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LN Wundersitz

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TITLE

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AUTHORS

LN Wundersitz

PERFORMING ORGANISATION

Centre for Automotive Safety Research
The University of Adelaide
South Australia 5005
AUSTRALIA

SPONSORED BY

Department of Planning, Transport and Infrastructure
GPO Box 1533
Adelaide SA 5001
AUSTRALIA

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ABSTRACT

Despite improvements in road safety, young drivers continue to be over-represented in crashes. CASR has conducted three in-depth studies investigating rural and metropolitan crashes in South Australia over the last decade. In-depth investigation of crashes provides very detailed information on crashes that otherwise could not be obtained from aggregate police-reported crash data. To gain a better understanding of the specific factors that lead to young driver crash involvement, this study used the comprehensive information collected from in-depth crash investigation to examine the causes and contributing factors leading to young driver crashes. Analyses by age group and level of experience were undertaken to determine whether the incidence of specific driver errors varied over the first few years of driving and could account for the substantial decline in crashes during that time. The study also examined specific driver errors and contributing factors associated with young driver risk-taking behaviour and with those who made simple mistakes or errors that lead to crash involvement. Detailed information for 256 drivers aged between 16 and 24 years was examined to identify behaviours contributing to young driver crash involvement. Based on findings from the analysis, measures that might reduce the incidence and severity of young driver crashes are discussed within a Safe System framework.

KEYWORDS

Young driver, crash investigation, crash causation

Summary

Young drivers are over-represented in crashes. To gain a greater understanding of the specific factors that lead to young driver crash involvement, this study used comprehensive information gathered from in-depth at-scene crash investigation to identify characteristics associated with young drivers and their crashes, and examine the causes and contributing factors leading to young driver crashes.

Analyses by age group (16-19 years, 20-24 years) and level of experience (P-plates<1 year, P-plates≥1 year) were undertaken to determine whether the incidence of specific driver errors varied over the first few years of driving and could account for the substantial decline in crashes during that period. In addition, the study aimed to identify any gender differences in broad driver errors and contributing factors and to determine specific driver errors and contributing factors associated with young driver risk-taking behaviour and with those who made simple mistakes or errors that lead to crash involvement.

The study sample consisted of 256 young drivers aged 16 to 24 years who were involved in a crash on South Australian roads that was investigated at-scene and in-depth by the CASR crash investigation team. The key findings from this analysis were the following:

CHARACTERISTICS OF YOUNG DRIVERS AND THEIR CRASHES

- Young and less experienced drivers were more likely to be involved in single vehicle crashes and crashes that occurred in rural areas, on undivided roads and on roads with higher speed limits than slightly older and more experienced young drivers. They were also much more likely to have peer passengers in the vehicle when they crashed.

ERRORS AND CONTRIBUTING FACTORS

- Consistent with previous research, three quarters of young drivers in the sample committed at least one error resulting in a crash, suggesting young driver over-involvement in errors leading to crashes.
- Overall, the most frequent errors resulting in young driver crashes were decision making errors followed by vehicle operation errors and errors relating to perception.
- Less experienced drivers made significantly more vehicle operation errors, particularly failing to adequately control the vehicle while more experienced young drivers made more perception errors relating to visibility and observation. These findings support existing research that suggests vehicle control skills increase rapidly with experience while perceptual and decision making skills take more time to develop.
- For contributing factors, analyses by the broad categories of driver, environment and vehicle factors indicated that there were no significant differences by age group, level of driving experience or sex. Therefore, measures targeting the most common factors contributing to young driver crashes identified in this study (responding to the behaviour of other road users, the physiological impairment of drivers, and coping with environmental conditions and road infrastructure) might be beneficial for all young drivers.
- For the broadly-based driver error categories and contributing factors, there were no statistically significant differences by sex. However there was a trend for males to make more decision based errors such as speeding and to have an impaired physiological state, compared to females.

- A higher prevalence of speeding and fatigue was reported in this study compared to other similar studies investigating young driver crashes. It is likely that this is due to the level of detailed information acquired through in-depth methods and the use of computer reconstructions to determine travelling speeds.

RISK-TAKING AND ERRORS

- Despite a perception that many young driver crashes are due to risk-taking behaviour, this study found that the majority (70%) of young driver behaviour leading to crashes was not primarily caused by risk-taking behaviour but due to young drivers making errors in which they failed to use routine safe operating practices.
- Young drivers who exhibited risk-taking behaviour were more likely to be male, drive a high performance vehicle, have peer passengers in the vehicle and be more seriously injured in the crash than young drivers who made simple errors. Crashes involving risk-taking behaviour were also more likely to occur at night and on weekends.
- Young drivers classified as participating in risk-taking behaviour made significantly more decision making errors, particularly driving at excessive speed and undertaking dangerous overtaking manoeuvres, while young drivers displaying erroneous behaviour were significantly more likely to make errors related to perception, particularly errors related to observation.

Based on the findings from this research, a number of system-wide solutions were suggested to reduce both the incidence and severity of young driver crashes. They include in-vehicle technology such as intelligent speed adaptation, electronic stability control and collision avoidance systems, and improvements to the graduated licensing scheme such as passenger restrictions.

Contents

1 Introduction

YOUNG DRIVER CRASHES

In spite of improvements in road safety, young drivers aged 16 to 24 years continue to be over-represented in crashes. Data from 2008 to 2010 indicates that people aged 16 to 24 years made up 14% of all South Australian licence holders but accounted for 25% of drivers and riders killed and 26% of drivers and riders seriously injured in road crashes (TARS database). Further analysis indicates that drivers aged 16 to 19 years have a higher rate of death or injury for every 10,000 licensed drivers compared to drivers aged 20 to 24 years and drivers aged 25 years and above (TARS database).

The likely reasons for the over-representation of young drivers in crash statistics include a lack of driving experience, risk taking behaviour and greater exposure to risk but little is known about the circumstances leading to their crashes and whether this varies between younger and slightly older novice drivers. For example, a recent study conducted by the Centre for Automotive Safety Research (CASR) for Austroads (Kloeden, 2008) examined a large sample of young South Australian drivers and found a sharp increase in crash involvement immediately after obtaining a provisional licence followed by a decrease in crashes after 6 to 12 months and continued reductions thereafter. This finding is consistent with research from North America (e.g. Mayhew, Simpson, & Pak, 2003). While the results were suggestive of the importance of driving experience, experience could not be separated from the effects of risk taking and exposure and detailed causes and contributing factors associated with individual crashes could not be determined from the aggregate police recorded crash data.

An American study examined driver behaviour that contributed to the non-fatal crashes of young drivers but was unable to identify any sizeable subsets of behaviours in which novice drivers (16-17 years) were over-represented (McKnight & McKnight, 2003). The authors conceded that larger differences might have been found if the analysis accounted for the amount of actual driving experience rather than being age-based. Moreover, the study relied on making inferences about driver behaviour from narrative crash descriptions in police reports.

Other studies have also attempted to understand the factors contributing to young driver crashes by using crash data from police reports (Braitman, Kirley, McCartt, & Chaudhary, 2008; Clarke, Ward, & Truman, 2005). However, police crash reports are severely limited in the amount of information they contain on crash circumstances and contributing factors. For example, the influence of peer passengers on the driver is unlikely to be recorded on a crash form. Sandin (2009) argues that databases containing police-reported crashes are not appropriate for analyses of crash causation because police are primarily interested in assigning responsibility for the crash and the data are simplified and standardised. Braitman et al. (2008) attempted to supplement data from police reports with interviews with participating drivers to determine factors leading to novice driver crashes. However, interview data can be subject to poor recall and socially desirable responses.

The in-depth at-scene investigation of crashes provides a rich source of detailed evidence-based information on individual crashes and provides valuable insight into specific risk factors, and their interaction, that otherwise would not be identified from the examination of aggregate police crash data. Researchers acknowledge that in-depth crash investigation data is useful for producing new or additional information, clarifying the interaction between contributory factors and for generating hypotheses of crash causation (Larsen, 2004; Midtland, Muskaug, Sagberg, & Jørgensen, 1995). In-depth case studies cannot be expected to be representative but they are important for providing information that is unattainable by other means (Grayson & Hakkert, 1987).

A very recent study examined the prevalence of driving-related errors among a representative sample of 15 to 18 year old drivers in the United States (Curry, Hafetz, Kallan, Winston, & Durbin, 2011). Data was obtained from at-scene crash investigation conducted by the National Highway Traffic Safety Administration as part of the National Motor Vehicle Crash Causation Survey. While the nationally representative sample was commendable, the study did not take into consideration the different levels of driving experience within the young driver sample.

Research using in-depth crash investigation data to identify specific young driver errors and behaviours leading to a crash and any differences by age group and level of driving experience within the young driver population is clearly lacking. Previous studies have focused primarily on the youngest drivers and have not considered whether different subsets of behaviours might be responsible for the variation in crash involvement rates by age group and level of driving experience.

IDENTIFYING CAUSES AND CONTRIBUTING FACTORS

It is generally acknowledged that the majority of road crashes are caused by more than one factor and these different factors often interact together with one facilitating another. In many police crash reporting systems, only one contributing factor or error is designated per crash. Consequently, these crash reporting systems are subject to over-simplifying crash events that often have quite complex causes.

