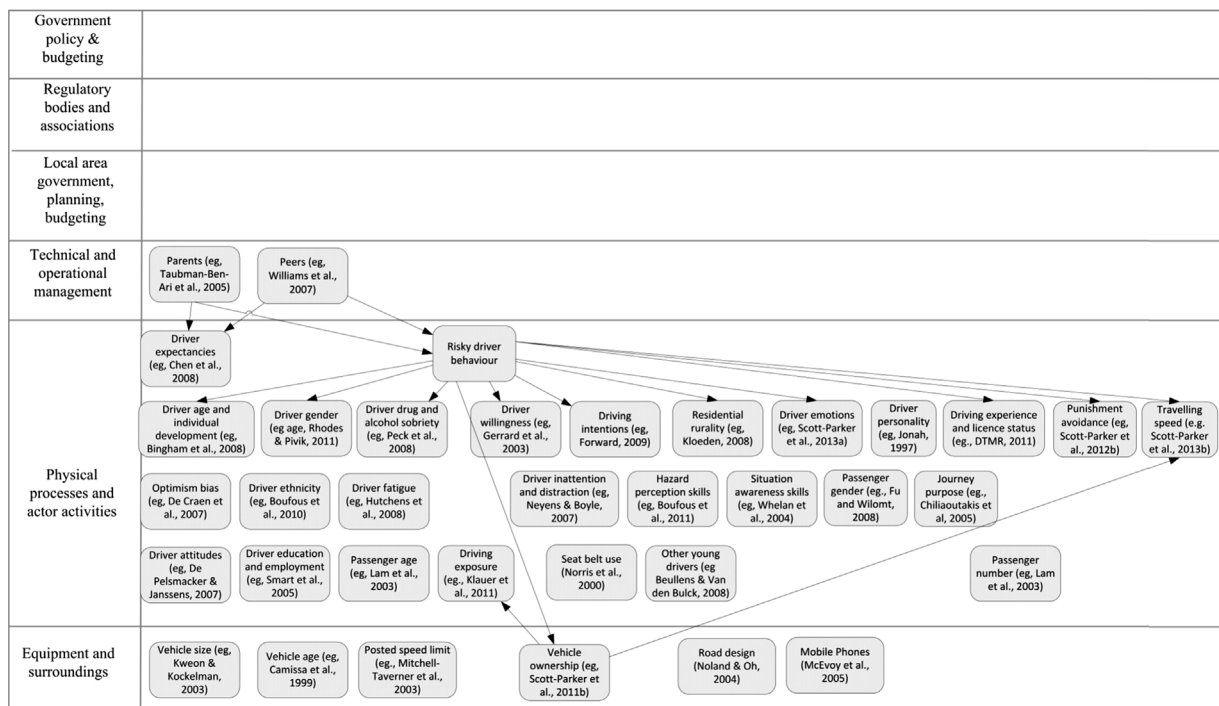


Fig. 2. AcciMap of factors contributing to young driver crashes in the global context. See Refs. [Beullens and Van den Bulck \(2008\)](#), [Bingham et al. \(2008\)](#), [Boufous et al. \(2010\)](#), [Cammisa et al. \(1999\)](#), [Chen et al. \(2008\)](#), [Chliaoutakis et al. \(2005\)](#), [deCraen et al. \(2007\)](#), [De Pelsmacker and Janssens \(2007\)](#), [DTMR \(2012\)](#), [Forward \(2009\)](#), [Fu and Wilmot \(2008\)](#), [Gerrard et al. \(2003\)](#), [Hutchens et al. \(2008\)](#), [Jonah \(1997\)](#), [Klauser et al. \(2011\)](#), [Kloeden \(2008\)](#), [Kweon and Kockelman \(2003\)](#), [Lam et al. \(2003\)](#), [McEvoy et al. \(2005\)](#), [Neyens and Boyle \(2007\)](#), [Noland and Oh \(2004\)](#), [Norris et al. \(2000\)](#), [Scott-Parker et al. \(2011b\)](#), [Scott-Parker et al. \(2013a,b\)](#), [Smart et al. \(2005\)](#), [Taubman-Ben-Ari et al. \(2005\)](#), [Williams et al. \(2007\)](#).

increases crash risk. As a result of such limitations, interventions are limited in their capacity to effect improvements in young driver road safety.

