In-depth analysis of crashes involving younger drivers

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Abstract

Young drivers aged 16 to 24 years are over-represented in crashes worldwide. A better understanding of young driver behaviour and the circumstances leading to crash involvement might assist in reducing young driver road trauma. The Centre for Automotive Safety Research (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 detailed information on crashes that otherwise could not be obtained from aggregate police-reported crash data. This paper uses 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 (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 time. Detailed information for 256 drivers aged between 16 and 24 years was examined to identify behaviours contributing to young driver crash involvement. Based on the findings from the analysis, 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.

Keywords: Young driver; crash investigation; crash causation

1. Introduction

1.1. Young driver crashes

In spite of improvements in road safety, young drivers 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/riders killed and 26% of drivers/riders seriously injured in road crashes (TARS database[1]). In addition, 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 probable 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. A recent study (Kloeden, 2008) examined a large sample of young South Australian drivers and found a sharp increase in crashes immediately after obtaining a provisional licence followed by a decrease in crashes after 6 to 12 months with continued reductions thereafter; a finding consistent with research from other countries (e.g. Mayhew, Simpson, & Pak, 2003). The results were suggestive of the importance of driving experience but 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 established from the aggregate police recorded data.

A US study (McKnight & McKnight, 2003) examining behaviour contributing to novice driver (16-17 years) non-fatal crashes was unable to identify any subsets of behaviours in which novice drivers were over-represented. The authors conceded that larger differences might

[1] TARS - Traffic Accident Reporting System

have been attained if the analysis accounted for the amount of actual driving experience rather than being age-based. Furthermore, the study relied on making inferences about driver behaviour from narrative crash descriptions in police reports.

Other research has also used crash data from police reports to understand the factors contributing to young driver crashes (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. Sandin (2009) argues that police-reported crash data are not appropriate for analyses of crash causation because police are primarily concerned with assigning legal responsibility for the crash and the data are simplified and standardised. Some studies supplement police crash data with interviews from participating drivers (e.g. Braitman et al., 2008). However, interview data can be subject to poor recall and socially desirable responses.

In-depth at-scene investigation of crashes provides a rich source of detailed evidence-based information on individual crashes and gives valuable insight into specific risk factors and their interaction, which otherwise would not be identifiable from the examination of aggregate police crash data. While in-depth case studies cannot be expected to be representative, they are still important for providing information that is unattainable by other means (Grayson & Hakkert, 1987). A recent study used data obtained from at-scene crash investigation to investigate 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). However, 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 is clearly lacking. Previous studies have focused on the youngest drivers and have not considered whether different subsets of behaviours might contribute to the variation in crash involvement rates by age group and level of driving experience.

1.2. Identifying causes and contributing factors

The majority of road crashes are usually 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 assigned per crash. Consequently, these crash reporting systems are susceptible to over-simplifying complex crash events.

Systems that attempt to classify the causes of crashes predominantly 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 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 errors. For instance, a driver that fails to give way may have had their vision obstructed (human error: perception/visibility error) due to a large parked vehicle (contributing factor: environmental). A review of the literature and current crash studies found that many crash causation classification systems used across Europe did not separate human errors from the factors which lead to these failures (van Elslande, Naing, & Engel, 2008).

To obtain a greater understanding of the specific factors that lead to young driver crash involvement, this paper uses information from the Centre for Automotive Safety Research's (CASR) in-depth at-scene crash investigations to examine the causes and contributing factors leading to young driver crashes. The use of in-depth data allows the causes of young driver crashes to 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 paper investigates whether there are any differences in driver errors and contributing factors

leading to crashes between these two age groups. This paper also addresses 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.

2. Method

This paper examined young driver crashes from three in-depth studies investigating rural and metropolitan crashes in South Australia undertaken by CASR over the 12 year period 1998-2009.

2.1. CASR in-depth crash investigation

CASR's 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 of the crash scene, crash involved vehicles are inspected and a survey of the crash location is undertaken 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 each 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 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 practical. Further information is obtained through face to face interviews with consenting crash participants and witnesses 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, alcohol and drug use, possible distractions, 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. Case collection is most commonly conducted during standard office hours (daytime, weekdays) although a proportion of case collection can occur outside these times. Therefore, the sample of crashes is not fully representative. 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.