Many systems that attempt to classify the causes of crashes focus on the road user and their failures that contributed to crash causation (e.g. failed to give way). These human failures or errors are then treated as the main cause of the crash without consideration of the reasons or factors behind them such as the environment or road conditions, the vehicle, or driver impairment. Also, these contributing factors are often confused with the actual human failures or errors. For example, a driver that fails to give way may have had their vision obstructed (human failure: perception/visibility error) due to a large parked vehicle (contributing factor: environmental). A review of the literature and current crash studies by van Eslande et al. (2008) found that many crash causation classification systems used across Europe do not separate errors (or human failures) from the factors which lead to these failures.

ERRORS AND RISK TAKING

While determining the relative importance of inexperience and risk taking in young driver crashes is highly desirable, it is very difficult to accurately determine what behaviour constitutes or represents ‘inexperience’ given that the sample of drivers are mostly, by definition, inexperienced drivers. To understand the circumstances behind young driver crashes, a more useful distinction is that between young driver risk taking behaviour and driver errors that lead to a crash. Indeed, there is a perception among the public that many young driver crashes are due to risk-taking behaviour.

Within the road system there are compliant road users who may make an error that leads to a crash, and there are also road users who deliberately take risks and display dangerous behaviours that lead to a crash. In this study, risk-taking was defined as behaviour leading to a crash that is deliberately unsafe and can be changed at will if the driver chooses to (e.g. deliberately exceeding the speed limit). The behaviour is intentional although the driver may or may not be aware that the behaviour is risky. For example, a driver may have performed an unsafe overtaking manoeuvre such as overtaking where there is a solid white painted line (the overtaking itself was an intentional planned behaviour and it was risky). In many cases the behaviour may have been deliberately risky (e.g. the driver was impatient) but it other cases the driver may have been unaware it was risky because they had limited experience in overtaking. It is often difficult to establish a driver’s awareness of whether a behaviour is perceived to be risky, even with more detailed in-depth data, therefore the definition of risk-taking

behaviour in this study was based on the driver's actions rather than the driver's perception of the level of risk associated with their actions.

Reason, Manstead, Stradling, Baxter, & Campbell (1990) conducted one of the most well known studies that sought to make a distinction between driver errors and violations to provide a better classification system for crash investigators. Errors were defined as the failure of planned actions to achieve their intended goals (slips, lapses, mistakes) while violations were described as deliberate deviations from safe operations. While the authors acknowledged the influence of the wider social context surrounding violations, errors were primarily considered in relation to the cognitive processes of the individual (Reason et al., 1990 p. 1316) and so the study did not address potential system wide interventions. Indeed, previous research has concentrated on estimating the contribution of individual driver errors rather than system wide failures (for a review of human error models see Salmon, Lenne, Stanton, Jenkins, & Walker, 2010).

A recent landmark study examined the relative contribution of extreme driving behaviour and system failures (i.e. making a simple mistake or error) in a sample of casualty crashes occurring on South Australian roads (Wundersitz & Baldock, 2011). The study found that the majority of fatal (57%) and non-fatal (97% metropolitan, 91% rural) crashes were due to system failures. However, this study did not specifically look at young driver crashes.

Previous studies that have attempted to determine the circumstances behind young driver crashes have resulted in mixed findings. McKnight and McKnight (2003) concluded that most non-fatal crashes in their sample resulted from a failure to use 'routine safe operating practices' and a failure to recognise the dangers associated with them rather than deliberate risk taking while Clarke et al. (2002) found that police-reported young driver crashes were more frequently the result of risk taking factors rather than skill deficits. Braitman et al. (2008) did not specifically make a distinction between driver errors and risk-taking behaviour but simply concluded that young driver crashes were predominantly due to driver error rather than vehicle or environmental/road factors. The most recent study by Curry et al. (2011) reported that the majority of young driver crashes were not primarily caused by intentional risk taking behaviour.

It is important to make the distinction between errors and risk-taking behaviours so that interventions can be tailored to guide and protect young drivers as they enter and progress through the road transport system (e.g. graduated licensing schemes are designed to provide a progression from simple low risk driving conditions to more complex situations as drivers gain experience and maturity) and also so that the road system is designed in a way that is forgiving when young drivers make mistakes (i.e. safe vehicle design, safe speeds, safe roadside infrastructure), consistent with Safe System principles.

OUTLINE OF STUDY

To obtain a greater understanding of the specific factors that lead to young driver crash involvement, this study uses information gathered from in-depth at-scene crash investigation to examine the causes and contributing factors leading to young driver crashes. The crash investigation files of young drivers aged 16 to 24 years who were involved in a crash on South Australian roads and were investigated at-scene and in-depth by the Centre for Automotive Safety Research (CASR) were examined in this study. In-depth crash investigations provide the most detailed information on crashes available. By examining a series of young driver crashes that have been investigated in-depth, the causes of young driver crashes can be determined and placed into a detailed context of an individual driver's experience.

Given the differences in crash involvement rates between the youngest drivers aged 16 to 19 years and those that are slightly older (i.e. aged 20 to 24 years), this study will investigate whether there are any differences in driver errors and contributing factors leading to crashes between these two age groups. In addition, this study will attempt to address a gap in the literature by examining if there are any differences in the driver errors and contributing factors between young drivers who have less driving experience than other young drivers. Gender differences in broad driver errors and contributing factors will also be briefly explored.

Finally, the study also explores driver errors and contributing factors associated with young driver risk-taking behaviour and with those who make simple mistakes that lead to crashes within a system-wide perspective. Based on findings from the analysis, improvements to the transport system that are likely to reduce the incidence and severity of young driver crashes will be discussed within a Safe System framework.

2 Method

2.1 CASR In-depth crash investigation

CASR has conducted three in-depth studies investigating rural and metropolitan crashes in South Australia over the past decade. The crash investigation process begins when the crash investigation team is alerted that an ambulance is called to a crash in the study area. The team attends the scene as soon as possible following the crash. Once at the crash location photographs are taken to document the crash scene and the crash involved vehicles are inspected, often before being moved. A survey of the crash location is also conducted recording the road geometry, relevant roadside features, the position of the vehicles and any associated skid or tyre marks. Video footage of the approach to the crash site from a driver's perspective is also recorded.

Follow-up investigations involve obtaining driver licensing details, a police report and hospital case notes describing injuries resulting from the crash. A coroner's report is obtained and reviewed for fatal crashes. In addition, the road design and crash history of the site is reviewed and computer aided crash reconstruction is undertaken where relevant and practicable. Further information on the crash is obtained through face to face interviews with consenting crash participants including personal details, driving experience and driver history (crashes and traffic offences), driving exposure, familiarity with the road and vehicle driven during the crash, trip details, possible distractions, alcohol and drug use, emotional and fatigue factors, pre-existing medical and physical conditions, perception of the crash and contributing factors, and clarification of the crash sequence including vehicle/pedestrian movements and positions.

When all the evidence has been collected, each case is reviewed by a multidisciplinary group of experienced CASR crash investigation staff to identify factors that contributed to the causation of the crash and the resulting injuries.

The study examined data for 240 young driver crashes from three in-depth studies recorded in three separate databases. These were the rural in-depth crash investigation database 1998-2000, the metropolitan in-depth crash investigation database 2002-2005 and the in-depth casualty crash investigation database 2006-2011. Note that the in-depth casualty crash study is currently active but only young driver crashes up to the end of 2009 were included in this study to ensure all cases were complete.

Crashes eligible for inclusion in the rural crash study were those occurring beyond the Adelaide metropolitan area but within 100km of the CBD for which an ambulance was called to attend. Crashes eligible for inclusion in the metropolitan crash study were those occurring within the Adelaide metropolitan area and for which there was ambulance transport of at least one crash participant. The most recent study included all crashes in the Adelaide metropolitan area and surrounding rural areas up to 100km from the CBD for which there was ambulance transport of at least one crash participant.

The case collection for all in-depth studies was most commonly conducted during standard office hours (daytime, weekdays). A proportion of case collection did occur outside of these times and hence the databases could not be said to be fully representative in that sense.

The study sample is comprised of 256 young drivers aged 16 to 24 years who were involved in a crash on South Australian roads that was investigated at-scene and in-depth by the CASR crash investigation team. The distribution of the young driver sample by age at the time of the crash for each in-depth database is shown in Table 2.1.

Overall, in the young driver sample there were 35 crashes resulting in a fatality (15%), 78 crashes (33%) requiring the admission to hospital of at least one crash participant, while the remaining 127 crashes (53%) resulted in injury severity levels ranging from non-injury to hospital treatment.

Table 2.1
Characteristics of young driver sample

In-depth crash investigation database	Young driver crashes	Drivers 16-19years	Drivers 20-24years	Total no. of young drivers
Rural study 1998-2000 (N=236 crashes)	93	53	46	99
Adelaide metropolitan study 2002-2005 (N=298 crashes)	93	40	60	100
Casualty crash study 2006-2009 (N=194 crashes)	54	35	22	57
Total	240	128	128	256

2.2 Classification of errors and contributing factors

The categorisation of human errors and factors contributing to young driver crashes in this study was based on the review of a number of different classification systems and taxonomies available in the literature, from both road transportation and other safety related areas (i.e. aviation). The following classification systems were reviewed:

- HFACS – Human Factors Analysis and Classification System (United States) (Wiegmann & Shappell, 2003)
- TRACE - Traffic Accident Causation in Europe (France) (van Elslande et al., 2008)
- DREAM – Driving Reliability and Error Analysis Method (Sweden) (Ljung, 2002)
- ACASS – Accident Causation Analysis with Seven Steps (Germany) (Pund, Otte, & Jansch, 2006)
- Crash Contributing Factors Taxonomy (United States) (Wierwille et al., 2002)
- Driver Error Causal Factors Taxonomy (United Kingdom) (Stanton & Salmon, 2009)

With respect to human factors, the analysis of errors in this study uses a system of classifying the errors into categories of perception, decision making or vehicle operation. This system of categorisation was first used by CASR for a case analysis of crashes investigated during the in-depth Adelaide metropolitan study 2002-2005 (Baldock et al., 2011).