This suggests either that (a) more research is required to identify what these factors are, or (b) that, in contradiction to contemporary systems-based accident causation models (e.g., [Rasmussen, 1997](#); [Dekker et al., 2011](#)), young driver crashes are a function of the drivers themselves, their vehicle, their peers, and their parents, with the remaining road transport components playing no part in road safety outcomes. This is unlikely, therefore, the lack of factors at the top three levels in [Fig. 2](#) suggests that currently we do not fully understand how decisions and actions at these levels impact upon young driver behaviour.

5. Young driver road safety countermeasures

[Fig. 2](#) demonstrates that the overall young driver system has not been fully elucidated when examining the causes of young driver crashes. Next, a review of the literature on young driver crash countermeasures was used to populate an AcciMap (see [Fig. 3](#)). As can be seen, countermeasures have focussed on either enhancing young driver skill sets through education or training or on modifying their behaviour via in-vehicle technologies, infrastructure design, and graduated licensing systems.

Similar to factors influential in young driver road safety, the majority of the extant literature has not investigated the interactions amongst these countermeasures. Illustrative exemplars only based upon a number of papers cited within [Fig. 3](#) are provided for the reader's information. For example, the considerable role of parents in the driving career of their novice child from the Learner licence period (e.g., [Scott-Parker et al., 2011a](#)) through the Provisional licence period (e.g., [Scott-Parker et al., 2012a](#)), and interrelationships such as the positive road safety outcomes associated with parent support programs such as Checkpoints (e.g.,

[Simons-Morton et al., 2006](#)) which can augment driver training (e.g., [Stanley and Mueller, 2010](#)) and licensing programs ([Williams, 2007](#)) suggests that a multitude of interrelationships are important in overall young driver road safety. Interestingly, whilst the evidence regarding driving training and reduced crash risk is mired in controversy principally as a result of issues pertaining to methodology (e.g., [Beanland et al., 2013](#)), research suggests that individual driver coaching can improve driving skills and situation awareness (e.g., [Stanton et al., 2007](#)). This reflects the untapped potential for existing driver-centric approaches to actually have a more systemic impact.

In addition, the repeated representation of parents in each of the three figures suggests that actors and interventions should more effectively capitalise on their considerable role in young driver road safety (see earlier comment regarding the potential implementation by licensing authorities [at level 1] of an extended-supervision program targeting parents [at level 3] of newly-licensed novice drivers). Again the incomplete nature of this AcciMap highlights areas in which there is a lack of research and therefore deficits in our understandings of the broader impacts and interrelationships between the varieties of young driver interventions. Further, the interventions seem to be piecemeal in nature and do not fully reflect the policies and practices of higher – and lower – levels represented in a systems approach.

[Fig. 3](#) also illustrates that the contemporary driver-centric approach to interventions is consistent with [Dekker's et al. \(2011\)](#) concept of drift-into-failure (DIF). First, interventions targeting young driver safety are largely determined by the availability of resources and competition between competing interests. Interventions also tend to be reactive, representing DIF's decrementalism (e.g., road rules, regulations and enforcement have struggled to manage the on-road risks of ever more advanced technologies such as mobile phones during transit, with small, gradual decrements in what is allowed to be used in vehicles, like global positioning devices, culminating in considerable risks). Sensitive dependence