2.2. Classification of errors and contributing factors

The categorisation of human errors and factors contributing to young driver crashes in the present study was based on the review of several different classification systems from road transportation and other safety related areas (i.e. Human Factors Analysis and Classification System, Wiegmann & Shappell, 2003; Traffic Accident Causation in Europe, van Elslande et al., 2008; Driving Reliability and Error Analysis Method, Ljung, 2002; Accident Causation Analysis with Seven Steps, Pund, Otte, & Jansch, 2006; Crash Contributing Factors Taxonomy, Wierwille et al., 2002; Driver Error Causal Factors Taxonomy, 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 (visibility, observation, recognition), decision making or vehicle operation. This system of categorisation has previously been used by CASR for a case analysis of crashes (Baldock et al., 2011). The categorisation system is similar in some respects to the Accident Causation Analysis with Seven Steps method (Pund et al., 2006), which analyses the response of the driver to a traffic conflict.

However, the system used in this paper also considers the decisions and actions taken by the driver that created the traffic conflict in the first place.

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. Inadequate conditions in any of the three broad categories can potentially impact on road user behaviour resulting in driver errors. Each of these three broad factors was further deconstructed into more specific contributing factors (see Table 4).

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

2.3. Study procedure

Based on a review of all the in-depth data collected for each crash, both human errors and factors contributing to the human errors were considered. More than one human error and more than one contributing factor were designated 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 assigned 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 coding. The check revealed 83% agreement between the two independent researchers' assessments.

For the analyses, drivers were split into two age groups (16-19 years, 20-24 years). For driving experience, drivers who held a learner's permit or had their provisional licence for less than 12 months (P-plates<1yr) were compared to drivers who had held a provisional licence for 12 months or more or held a full driver's licence (P-plates≥1yr). It is acknowledged that this is a proxy measure for driving experience as some drivers at the same licensing stage could have driven more kilometres or spent more time driving than other drivers.

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

3. Results

3.1. Characteristics of young drivers and their crashes

In this sample, 256 young drivers aged 16-24 years were involved in 240 crashes on South Australian roads over the 12 year study period. Around 15% of crashes resulted in a fatality, 33% required admission to hospital for at least one crash participant, while the remaining 53% resulted in injury severity levels ranging from non-injury to hospital treatment.

The characteristics of the drivers and the vehicles they were driving when they crashed are shown in **Table 1** by age group and driving experience. 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 changed over the 12 year study period. The majority of drivers involved in a crash were male but there were no gender differences by age group or driving experience.

The crashes of younger and less experienced drivers were more likely to involve the carrying of peer passengers in the vehicle, particularly two or more peer passengers, than the crashes of slightly older and more experienced drivers. Peer passengers were defined as

passengers aged 16-24 years although most (93% of those whose age was known) passengers were aged under 21 years.

Table 1: Demographic and vehicle characteristics of young drivers involved in crashes by age group and driving experience

Characteristic	Age group (%)				Driving experience(%)			
	16-19 yrs (N=128)	20-24 yrs (N=128)	Total (N=256)	X^2	P-plates<1 yr (N=65)	P-plates≥1 yr (N=178)	Total (N=243)	X^2
Sex								
Male	62.5	64.1	162	0.07	58.5	64.6	153	0.77
Female	37.5	35.9	94		41.5	35.4	90	
Licence status								
Learner	1.6	-	2	162.78**				
Provisional	89.5	9.5	125					
Full	7.9	85.7	118					
Unlicensed	1.6	4.8	8					
Number of peer passengers								
None	67.2	83.6	193	11.23**	61.5	82.6	187	12.35**
One	18.8	12.5	40		23.1	11.8	36	
Two or more	14.1	3.9	23		15.4	5.6	20	
Vehicle type								
Passenger car	93.0	81.3	223	9.49*	98.5	82.0	210	11.45*
4WD / SUV	0.8	5.5	8		1.5	3.9	8	
Utility / Van	5.5	9.4	19		-	10.7	19	
Heavy vehicle	0.8	3.9	6		-	3.4	6	
Age of vehicle *								
<15 years	45.3	58.3	132	4.29*	44.6	54.2	125	1.76
15 years +	54.7	41.7	123		55.4	45.8	117	
High performance vehicle								
No	94.0	93.7	228	0.01	96.6	93.1	217	0.93
Yes	6.0	6.3	15		3.4	6.9	14	

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

Younger and less experienced drivers 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 the slightly older and more experienced drivers. 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). Of interest, 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.

The characteristics of the crashes in which this sample of young drivers were involved are presented in **Table 2**. Most of the young driver crashes occurred during the day and on weekdays which most likely reflects the hours when crash investigation was undertaken. However drivers aged 16-19 years had more crashes on the weekend than older young drivers.

With respect to crash type, younger and less experienced drivers were more likely to be involved in single vehicle crashes. Drivers aged 20-24 years were more likely to be involved in a collision with a pedestrian than their younger counterparts while more experienced young drivers were more likely to be involved in multiple vehicle crashes, particularly those at intersections, compared to less experienced drivers.