The categorisation system is similar in some respects to the Accident Causation Analysis with Seven Steps (ACASS) method developed for use in the German In-Depth Accident Study (GIDAS) (Pund et al., 2006). The ACASS system analyses the response of the driver to a traffic conflict. The chain of events is divided into seven chronological steps: three steps of perception (visibility, observation, recognition), two steps of assessment (evaluation and planning), and two of action (selection and execution). Errors can be made at any of these steps, involving potential errors of visibility (visibility hampered), observation (inattentive), recognition (situation attended to but not taken in), evaluation (situation not recognised or misdiagnosed), planning (incomplete or faulty planning on basis of prior evaluation), action selection (action wrongly chosen or no choice made) and action execution (incorrect action or no action at all) (Pund et al., 2006).

The system used in this study retains some elements of the ACASS categorisation but also considers the decisions and actions taken by the driver that created the traffic conflict in the first place. The three

categories of perception errors are retained (visibility, observation, recognition), while other error types are classified as either decision-making errors or vehicle operation errors.

In addition to the human errors, other factors contributing to young driver crashes are also considered: condition of the driver, environmental factors and vehicle factors. These categories were derived from a synthesis of the classification systems reviewed however, the categories most closely resemble the TRACE system developed for crash investigation work in France (van Elslande et al., 2008) and the Crash Contributing Factors Taxonomy developed in the United States (Wierwille et al., 2002). Inadequate conditions in any of the three broad categories of contributing factors can potentially impact on road user behaviour such that driver errors are made. Each of these three broad factors can be further deconstructed to identify more specific contributing factors. A summary of each broad contributing factor group and specific factors is presented below:

1. Condition of the driver - The adverse condition of the driver involved including physiological state (e.g. temporary impairment due to alcohol, drugs, fatigue, or medical illness), mental state (e.g. emotionally upset, in a hurry), permanent physical or mental limitations (e.g. impaired vision, hearing, motor skills or cognitive capacity) and experience of the driver (e.g. unfamiliarity with the road, vehicle or conditions).

2. Environmental factors - The environmental conditions that can influence road user behaviour including road geometry or layout (e.g. poor road alignment, complex layout), road infrastructure (e.g. poor delineation, inadequate signage, unsealed shoulders), road maintenance or condition of the road surface (e.g. loose gravel, pot holes), obstruction of the road users view (e.g. parked vehicles, roadside vegetation), environmental conditions (e.g. adverse weather conditions affecting the road or visibility, unexpected hazard such as an animal) and conditions caused by other road users (e.g. unexpected road user behaviour, passenger effects).

While it might be argued that the behaviour of other road users and environmental conditions should be separated from road factors (i.e. infrastructure, geometry, maintenance), as is the case in the Stanton and Salmon (2009) taxonomy of causal factors, all of these factors are incorporated under ‘environmental factors’ in this study because it was felt that they are all part of the environment drivers must contend with during the driving task.

3. Vehicle factors - The deficient conditions of the vehicles used within the road transport system such as design features (e.g. poor user interface, low vehicle conspicuity), mechanical condition (e.g. brake or steering failure, bald tyres) and load related issues (e.g. unsecured or shifting).

Note that this list of driver errors and contributing factors is not a taxonomy of causes of crashes but more of a means of grouping similar causes and contributing factors to allow the presentation of relative frequencies. Statistical analyses were not the primary focus of the study although some simple statistics were used to characterise the sample.

Young driver behaviour leading to the crash was further categorised as either due to risk-taking or due to making a simple mistake or error. This distinction is loosely based on Reason et al’s (1990) broad classification of aberrant driver behaviour as due to either errors or violations. Risk-taking was defined in this study as behaviour leading to a crash that is deliberately unsafe and can be changed at will if the driver chooses to. The behaviour is intentional although the driver may or may not be aware that the behaviour is risky. Some examples of risk-taking behaviour include deliberately exceeding the speed limit, driving with an illegal BAC or dangerous overtaking. For example, a driver may have performed an unsafe overtaking manoeuvre where there is a solid white painted line (the overtaking itself was an intentional planned behaviour and it was risky). While in many cases the behaviour may

have been deliberately risky (e.g. the driver was impatient) in other cases the driver may have been unaware it was risky because they had limited experience in overtaking. Due to the difficulty in establishing a driver's awareness of whether a behaviour is perceived to be risky or not, even with detailed in-depth data, the definition of risk-taking behaviour in this study was based on the driver's actions rather than the driver's perception of the level of risk associated with their actions. Errors were defined as the unintentional failure of driver actions to achieve intended goals in response to a traffic conflict. For example, errors might occur when attempting complex tasks such as changing lanes on a busy multiple lane road or might be due to a lack of attention when driving.

2.3 Study procedure

In the present study, both human errors and factors contributing or causing the human errors were considered, based on a review of all the in-depth data collected for each crash. More than one human error and more than one contributing factor were assigned to a young driver where necessary. The causes of driver error were determined without consideration of legal culpability. If two young drivers were involved in a crash, they were counted individually.

One experienced researcher coded the driver errors and contributing factors for all young drivers in the sample to maintain consistency. A second experienced researcher reviewed a random sample of the cases (5%) to check the reliability of the researcher's assignment of errors and factors. The check revealed that there was 83.3% agreement between the two independent researchers' assessments of errors and contributing factors.

The designation of young driver behaviour as either due to risk-taking or errors was based on a review of all behaviours and factors contributing to the crash. In some cases driver behaviour in a crash could not be classified as either making an error or risk-taking and so these drivers were excluded from the analysis (i.e. driver behaviour did not contribute to the crash). While both types of behaviours may have contributed to a young driver crash, the behaviour deemed most critical to causing the crash was selected.

3 Results

The results from the analysis of the characteristics of young drivers and their crashes (Section 3.1) and driver errors and contributing factors (Section 3.2) are presented by firstly comparing age groups and then secondly by comparing drivers with different levels of driving experience. Sex differences in driver errors and contributing factors are also briefly examined. The final section of the analysis compares drivers who displayed risk-taking behaviour and those who made errors (Section 3.3).

Drivers were split into the age groups of 16-19 years and 20-24 years to reflect the usual demographic separation for this age range. With respect to driving experience, drivers who held a learner's permit or had been on their provisional licence for less than 12 months were compared to drivers who had held a provisional licence for 12 months or more or held a full driver's licence. Research indicates that crash rates for young drivers decrease significantly 6-12 months after provisional licensing with crashes before this point in time most likely due to inexperience (Kloeden, 2008). It is acknowledged that this is a proxy measure for driving experience as some drivers at the same licensing stage could have driven many more kilometres or spent much more time driving than other drivers. Data pertaining to the type of licence held by a young driver was obtained from the TRUMPS licensing system maintained by the Department for Transport, Energy and Infrastructure. Note that for 13 drivers, there were insufficient details to determine their level of driving experience.

The sample of crashes is not representative, therefore results give an indication of trends rather than the actual frequency of young driver characteristics, driver errors and contributing factors.

3.1 Characteristics of young drivers and their crashes

3.1.1 Analysis by young driver age

A total of 256 young drivers aged 16-24 years were involved in 240 crashes on South Australian roads over the study period. The characteristics of these drivers, and the vehicles they were driving when they crashed are shown in Table 3.1 by age group. The majority of drivers from both age groups were male. Chi-square statistical analyses indicated that drivers aged 16-19 years were more likely to be on a provisional licence while drivers aged 20-24 years were more likely to hold a full driver's licence. Note that the minimum age of provisional licensure and minimum period of time spent at each licensing stage has changed over the 12 year study period.

The majority of drivers from both age groups were driving a passenger car at the time of the crash but drivers aged 20-24 years were more likely to be driving other vehicle types such as four wheel drives, utilities or heavy vehicles. Drivers aged 16-19 years were more likely to be driving older vehicles aged 15 years and over. That is, 55% of drivers aged 16-19 years were driving vehicles in the 75th percentile of vehicles in the South Australian fleet. Figure 3.1 shows the distribution of vehicle age for young drivers in greater detail; the greatest proportion of drivers aged 16-19 years (27%) were driving vehicles aged 16-20 years when they crashed, while the greatest proportion of drivers aged 20-24 years (25%) were driving a vehicle aged 6-10 years. Around 6% of vehicles driven by young drivers in crashes were deemed to be 'high performance vehicles' according to the South Australian Government's definition (e.g. modified, turbo or V8 engine).