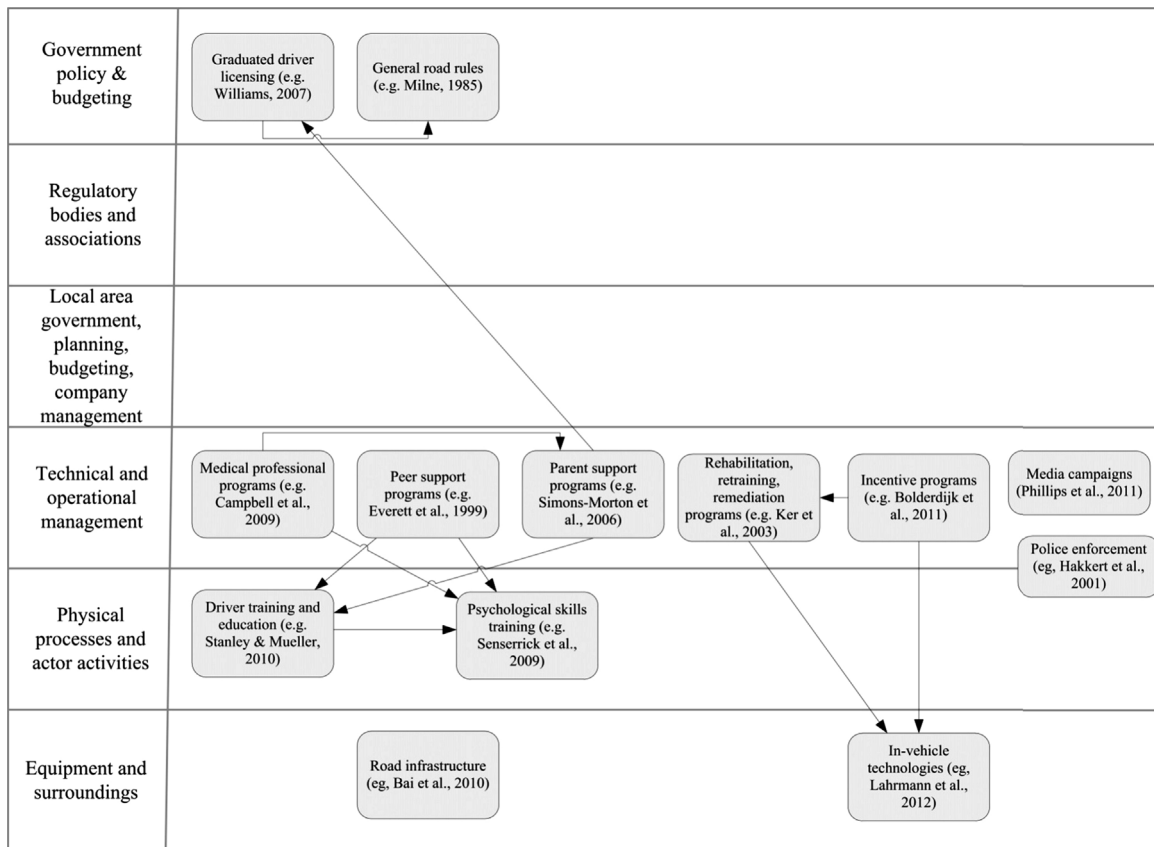


Fig. 3. AcciMap of young driver road safety countermeasures implemented in motorised jurisdictions around the world. See Refs. [Bai et al. \(2010\)](#), [Bolderdijk et al. \(2011\)](#), [Campbell et al. \(2009\)](#), [Everett et al. \(1999\)](#), [Hakkert et al. \(2001\)](#), [Ker et al. \(2003\)](#), [Lahrmann et al. \(2012\)](#), [Milne \(1985\)](#), [Phillips et al. \(2011\)](#), [Senserrick et al. \(2009\)](#).