Drivers aged 16-19 years were more likely to be involved in a crash while carrying peer passengers in the vehicle, particularly two or more peer passengers, than drivers aged 20-24 years. Peer passengers were defined as passengers aged 16-24 years although most (91% of those whose age was known) passengers were aged under 21 years. While a similar proportion of drivers from both age

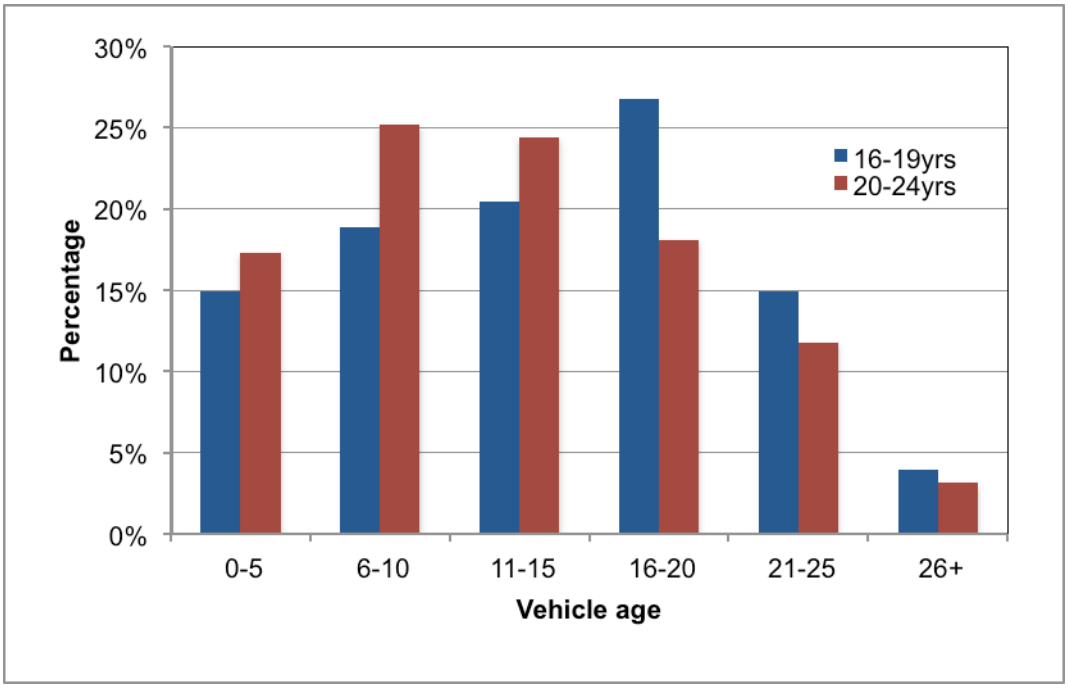
groups received fatal/serious injuries (28%), drivers aged 20-24 years were more likely to not incur any injuries in the crash compared to the youngest drivers.

Table 3.1
Demographic and vehicle characteristics of young drivers involved in crashes by age group

Characteristic	Age group (%)				
	16-19 yrs (N=128)	20-24 yrs (N=128)	Total (N=256)	X^2	*df*
Sex					
Male	62.5	64.1	162	0.07	1
Female	37.5	35.9	94		
Licence status					
Learner	1.6	-	2	162.78**	3
Provisional	89.5	9.5	125		
Full	7.9	85.7	118		
Unlicensed	1.6	4.8	8		
Vehicle type					
Passenger car	93.0	81.3	223	9.49*	3
4WD / SUV	0.8	5.5	8		
Utility / Van	5.5	9.4	19		
Heavy vehicle	0.8	3.9	6		
Age of vehicle *					
<15 years	45.3	58.3	132	4.29*	1
15 years +	54.7	41.7	123		
High performance vehicle					
No	94.0	93.7	228	0.01	1
Yes	6.0	6.3	15		
Number of peer passengers					
None	67.2	83.6	193	11.23**	2
One	18.8	12.5	40		
Two or more	14.1	3.9	23		
Injury severity					
Fatal	7.1	5.5	16	8.08*	3
Serious injury	21.3	22.0	55		
Minor injury	49.6	35.4	108		
No injury	22.0	37.0	75		

*p<.05, **p<.01

Figure 3.1
Distribution of age of vehicles driven by young drivers involved in crashes, by age group



The characteristics of the crashes in which this sample of young drivers were involved are presented in Table 3.2. In this sample of crashes, drivers aged 16-19 years were more likely to be involved in crashes in rural areas than drivers aged 20-24 years. Most of the young driver crashes in this study occurred during the day and on weekdays which most likely reflects the hours when crash investigation was undertaken. However drivers aged 16-19 years were more likely to have crashes on the weekend than older young drivers. With respect to crash type, drivers aged 16-19 years were more likely to be involved in a single vehicle crash than drivers aged 20-24 years; drivers aged 20-24 years were more likely to be involved in a collision with a pedestrian than the youngest drivers.

In terms of the road environment, young drivers aged 16-19 years were more likely to have crashed on a road with a speed limit of 70km/h or greater and on an undivided road compared to drivers aged 20-24 years.

Table 3.2
Crash characteristics of young drivers by age group

Characteristic	Age group (%)				
	16-19 yrs (N=128)	20-24 yrs (N=128)	Total (N=256)	X^2	*df*
Location					
Metro	35.9	50.0	110	5.17*	1
Rural	64.1	50.0	146		
Time of day					
Day	88.3	85.2	222	0.54	1
Night	11.7	14.8	34		
Day of week					
Weekday	82.0	93.0	224	7.00**	1
Weekend	18.0	7.0	32		
Crash type					
Pedestrian	2.4	11.7	18	11.99**	3
Single vehicle	37.8	24.2	79		
Multiple vehicle - Intersection	31.5	32.0	81		
Multiple vehicle - Midblock	28.3	32.0	77		
Speed limit of road					
60 km/h or less	38.3	52.3	116	5.11*	1
70km/h or more	61.7	47.7	140		
Road separation					
Undivided	72.7	57.8	167	6.22*	1
Divided	27.3	42.2	89		
Road surface					
Sealed	96.1	96.9	247	0.12	1
Unsealed	3.9	3.1	9		
Roadside shoulder					
Sealed	12.5	15.6	36	6.21	3
Unsealed	43.0	28.1	91		
Partial	1.6	1.6	4		
NA (inc. no shoulder)	43.0	54.7	125		

*p<.05, **p<.01

3.1.2 Analysis by young driver experience

The demographic and vehicle characteristics of the sample of young drivers involved in crashes are presented by level of driving experience in Table 3.3. Chi-square analysis revealed few statistically significant differences by driving experience. Young drivers with less experience (i.e. learner's permit or provisional licence for less than 12 months) were less likely to be driving a vehicle other than a passenger car (i.e. SUV, utility, heavy vehicle) at the time of the crash compared to young drivers with more experience (i.e. provisional licence for 12 months or longer or full driver's licence). Young drivers with less experience were also more likely to have peer passengers in the vehicle at the time of the crash compared to more experienced young drivers. Around 95% of their passengers (with a known age) were aged under 21 years. Both of these findings were observed when comparing age groups.

Table 3.3
Demographic and vehicle characteristics of young drivers involved in crashes by driving experience

Characteristic	Driving experience(%)				
	P-plates<1 yr (N=65)	P-plates≥1 yr (N=178)	Total (N=243)	X^2	*df*
Sex					
Male	58.5	64.6	153	0.77	1
Female	41.5	35.4	90		
Vehicle type					
Passenger car	98.5	82.0	210	11.45*	3
4WD / SUV	1.5	3.9	8		
Utility / Van	-	10.7	19		
Heavy vehicle	-	3.4	6		
Age of vehicle					
<15 years	44.6	54.2	125	1.76	1
15 years +	55.4	45.8	117		
High performance vehicle					
No	96.6	93.1	217	0.93	1
Yes	3.4	6.9	14		
Number of peer passengers					
None	61.5	82.6	187	12.35**	2
One	23.1	11.8	36		
Two or more	15.4	5.6	20		
Injury severity					
Fatal	6.2	5.7	14	0.4	3
Serious injury	23.1	19.9	50		
Minor injury	43.1	43.8	105		
No injury	27.7	30.7	72		

*p<.05, **p<.01

Table 3.4 shows the characteristics of the crashes in which young drivers were involved by driving experience. Statistical analyses indicate that young drivers with less experience were more likely to crash in rural areas than more experienced young drivers, similar to the findings by age group. Less experienced young drivers were also more likely to be involved in single vehicle crashes while more experienced young drivers were more likely to be involved in multiple vehicle crashes, particularly those at intersections.

With respect to the road environment, young drivers with less experience were more likely to crash on a road with a speed limit of 70km/h or greater and on an undivided road compared to young drivers with more driving experience.

Table 3.4
Crash characteristics of young drivers by driving experience

Characteristic	Driving experience (%)				
	P-plates<1 yr (N=65)	P-plates≥1 yr (N=178)	Total (N=243)	X^2	*df*
Location					
Metro	27.7	48.9	105	8.71**	1
Rural	72.3	51.1	138		
Time of day					
Day	90.8	86.0	212	0.99	1
Night	9.2	14.0	31		
Day of week					
Weekday	86.2	88.2	213	0.19	1
Weekend	13.8	11.8	30		
Crash type					
Pedestrian	6.3	7.9	18	8.92*	3
Single vehicle	45.3	25.8	75		
Multiple vehicle - Intersection	21.9	35.4	77		
Multiple vehicle - Midblock	26.6	30.9	72		
Speed limit of road					
60 km/h or less	32.3	48.9	108	5.29*	1
70km/h or more	67.7	51.1	135		
Road separation					
Undivided	81.5	59.6	159	10.18**	1
Divided	18.5	40.4	84		
Road surface					
Sealed	95.4	96.6	234	0.21	1
Unsealed	4.6	3.4	9		
Roadside shoulder					
Sealed	10.8	14.0	32	7.01	3
Unsealed	49.2	30.9	87		
Partial	1.5	1.7	4		
NA (inc. no shoulder)	38.5	53.4	120		

*p<.05, **p<.01

3.2 Driver errors and contributing factors

The driver error status for young drivers involved in a crash is displayed in Table 3.5 by age group and level of driving experience. A driver error was identified for 73% of young drivers in the study. Around 25% of young drivers were not assigned a driver error and this assignment was independent of legal culpability. For six young drivers, there was not enough information to determine specific driver errors or significant contributing factors. These six cases were omitted from subsequent analyses. As mentioned previously, the level of driving experience for 13 drivers could not be determined (i.e. unlicensed *n*=8, interstate licence *n*=2, unknown *n*=3). These drivers were excluded from all subsequent analyses by level of driving experience.

Table 3.5
Driver error status for young drivers involved in crashes by age group and driving experience

	Age group			Driving experience		
	16-19 yrs	20-24 yrs	Total (N)	P-plates<1 yr	P-plates≥1 yr	Total (N)
Driver error	104	82	186	55	120	175
No error	22	42	64	8	54	62
Unable to determine	2	4	6	2	4	6
Total (N)	128	128	256	65	178	243

In the following tables 90 (48%) drivers were assigned more than one error and 85 (46%) drivers were assigned more than one contributing factor that resulted in a crash.

3.2.1 Analysis by young driver age

Table 3.6 shows the distribution of driver errors in young driver crashes by driver age group: 16-19 years and 20-24 years. Overall, the most common young driver errors were decision making errors (62%), followed by vehicle operation errors (51%) and perception errors (43%: 20% observation, 7% recognition, 16% visibility). The most common specific errors were inadequate directional control (36%), excessive speed (22%), speeding for conditions (11%) and misjudgement of gap/speed (10%). Of the errors related to inadequate directional control, 27 involved over-correcting, under-steering or over-steering the vehicle on a curve, 17 involved over-correcting on a straight section of road and the remaining 23 were attributable to a loss of control in response to specific conditions such as a wet road or tyre puncture, or as a result of driver behaviour such as quick acceleration after making a right turn.

Statistical analyses indicated that there were no differences between the five broad categories of driver error by driver age group ($X^2(4)=3.62$, $p=.460$). The most common specific driver errors among the youngest drivers (aged 16-19 years) were inadequate directional control (40%), excessive speed (23%) and speeding for conditions (15%) while for drivers aged 20-24 years the most common errors were inadequate directional control (31%), excessive speed (20%) and misjudgement of gap/speed (15%).

Table 3.6
Distribution of driver errors in young driver crashes by age group

Driver errors	Age group (%)		
	16-19 yrs (N=104)	20-24 yrs (N=82)	Total (N=186)
Perception: Observation (Total)	*17.3*	*23.2*	*37*
Competition for attention	1.0	1.2	2
Distraction in & out of vehicle	9.6	8.6	17
Fail to look	2.9	1.2	4
Inattention	-	6.1	5
Observation incomplete	3.8	6.1	9
Perception: Recognition (Total)	*5.8*	*8.5*	*13*
Delayed cognitive processing	2.9	1.2	4
Look but don't see	2.9	7.3	9
Perception: Visibility (Total)	*13.5*	*19.5*	*30*
Vision obscured by environment	5.8	12.2	16
Vision obscured - person related	7.7	7.3	14
Decision making (Total)	*62.5*	*61.0*	*115*
Close following	1.9	1.2	3
Dangerous overtaking	3.8	3.7	7
Excessive speed	23.1	19.5	40
False assumption	5.8	3.7	9
Improper manoeuvre	2.9	3.7	6
Impulsive decision	1.9	3.7	5
Misjudgement of gap/speed	6.7	14.6	19
Recklessness/racing	1.0	4.9	5
Speeding for conditions	15.4	6.1	21
Vehicle operation (Total)	*55.8*	*43.9*	*94*
Fail to take appropriate avoidance action	2.9	3.7	6
Inadequate directional control	40.3	30.5	67
Panic	5.8	2.4	8
Poor/wrong technique	1.9	-	2
Vehicle positioning	4.8	7.3	11

Note: Percentages sum to greater than 100 because multiple factors could be coded per driver.

Factors contributing to young driver errors in crashes are presented in Table 3.7 by age group. When comparing the broad categories of driver, environmental and vehicle factors, analysis indicated that there was no statistically significant difference by age group ($X^2(2)=2.48$, $p=.289$). Overall, the most common factors contributing to young driver behaviour resulting in a crash were the behaviour of other road users (25%) and the impaired physiological state of the driver (22%). The most problematic specific behaviour was responding to the unexpected behaviour of other road users such as pedestrians (*n*=9), motorcycle riders (*n*=2) and other traffic (*n*=29) (e.g. perceived to be travelling over the centre line, slow moving or stationary on the road, sudden change of lanes).

The most frequent contributing factors for drivers aged 16-19 years were driver physiological state (26%) and road infrastructure (26%) particularly unsealed shoulders, followed by driver experience (18%) particularly unfamiliarity with the road. For drivers aged 20-24 years, the most frequent contributing factors were other road user behaviour (35%), particularly unexpected behaviour, environmental conditions (26%), particularly unexpected hazards and wet road conditions, and driver physiological state (17%).

Table 3.7
Distribution of contributing factors in young driver crashes by age group

	Contributing factors	Age group (%)		
		16-19 yrs (N=104)	20-24 yrs (N=82)	Total (N=186)
Driver	*Physiological state (Total)*	*26.0*	*17.1*	*41*
	Alcohol	7.7	3.7	11
	Drugs	4.8	2.4	7
	Fatigue	9.6	7.3	16
	Medical illness	3.8	3.7	7
	Mental state (Total)	*3.8*	*4.9*	*8*
	Mood/emotional distraction	2.9	2.4	5
	In a hurry	1.0	1.2	2
	Suicidal tendencies	-	1.2	1
	Experience (Total)	*18.3*	*15.9*	*32*
	Unfamiliar with road	11.5	7.3	18
	Unfamiliar with vehicle	3.8	4.9	8
	Unfamiliar with conditions	2.9	3.7	6
Environment	*Road geometry (Total)*	*11.5*	*11.0*	*21*
	Layout	5.8	3.7	9
	Alignment	5.8	3.7	9
	Width	-	3.7	3
	Road infrastructure (Total)	*26.0*	*11.0*	*36*
	Road delineation	2.9	-	3
	Signage	5.8	2.4	8
	Unsealed shoulder	16.3	8.5	24
	Signal sequence	1.0	-	1
	Road maintenance (Total)	*4.8*	*3.7*	*8*
	Debris on road	1.9	3.7	5
	Loose gravel	1.9	-	2
	Worn out road markings	1.0	-	1
	View obstructed (Total)	*11.5*	*15.9*	*25*
	Other traffic	4.8	9.8	13
	Parked vehicle	-	1.2	1
	Sight distance	4.8	2.4	7
	Vegetation	1.9	2.4	4
	Conditions (Total)	*14.4*	*25.6*	*36*
	Unexpected hazard	4.8	11.0	9
	Wet road condition	8.7	11.0	18
	Visibility limited	1.0	3.7	4
	Other road users (Total)	*16.3*	*35.4*	*46*
	Unexpected road user behaviour	11.5	34.1	40
	Passenger effects	4.8	1.2	6
Vehicle	*Design (Total)*	*5.8*	*2.4*	*8*
	Conspicuity	4.8	1.2	6
	High performance vehicle	1.0	-	1
	Tinted windows	-	1.2	1
	Load (Total)	-	*1.2*	*1*
	Shifting, uneven	-	1.2	1
	Mechanical condition (Total)	*5.8*	*8.5*	*13*
	Brakes	1.0	3.7	4
	Tyres	4.8	3.7	8
	Poor maintenance	-	1.2	1

Note: Percentages sum to greater than 100 because multiple factors could be coded per driver.

3.2.2 Analysis by young driver experience

A summary of driver errors resulting in young driver crash involvement is shown in Table 3.8 by level of driving experience: learner's permit or provisional licence held for less than one year (P-plates <1 year) and provisional licence held for one year or more or full licence (P-plates ≥1 year). When comparing the five broad driver error categories, statistical analysis indicated that less experienced young drivers were more likely to make vehicle operation errors (71% vs. 43%) and less likely to make perception errors involving visibility (7% vs. 21%) compared to more experienced drivers ($X^2(4)=10.59$, $p=.032$).

The most common specific driver errors for less experienced drivers were inadequate directional control (55%), excessive speed (24%) and speeding for conditions (20%). More experienced drivers most frequently made errors involving inadequate directional control (29%), excessive speed (20%), misjudgement of gaps or speed (12%) and failure to account for vision obscured by the environment (12%).

Table 3.8
Distribution of driver errors in young driver crashes by driving experience

Driver errors	Driving experience (%)		
	P-plates<1 yr (N=55)	P-plates≥1 yr (N=120)	Total (N=175)
Perception: Observation (Total)	*16.4*	*21.7*	*35*
Competition for attention	-	1.7	2
Distraction in and out of vehicle	12.7	8.3	17
Fail to look	1.8	2.5	4
Inattention	-	3.3	4
Observation incomplete	1.8	6.7	9
Perception: Recognition (Total)	*5.5*	*8.3*	*13*
Delayed cognitive processing	1.8	2.5	4
Look but don't see	3.6	5.0	8
Total Perception: Visibility (Total)	*7.3*	*20.8*	*29*
Vision obscured by environment	3.6	11.7	16
Vision obscured - person related	3.6	9.2	13
Decision making (Total)	*65.5*	*56.7*	*104*
Close following	3.6	0.8	3
Dangerous overtaking	1.8	4.2	6
Excessive speed	23.6	20.0	37
False assumption	3.6	5.8	9
Improper manoeuvre	3.6	2.5	5
Impulsive decision	-	2.5	3
Misjudgement of gap/speed	7.3	11.7	18
Recklessness/racing	1.8	1.7	3
Speeding for conditions	20.0	7.5	20
Vehicle operation (Total)	*70.9*	*42.5*	*90*
Fail to take appropriate avoidance action	1.8	4.2	6
Inadequate directional control	54.5	28.5	64
Panic	3.6	5.0	8
Poor/wrong technique	1.8	0.8	2
Vehicle positioning	9.1	4.2	10

Note: Percentages sum to greater than 100 because multiple factors could be coded per driver.