on initial conditions, the third DIF characteristic, recognises that one small change can result in unforeseen changes of great magnitude: the enormous popularity of and affordability for mobile phones amongst young drivers could not have been reasonably predicted when they emerged in the public domain nearly three decades ago. Mobile phones can also exemplify the fourth DIF characteristic: unruly technology, such that the nature and extent of the impact of mobile phones upon young driver road safety also could not reasonably have been predicted in a pre-texting and pre-internet era (with mobile phone use whilst driving consistent with ideologies of behavioural adaptation, [Senserrick and Mitsopoulos-Rubens, 2013](#)). The fifth DIF characteristic, contribution of the protective structure, recognises that interventions can actualise unforeseen system risks, thereby negatively impacting young driver road safety. For example, incentive programs which reward drivers for 'safe driving' evidenced as no crashes and no offences may lead to underreporting of crashes (or fleeing the scene of a serious incident) and encourage drivers to avoid police detection (or engage in police chases to avoid punishment). To avoid DIF, it is vital that actors in young driver road safety are known (see [Fig. 1](#)). In addition, whilst the actor map demonstrates the young driver's protective structure, the protective structure may be acting ineffectively.

6. Where to now? An agenda for shared responsibility for road safety

The intention of this paper is to initiate systems dialogue in the sphere of young driver road safety, and indeed more broadly in road safety for all road users. As such, a solid foundation to guide additional systems-based investigations into young driver road safety is required, and the representations presented in

the three figures provide some core conclusions that are worth noting for future young driver road safety research. First, multiple actors and organisations across the road 'system' play a role in young driver behaviour and safety and are thus co-responsible for young driver safety. Second, despite this co-responsibility, our knowledge of young driver crash contributing factors is limited to factors related to the young drivers themselves, their parents and peers, their vehicles, and other road users. In addition, the crash causing interactions between different factors remain ambiguous. From a systems perspective, this effectively means that there are significant contributory factors (in addition to the unknown quantum of error variance) that remain unknown. Third, perhaps as a by-product of the limited knowledge base, interventions designed to enhance young driver behaviour and safety do not address the overall system; rather, they deal predominantly with the young drivers themselves by attempting to enhance their capabilities. Whilst this is not surprising and has proven successful to an extent, it represents a blame culture in that young drivers are seen to be the sole source of young driver crashes. As a corollary, other factors influencing the young driver road toll remain untouched. The worrying conclusion then is that, since the shared responsibility approach has not been realised, there are still various factors across the system influencing the behaviour of young drivers in undesirable ways. A systems approach to safety argues that component fixes are inappropriate and that system reform is the most suitable safety intervention (e.g., [Dekker et al., 2011](#); [Reason, 2008](#)). The extent to which system reform is happening in this case of young drivers is questionable.

Therefore the Authors posit the following research agenda which is relevant not only within the Queensland, Australia, context, but more broadly in young driver road safety systems throughout all motorised jurisdictions:

- (1) Transparency of actors, their role and alliances in young driver road safety. Although this has been initiated through presentation of the Actor Map in Fig. 1, a detailed description of the actors and their roles in young driver safety is required to identify who exactly is sharing the responsibility for young driver road safety. The actors identified in Fig. 1 play a role in the Queensland young driver road safety context. As such, further research efforts are required to identify the actors important in other motorised jurisdictions not only nationally but internationally.
- (2) Delineating relationships amongst actors; amongst risk factors; amongst countermeasures; and between actors, risk factors, and countermeasures. This will further enhance our understanding of how responsibility for young driver road safety is shared, from inter-actor interaction – effective or otherwise – to accountability for implementing non-evidence-based countermeasures, in addition to discerning ‘reinvention of the wheel’ and underutilisation of financial and social capital. Furthermore, it may realise heretofore unrecognised avenues of intervention and underutilised resources.
- (3) Identifying and removing or minimising any obstacles to a systems approach for actors and countermeasures. Actors must work together in an integrated way, and any structural barriers must be addressed and, ideally, be removed. One such barrier is the confusion between the safe systems approach and the systems thinking approach. The former underpinning road strategies, however, is different from the latter. Conversely, mechanisms to sustain vertical integration amongst the actors need to be introduced.
- (4) Developing and applying mechanisms for facilitating and ensuring vertical integration in the young driver road safety system. In its current state the young driver road safety system, in Queensland at least and likely in other motorised jurisdictions also, appears to be a dysfunctional system which lacks vertical integration between the levels. Many actors at the higher levels of the system have the power to influence young driver safety; however, interventions largely focus on the bottom two levels of the system. An effective and efficient system is not only possible but essential.
- (5) Refining countermeasures using a theoretical approach grounded in systems thinking. Whilst the characteristics and influences which have been found to contribute to young driver crashes are clearly demarcated in Fig. 2, it is noteworthy that a multitude of these variables likely interact at any time to impact and influence the driving behaviour of young drivers. Typical driver-centric approaches of analysis are limited in their capacity to consider the interactions within and between the various contributing factors. Further, the countermeasures represented in Fig. 3 also appear to be discrete, and research has demonstrated that combined efforts appear to be the most effective (e.g., on-road enforcement of speed limits in conjunction with education regarding risks associated with speeding at night, including on road curves and in rain Harrison et al., 1999). The preponderance of research developing, implementing and evaluating these measures, however, does not consider such interactions, nor does it consider any relationships amongst these measures and key actors in young driver road safety.
- (6) Methodologically-rigorous evaluation of countermeasures operationalising a systems approach. Collection of information on the causal factors associated with crashes should go beyond driver error. Previous research has attempted to systemically analyse road traffic crashes using various systems frameworks, unsuccessfully, even when combining the best data systems. For example, Salmon et al. (2010) used Reason’s Swiss Cheese model (1990) and Rasmussen’s framework in an attempt to place crash causing factors across the road system. The analyses demonstrated that even the most detailed crash reporting

systems only provide data for the lower levels (e.g., driver, vehicle and environment) of the frameworks tested.

To achieve substantial improvements in young driver road safety, the following policy applications agenda is required:

- (A) A reframing of road safety research to a systems approach which targets variables at all levels is required (Salmon et al., 2012b). The need for going beyond crash-causation variables to effectively intervene has been recently acknowledged (e.g., Hopkins, in press), further supporting the application of a systems approach to improving young driver road safety.
- (B) It is fundamental that a systems approach operationalises the most suitable model for understanding young driver road safety, and the authors recommend that Rasmussen’s RMF and the AcciMap technique be tested further in road safety efforts. Whilst other methods exist, such as HFACS and STAMP, AcciMap is more suitable as it is generic (HFACS was developed specifically for aviation systems) and is easier to apply and less resource intensive than methods such as STAMP (Salmon et al., 2012a).
- (C) There needs to be a fidelity to effective interventions, that is, to interventions that have been found to increase safety within the young driver road safety system.
- (D) In the circumstance of the Queensland context, there is no single agency with remit and responsibility for setting policy, monitoring, and operationalising road safety in general, and young driver road safety specifically.

As noted by Berwick (2003, p. 449), “every system is perfectly designed to achieve exactly the results it gets”. Accordingly, the authors assert that a more integrated system will achieve better results. In addition, it is also noteworthy that a systems approach to road safety more generally is likely to have benefits more specifically for young drivers, and such an approach could be a logical next step on the research agenda.

7. Conclusions

The young driver road safety literature abounds in research which explores the multitude of contributing factors influential in risky driving behaviour and in road crashes specifically. A breadth of interventions has been applied in motorised jurisdictions around the world. Yet young drivers continue to be killed at rates double than that expected from the driving population age profile. It appears that the traditional driver-centric approach to young driver road safety, which lays much of the blame upon the young drivers themselves, is not working. A systems approach, which can not only integrate findings from the driver-centric approach but also deepen our understanding of young driver road safety through the complex web of interrelationships between contributing factors, interventions and actors, offers a unique solution to the pervasive problem of young driver road safety. Until such time as a systems approach is operationalised within the domain of young driver road safety, interventions will continue to be applied in a piecemeal fashion. Moreover, the road safety focus will primarily remain on ‘fixing’ the young driver which is to the detriment not only of the young driver, but also their passengers and to all others who share the road with them.

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