Table 3.9 shows the distribution of contributing factors that resulted in young driver crash involvement by level of driving experience. Analysis of the broad categories of driver, environmental and vehicle factors, indicates that there was no difference by level of driving experience ($X^2(2)=0.98$, $p=.613$).

The most common factors contributing to less experienced young driver involvement in crashes were road infrastructure (36%) particularly unsealed shoulders, other road user behaviour (18%), driver experience (18%) such as unfamiliarity with the road, and environmental conditions (15%) particularly wet roads. In contrast, the most common factors contributing to the crash involvement of more experienced young drivers were other road user behaviour (28%) particularly unexpected behaviour, driver physiological state (25%), and environmental conditions (22%) such as unexpected hazards.

Table 3.9
Distribution of contributing factors in young driver crashes by driving experience

	Contributing factors	Driving experience (%)		
		P-plates<1 yr (N=55)	P-plates≥1 yr (N=120)	Total (N=175)
Driver	*Physiological state (Total)*	*12.7*	*25.0*	*37*
	Alcohol	1.8	7.5	10
	Drugs	1.8	4.2	6
	Fatigue	5.5	9.2	14
	Medical illness	3.6	4.2	7
	Mental state (Total)	*3.6*	*3.3*	*6*
	Mood/emotional distraction	3.6	2.5	5
	In a hurry	-	-	-
	Suicidal tendencies	-	0.8	1
	Experience (Total)	*18.2*	*16.7*	*30*
	Unfamiliar with road	9.1	10.0	17
	Unfamiliar with vehicle	3.6	4.2	7
	Unfamiliar with conditions	5.5	2.5	6
Environment	*Road geometry (Total)*	*12.7*	*10.8*	*20*
	Layout	3.6	5.0	8
	Alignment	9.1	3.3	9
	Width	-	2.5	3
	Road infrastructure (Total)	*36.4*	*12.5*	*35*
	Road delineation	1.8	1.7	3
	Signage	7.3	2.5	7
	Unsealed shoulder	25.5	8.3	24
	Signal sequence	1.8	-	1
	Road maintenance (Total)	*5.5*	*3.3*	*7*
	Debris on road	1.8	3.3	5
	Loose gravel	3.6	-	2
	Worn out road markings	-	-	-
	View obstructed (Total)	*9.1*	*15.8*	*24*
	Other traffic	1.8	10.0	13
	Parked vehicle	-	-	-
	Sight distance	5.5	3.3	7
	Vegetation	1.8	2.5	4
	Conditions (Total)	*14.5*	*22.5*	*35*
	Unexpected hazard	1.8	10.0	9
	Wet road condition	12.7	9.2	18
	Visibility limited	-	3.3	4
	Other road users (Total)	*18.2*	*28.3*	*44*
	Unexpected road user behaviour	10.9	28.3	40
	Passenger effects	7.3	-	4
Vehicle	*Design (Total)*	*1.8*	*5.8*	*8*
	Conspicuity	1.8	4.2	6
	High performance vehicle	-	0.8	1
	Tinted windows	-	0.8	1
	Load (Total)	-	*0.8*	*1*
	Shifting, uneven	-	0.8	1
	Mechanical condition (Total)	*9.1*	*6.7*	*13*
	Brakes	-	3.3	4
	Tyres	9.1	2.5	8
	Poor maintenance	-	0.8	1

Note: Percentages sum to greater than 100 because multiple factors could be coded per driver.

3.2.3 Analysis by sex

A summary of driver errors and contributing factors (broad categories only) in young driver crashes is presented in Table 3.10 by driver sex. While there was no overall statistically significant difference by driver sex for driver errors ($X^2(4)=9.01$, $p=.061$), there was a clear trend for males to make more decision making errors than females (71% vs. 41%) and females to make more vehicle operation errors than males (59% vs. 43%).

Contributing factors involving the driver, environment and vehicle did not differ significantly by driver sex ($X^2(2)=1.22$, $p=.543$). Closer inspection of sub categories suggests that the physiological state of drivers was a more common contributing factor among males (26%) than females (13%).

Table 3.10
Driver errors and contributing factors in young driver crashes by driver sex

Driver errors and contributing factors	Driver sex (%)	
	Male (N=122)	Female (N=70)
Driver errors		
Perception: Observation	16.4	21.4
Perception: Recognition	7.4	8.6
Perception: Visibility	15.6	15.7
Decision making	70.5	41.4
Vehicle operation	43.4	58.6
Contributing factors		
Driver		
Physiological state	26.2	12.9
Mental state	2.5	7.1
Experience	17.2	15.7
Environment		
Road geometry	10.7	11.4
Road infrastructure	31.1	41.4
Road maintenance	2.5	7.1
View obscured	14.8	10.0
Environmental conditions	19.7	17.1
Other road users	25.4	21.4
Vehicle		
Design	4.9	2.9
Load	0.8	-
Mechanical condition	6.6	7.1

Note: Percentages sum to greater than 100 because multiple factors could be coded per driver.

3.3 Risk-taking and errors

182 of the 256 young drivers in this study were identified as displaying behaviour leading to the crash which was categorised as either error/mistake (n=128, 70%) or risk-taking (n=54, 30%) .The behaviour of the remaining 74 drivers either did not involve making a mistake or risk-taking (i.e. the driver did not make an error that lead to the crash *n*=67), the driver had a medical condition that was the principal cause of the crash (i.e. loss of consciousness *n*=6) or the crash was intentional (i.e. suicide attempt *n*=1).

The demographic and vehicle characteristics of young drivers involved in crashes by categorisation of their behaviour leading to the crash (i.e. mistake/error or risk taking) are presented in Table 3.11. Statistical analyses indicated that young drivers with behaviour characterised as risk taking were more likely to be male than young drivers characterised as making an error. Young drivers who exhibited risk-taking behaviour were more likely to be driving a high performance vehicle and to have peer passengers in the vehicle than young drivers who made errors. Indeed 20% of risk-taking young drivers had two or more peer passengers in the vehicle compared to 7% of young drivers who made errors. Young drivers who took risks were more likely to be more severely injured in the crash than young drivers who made errors.

Of interest, age group and level of driving experience were not related to the young driver behavioural categories leading to the crash.

Table 3.11
Demographic and vehicle characteristics of young drivers by behaviour leading to a crash

Characteristic	Driver behaviour (%)				
	Errors (N=128)	Risk-taking (N=54)	Total (N=182)	X^2	*df*
Sex					
Male	56.3	79.6	115	8.92**	1
Female	43.8	20.4	67		
Age group					
16-19 years	53.1	59.3	100	0.58	1
20-24 years	46.9	40.7	82		
Driving experience					
P-plates <1 year	29.8	36.2	54	0.63	1
P-plates ≥1 year	70.2	63.8	117		
Vehicle type					
Passenger car	85.2	92.6	159	3.25	3
4WD / SUV	4.7	-	6		
Utility / Van	8.6	5.6	14		
Heavy vehicle	1.6	1.9	3		
Age of vehicle					
<15 years	59.1	46.3	100	2.50	1
15 years +	40.9	53.7	81		
High performance vehicle					
No	96.7	85.4	159	7.27**	1
Yes	3.3	14.6	11		
Number of peer passengers					
None	79.7	57.4	133	10.63**	2
One	13.3	22.2	29		
Two or more	7.0	20.4	20		
Injury severity					
Fatal	6.3	11.1	14	20.99**	3
Serious injury	16.7	46.3	46		
Minor injury	49.2	29.6	78		
No injury	27.8	13.0	42		

*p<.05, **p<.01

Table 3.12 shows crash characteristics associated with young driver risk taking or erroneous behaviour leading to a crash. Young drivers who exhibited risk-taking behaviour were more likely to crash at night time and on weekends than young drivers who made an error that lead to a crash. There were no other statistically significant differences by young driver behaviour related to the crash.

Table 3.12
Crash characteristics of young drivers by behaviour leading to a crash

Characteristic	Driver behaviour (%)				
	Errors (N=128)	Risk-taking (N=54)	Total (N=182)	X^2	*df*
Location					
Metro	35.2	35.2	64	<0.01	1
Rural	64.8	64.8	118		
Time of day					
Day	90.6	74.1	156	8.50**	1
Night	9.4	25.9	26		
Day of week					
Weekday	89.1	77.8	156	3.95*	1
Weekend	10.9	22.2	26		
Crash type					
Pedestrian	3.9	5.6	8	3.10	3
Single vehicle	39.8	40.7	73		
Multiple vehicle - Intersection	29.7	18.5	48		
Multiple vehicle - Midblock	26.6	35.2	53		
Speed limit of road					
60 km/h or less	38.3	40.7	71	0.10	1
70km/h or more	61.7	59.3	111		
Road separation					
Undivided	71.9	74.1	132	0.09	1
Divided	28.1	25.9	50		
Road surface					
Sealed	96.1	96.3	175	0.01	1
Unsealed	3.9	3.7	7		
Roadside shoulder					
Sealed	14.1	16.7	27	2.16	3
Unsealed	39.1	44.4	74		
Partial	1.6	3.7	4		
NA (inc. no shoulder)	45.3	35.2	77		

*p<.05, **p<.01

Young driver errors by behaviour leading to a crash are presented in Table 3.13. Young drivers who made errors were significantly more likely to make perceptual errors (observation, recognition and visibility) compared to drivers who exhibited risk taking behaviour ($X^2(4)=45.35$ $p<.001$) while risk-takers were much more likely to make decision making errors. The most common specific driver errors among those who made mistakes were inadequate directional control (32%), speeding for the conditions (13%) and misjudgement of gap/speed (13%). In contrast, the most common errors among young drivers who exhibited risk-taking behaviour were excessive speed (72%), inadequate directional control (46%) and dangerous overtaking (13%).

Table 3.13
Distribution of driver errors by young driver behaviour leading to a crash

Driver errors	Driver behaviour (%)	
	Errors (N=128)	Risk-taking (N=54)
Perception: Observation (Total)	*25.0*	*7.4*
Competition for attention	1.6	-
Distraction in and out of vehicle	11.7	3.7
Fail to look	2.3	1.9
Inattention	2.3	1.9
Observation incomplete	7.0	-
Perception: Recognition (Total)	*9.4*	*1.9*
Delayed cognitive processing	3.1	-
Look but don't see	6.3	1.9
Perception: Visibility (Total)	*17.2*	*3.7*
Vision obscured by environment	10.2	1.9
Vision obscured - person related	7.0	1.9
Decision making (Total)	*38.3*	*120.4*
Close following	1.6	1.9
Dangerous overtaking	-	13.0
Excessive speed	0.8	72.2
False assumption	5.5	3.7
Improper manoeuvre	3.1	1.9
Impulsive decision	1.6	5.6
Misjudgement of gap/speed	12.5	5.6
Recklessness/racing	-	9.3
Speeding for conditions	13.3	7.4
Vehicle operation (Total)	*50.0*	*51.9*
Fail to take appropriate avoidance action	3.1	1.9
Inadequate directional control	32.0	46.4
Panic	6.3	-
Poor/wrong technique	1.6	-
Vehicle positioning	7.0	3.7

Note: Percentages sum to greater than 100 because multiple factors could be coded per driver.

Table 3.14 shows contributing factors leading to young driver crashes by driver behaviour. Analysis by broad contributing factors (driver, environment and vehicle) revealed that there was no statistically significant difference by driver behaviour ($X^2(2)=4.00$ $p=.135$).

The most common contributing factors for young drivers who performed risk taking behaviour leading to the crash were impairment by physiological factors (32%) particularly alcohol, conditions caused by other road users (22%), and coping with road infrastructure issues (20%) particularly unsealed shoulders. For young drivers who displayed erroneous behaviour, the most common factors contributing to the crash were related to lack of driver experience (21%) such as unfamiliarity with the road, environmental factors (20%) such as wet roads, and dealing with other road user behaviour (19%), particularly unexpected behaviour.

Table 3.14
Distribution of contributing factors by young driver behaviour leading to a crash

	Contributing factors	Driver behaviour (%)	
		Errors (N=128)	Risk-taking (N=54)
Driver	*Physiological state (Total)*	*12.5*	*31.5*
	Alcohol	-	20.4
	Drugs	0.8	7.4
	Fatigue	11.7	1.9
	Medical illness	-	1.9
	Mental state (Total)	*3.1*	*5.6*
	Mood/emotional distraction	3.1	1.9
	In a hurry	-	3.7
	Experience (Total)	*21.1*	*9.3*
	Unfamiliar with road	13.3	1.9
	Unfamiliar with vehicle	3.1	7.4
	Unfamiliar with conditions	4.7	-
Environment	*Road geometry (Total)*	*12.5*	*5.6*
	Layout	5.5	3.7
	Alignment	4.7	1.9
	Width	2.3	-
	Road: infrastructure (Total)	*16.4*	*20.4*
	Road delineation	2.3	-
	Signage	3.1	5.6
	Unsealed shoulder	10.9	14.8
	Road: maintenance (Total)	*6.3*	-
	Debris on road	3.9	-
	Loose gravel	1.6	-
	Worn out road markings	0.8	-
	View obstructed (Total)	*7.8*	*1.9*
	Other traffic	2.3	-
	Sight distance	3.9	-
	Vegetation	1.6	1.9
	Conditions (Total)	*19.5*	*9.3*
	Unexpected hazard	7.0	3.7
	Wet road condition	10.2	5.6
	Visibility limited	2.3	-
	Other road users (Total)	*18.8*	*22.2*
	Unexpected road user behaviour	18.0	13.0
	Passenger effects	0.8	9.3
Vehicle	*Design (Total)*	*3.9*	*1.9*
	Conspicuity	3.1	-
	High performance vehicle	-	1.9
	Tinted windows	0.8	-
	Load (Total)	*0.8*	-
	Shifting, uneven	0.8	-
	Mechanical condition (Total)	*7.0*	*3.7*
	Brakes	1.6	-
	Tyres	4.7	3.7
	Poor maintenance	0.8	-

Note: Percentages sum to greater than 100 because multiple factors could be coded per driver.

4 Discussion

The present study using in-depth crash investigation data adds to the limited body of research examining young driver behaviour and the circumstances leading to crash involvement. Based on the findings from this research, measures that might reduce the number of young driver crashes and moderate the injury severity of such crashes are discussed with reference to Safe System principles.

4.1 Characteristics of young drivers and their crashes

Young and less experienced drivers were more likely to be involved in single vehicle crashes and crashes that occurred in rural areas, on undivided roads and on roads with higher speed limits than slightly older and more experienced young drivers. Drivers aged 16-19 years were also more likely to be driving older vehicles and to be involved in crashes on weekends compared to drivers aged 20-24 years. These findings suggest that there are potentially a number of areas that could be addressed to reduce young driver crashes due to both age and lack of experience. For example, in the case of single vehicle crashes, particularly in rural areas and where there are higher speed limits, sealing roadside shoulders and providing barrier protection in combination with clear zones around roadside objects (see Doecke & Woolley, 2010) could potentially prevent some loss of control crashes and also mitigate the consequences of such crashes.

In addition, young drivers should be encouraged to drive newer vehicles with safety features that are not available in older vehicles and can prevent crashes (e.g. electronic stability control, collision avoidance systems) or reduce the severity of a crash (e.g. airbags).

Interestingly, both young and inexperienced drivers were much more likely to have peer passengers in the vehicle when they crashed than older and more experienced drivers. The presence of peer passengers is known to increase crash risk and decrease driving performance among young drivers (e.g. Chen, Baker, Braver, & Li, 2000; Simons Morton, Lerner, & Singer, 2005). Passenger restrictions have been introduced as part of graduated licensing systems in other countries (i.e. United States, Canada and New Zealand) where they have been associated with a 5 to 38% reduction in young driver crashes. Peer passenger restrictions have also been introduced in Victoria, New South Wales and Queensland in various forms where they typically allow no more than one peer passenger aged under 21 years to be travelling with a provisional driver during the P1 phase.

The age of vehicle occupants other than the driver is not recorded in police reports in South Australia unless they were injured. Therefore, findings from this study provide one of the best indicators of the number of young driver crashes in South Australia involving peer passengers. While this study does not incorporate a representative sample, the findings suggest that for drivers who have had a provisional licence for less than 12 months (i.e. P1 phase) around 15% of crashes involved more than one passenger aged under 21 years (37% involved any passengers aged under 21 years) that might have been avoided if passenger restrictions were introduced in South Australia.

4.2 Errors and contributing factors

Driver errors have previously been reported as a major factor in fatal and non-fatal young driver crashes however this study examined the specific driver errors that resulted in young driver crash involvement. Around 73% of young drivers in the study were assigned a driver error, independent of legal culpability for the crash. This finding is consistent with other studies that have reported young drivers committed errors in three quarters of serious crashes (Curry et al., 2011) or were at-fault in

non-fatal crashes (Braitman et al., 2008). Together these findings suggest young driver over-involvement in errors leading to crashes.

Overall, the most frequent errors resulting in young driver crashes were decision making errors followed by vehicle operation errors and errors relating to perception. In terms of specific errors, the most common errors within the sample were inadequate directional control (36%), travelling at excessive speed (22%), speeding for the conditions (11%) and misjudgement of gap/speed (10%). An error involving poor directional control typically involved a driver losing control of the vehicle after travelling onto an unsealed shoulder on either a curve or straight section of road or losing control in response to wet conditions or debris on the road.

Analyses by age group and level of experience were undertaken to determine whether the incidence of specific driver errors varied over the first few years of driving and could account for the substantial decline in crashes during that period. Similar to McKnight and McKnight's (2003) study, findings from this study failed to identify any differences in driver errors by age group. However, dividing young drivers by level of experience based on their level of progression within the licensing process revealed some interesting findings. Less experienced drivers made more vehicle operation errors, particularly failing to adequately control the vehicle, than more experienced young drivers. Overall, more experienced drivers most frequently made decision making errors but relative to less experienced drivers, they made more perception errors relating to visibility or observation.

Collectively, these findings support existing research that suggests vehicle control skills appear to increase rapidly with experience while perceptual and decision making or cognitive skills take more time to develop. For example, crash data from newly licensed South Australian drivers involved in casualty crashes found "hit fixed object" (i.e. loss of control) crashes declined sharply after the first 6 to 12 months on a provisional licence (Kloeden, 2008). Catchpole et al. (1998) analysed Victorian casualty crash data from police crash reports and found drivers aged 18 to 20 years were more likely to be over-represented in single vehicle "off path" crashes than those aged 21 to 25 years. Lane departure warning devices and electronic stability control (ESC) are potential technological solutions to mitigate vehicle operation errors.

A higher prevalence of speeding, particularly excessive speed, was reported in this study compared to other studies investigating young driver crashes. The advantage of using in-depth data in the present study is that many cases were reconstructed using computer simulations to determine travelling speeds. Studies relying purely on the incidence of 'excessive speed' in police crash reports or self-disclosure of speeding behaviour during interviews are likely to provide an underestimate of the true level of speeding activity. Note that in the present study, there were a number of cases for which it was not possible to undertake reconstructions mainly due to insufficient information. Therefore, some driver errors involving low level speeding may not have been identified resulting in a small degree of underestimation.

With respect to contributing factors, analyses by the broad categories of driver, environment and vehicle factors indicated that there were no significant differences by age group, level of experience or sex. These findings suggest that measures targeting the most common factors contributing to young driver crashes identified in this study might be beneficial for all young drivers regardless of age or experience. Overall the most common factors contributing to young driver crashes were responses to the behaviour of other road users, the physiological impairment of drivers, environmental conditions and road infrastructure.

Young drivers' failure to cope with conflicts created by other road users, particularly the unexpected actions of other road users, was identified in Catchpole et al's (1998) earlier study of casualty crash

data. In line with the findings from this study, the previous study also found no difference between young driver age groups for these types of crashes, suggesting that coping with other road users unexpected behaviour requires skills that take time to develop. Closer analysis of driver errors associated with these specific young driver crashes in the present study revealed a number of difficulties experienced by young drivers. In ten cases the driver made perceptual errors in which they either failed to observe the potential conflict, did not recognise the unexpected behaviour in time to respond to it or were distracted. In a further 4 cases the driver was unable to anticipate the road user's behaviour because their view was obstructed by an environmental factor. In 17 cases the difficulty was not due to perception but decision making in response to the conflict. For eight of these cases the driver was travelling at excessive speed, meaning that there was probably insufficient time to initiate a response. In six cases the driver misjudged either the time or space required to avoid the conflict and in three cases the driver made a false assumption about the behaviour of the other road user.

Interestingly, fatigue was the most commonly identified physiological state found to impair young drivers in this study, even more so than alcohol. Indeed impairment by fatigue was identified more frequently as a contributing factor in the present study (8.6%) compared to similar studies investigating young driver behaviour in crashes (i.e. Braitman, et al (2008) 3%; McKnight and McKnight (2003) 1.7%). The higher level of impairment by fatigue identified in the present study might be attributed to the detailed evidence-based information collected during at-scene in-depth crash investigation and subsequent self-disclosure during interviews. In contrast, few people are likely to admit to police that they fell asleep or were fatigued while driving therefore police reported data is likely to underestimate the role of fatigue in crashes. Nevertheless, findings from this study are consistent with other research that indicates fatigue is a significant risk factor for all young drivers disregarding their age and level of skills. Research from New South Wales reported that among young drivers of nearly all license status and across all ages, the risk of crash injury due to fatigue increased by more than two times when compared with drivers who were not fatigued (Lam, 2003). Night time driving restrictions have the potential to address fatigue at night time but it is not clear how daytime fatigue might be addressed by a graduated licensing system (Ferguson, 2003). An alternative solution for the future is vigilance monitoring systems that observe drivers eyes and provides a warning if eyes are off the road for too long.

In terms of environmental factors and road infrastructure, young drivers experienced the greatest difficulty in negotiating wet road conditions and maintaining control when travelling on unsealed shoulders. New technology such as electronic stability control (ESC) might be beneficial for avoiding loss of control on slippery roads due to wet weather conditions and prevent departures from traffic lanes onto unsealed shoulders. Programs to seal roadside shoulders are a system-wide approach that can be beneficial for all drivers.

For the broadly-based driver error categories and contributing factors, there were no statistically significant differences by sex. However there was a trend for males to make more decision based errors such as speeding and to be associated with factors that impaired their physiological state, compared to females, consistent with findings reported in other studies examining driver errors (Braitman et al., 2008; Curry et al., 2011; McKnight & McKnight, 2003). However, these other studies reported females committed more errors due to poor search and detection skills than males while in the present study females tended to make more vehicle operation errors compared to males.

4.3 Risk-taking and errors

There is a strong perception amongst the public that young driver crashes are primarily due to risk-taking behaviour. Clarke et al. (2005) concluded from their analysis of four types of young driver crashes gleaned from police reports that crashes were most frequently the result of risk-taking

behaviours rather than skill deficits. In contrast, the results from this study support and extend an increasing, yet still limited, body of research that show the majority (70%) of young driver behaviour leading to crashes were not primarily caused by risk-taking behaviour but due to young drivers making errors in which they failed to use routine safe operating practices (Curry et al., 2011; McKnight & McKnight, 2003).

Young drivers who exhibited risk-taking behaviour were more likely to be male, drive a high performance vehicle, have peer passengers in the vehicle and be more seriously injured in the crash than young drivers displaying erroneous behaviour that resulted in a crash. These factors have previously been associated with risk-taking behaviour in the literature (e.g. Laapotti & Keskinen, 2004; Simons Morton et al., 2005) although the link between high performance vehicles and risk-taking behaviour is more tenuous. Crashes involving risk-taking behaviour were also more likely to occur at night and on weekends compared to crashes involving simple errors. Clarke et al. (2005) also found risk taking behaviour more common at night time, suggesting that it was the purposes for which young drivers are on the road and the manner in which they drive that is the reason for greater crash involvement at night rather than darkness per se (i.e. less visibility).

Young drivers classified as participating in risk-taking behaviour made significantly more decision making errors than young drivers displaying erroneous behaviour, particularly driving at excessive speed and undertaking dangerous overtaking manoeuvres. Young drivers who made errors that resulted in a crash were significantly more likely to make errors related to perception, particularly errors related to observation, than drivers who displayed risk taking behaviour.

In-vehicle technology also offers potential system-wide solutions to reduce young driver errors due to both risk-taking and simple mistakes and to mitigate the consequences of these errors. Intelligent speed adaptation systems (ISA) that inform the driver of the current speed limit and may also advise or prevent the driver from exceeding the speed limit are a potential solution to reduce the incidence of excessive speed. A recent Australian report estimated that if ISA was implemented on young drivers' vehicles over 20 years, a 3-17% reduction in injury crashes might be expected when accounting for the over-representation of young drivers in speed related crashes (Doecke & Woolley, 2011). Auto-take systems could prevent dangerous overtaking by using sensors to detect gaps in traffic and execute an overtaking manoeuvre without intervention from the driver (various levels of automation would be possible) (see Stanton & Salmon, 2009). With respect to driver errors involving perception (observation, recognition and visibility), collision sensing and avoidance systems could be advantageous. Such systems can detect and warn the driver of other vehicles or even pedestrians that are likely to cross the projected path of the vehicle. Stanton and Salmon (2009) point out that the effectiveness of new technologies is dependent on the design of unambiguous interfaces that can clearly communicate the status of the system and does not create the possibility of new driver errors.

The most frequent contributing factors for risk-takers were attributable to physiological impairment, especially by alcohol. A policy of alcohol interlocks in all vehicles could provide a system wide approach to preventing drink driving but presents many practical and economic problems. In contrast, behaviours relating to a lack of experience such as unfamiliarity with the road, environmental conditions particularly wet roads, and the behaviour of other road users were the biggest factors contributing to the crashes of young drivers who made simple mistakes. These factors are suggestive that young drivers had some difficulty in coping with unexpected and unfamiliar conditions. Accruing more driving experience in different environmental conditions while being supervised (e.g. different types of roads, driving in wet conditions) might be useful for reducing the impact of these factors but creating a safer, more forgiving environment that accounts for these human errors is likely to be the most beneficial.

4.4 Limitations

The unique nature of in-depth at-scene crash investigation methodology permits the collection of detailed evidence-based information on individual drivers, their errors and other contributing factors that lead to crash involvement. However, there are some limitations associated with this study. The sample of young drivers involved in crashes is not representative, therefore results give an indication of trends or general orders of magnitude rather than the actual frequency of young driver characteristics, driver errors and contributing factors.

The sample used in this study also included fewer night time crashes (13.3%) in comparison to the number reported to police during the same period (34.5%, Source: TARS database). Therefore it is possible that our sample differs systematically in terms of the types of crashes that might be expected in a representative sample, for example, there may be fewer young driver crashes involving alcohol, crashes that are more likely to occur at night.

The assignment of errors and contributing factors was subjective but this may have been mitigated to some extent by the consistency of one experienced researcher reviewing all of the cases. In addition, as part of the crash investigation process all cases were reviewed by a multidisciplinary team of experienced crash investigators to determine causation factors.

4.5 Further research

This study was largely exploratory in providing a basic analysis of the errors and contributing factors that have resulted in young driver crash involvement over the last decade while considering factors such as age, level of experience, gender and contrasting risk-taking behaviour with erroneous behaviour. Specific measures that might further reduce young driver crashes were suggested based on the findings of the frequencies of errors and behaviours. Further investigation of the data could examine the interaction between driver errors and contributing factors and answer specific questions about subsets of young driver behaviour or crashes (e.g. single vehicle crashes, drivers exceeding the speed limit).

While it was not within the scope of this study, future research could examine the driving history (crashes and traffic offences) of this sample of young drivers to further understand the context in which these young driver crashed and whether their crash involvement had any impact on subsequent driving behaviour.

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