In terms of the road environment, the crashes of younger and less experienced drivers were more likely to be in rural areas, on roads with higher speed limits (70km/h or greater) and on undivided roads than the crashes of slightly older and more experienced young drivers.

Table 2: Crash characteristics of young drivers by age group and driving experience

Characteristic	Age group (%)				Driving experience(%)			
	16-19 yrs (N=128)	20-24 yrs (N=128)	Total (N=256)	X^2	P-plates<1 yr (N=65)	P-plates≥1 yr (N=178)	Total (N=243)	X^2
Location								
Metro	35.9	50.0	110	5.17*	27.7	48.9	105	8.71**
Rural	64.1	50.0	146		72.3	51.1	138	
Time of day								
Day	88.3	85.2	222	0.54	90.8	86.0	212	0.99
Night	11.7	14.8	34		9.2	14.0	31	
Day of week								
Weekday	82.0	93.0	224	7.00**	86.2	88.2	213	0.19
Weekend	18.0	7.0	32		13.8	11.8	30	
Crash type								
Pedestrian	2.4	11.7	18	11.99**	6.3	7.9	18	8.92*
Single vehicle	37.8	24.2	79		45.3	25.8	75	
Multi vehicle: Intersection	31.5	32.0	81		21.9	35.4	77	
Multi vehicle :Midblock	28.3	32.0	77		26.6	30.9	72	
Speed limit of road								
60 km/h or less	38.3	52.3	116	5.11*	32.3	48.9	108	5.29*
70km/h or more	61.7	47.7	140		67.7	51.1	135	
Road separation								
Undivided	72.7	57.8	167	6.22*	81.5	59.6	159	10.18**
Divided	27.3	42.2	89		18.5	40.4	84	

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

3.2. Driver errors and contributing factors

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. A total of 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. For six young drivers, there was not enough information to determine specific driver errors or contributing factors. These six cases were omitted from subsequent analyses. The level of driving experience for 13 drivers could not be determined (i.e. unlicensed n=8, interstate licence n=2, unknown n=3) so these drivers were excluded from all following analyses by level of driving experience.

Table 3 shows the distribution of driver errors in young driver crashes by driver age group and driving experience. 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). Statistical analyses comparing the five broad driver error categories by driving experience revealed 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 ($X^2(4)=10.59$, $p=.032$). 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 younger and less experienced drivers were inadequate directional control (40%, 55%, respectively), excessive speed (23%, 24%) and speeding for conditions (15%, 20%). Of all 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 segment of road and the remaining 23 were due 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.

Table 3: Distribution of driver errors in young driver crashes by age group and driving experience

Driver errors	Age group (%)		Driving experience [a] (%)		
	16-19 yrs (N=104)	20-24 yrs (N=82)	P-plates<1 yr (N=55)	P-plates≥1 yr (N=120)	Total (N=186)
Perception: Observation (Total)	*17.3*	*23.2*	*16.4*	*21.7*	*37*
Competition for attention	1.0	1.2	-	1.7	2
Distraction in & out of vehicle	9.6	8.6	12.7	8.3	17
Fail to look	2.9	1.2	1.8	2.5	4
Inattention	-	6.1	-	3.3	5
Observation incomplete	3.8	6.1	1.8	6.7	9
Perception: Recognition (Total)	*5.8*	*8.5*	*5.5*	*8.3*	*13*
Delayed cognitive processing	2.9	1.2	1.8	2.5	4
Look but don't see	2.9	7.3	3.6	5.0	9
Perception: Visibility (Total)	*13.5*	*19.5*	*7.3*	*20.8*	*30*
Vision obscured by environment	5.8	12.2	3.6	11.7	16
Vision obscured - person related	7.7	7.3	3.6	9.2	14
Decision making (Total)	*62.5*	*61.0*	*65.5*	*56.7*	*115*
Close following	1.9	1.2	3.6	0.8	3
Dangerous overtaking	3.8	3.7	1.8	4.2	7
Excessive speed	23.1	19.5	23.6	20.0	40
False assumption	5.8	3.7	3.6	5.8	9
Improper manoeuvre	2.9	3.7	3.6	2.5	6
Impulsive decision	1.9	3.7	-	2.5	5
Misjudgement of gap/speed	6.7	14.6	7.3	11.7	19
Recklessness/racing	1.0	4.9	1.8	1.7	5
Speeding for conditions	15.4	6.1	20.0	7.5	21
Vehicle operation (Total)	*55.8*	*43.9*	*70.9*	*42.5*	*94*
Fail to take appropriate avoidance action	2.9	3.7	1.8	4.2	6
Inadequate directional control	40.3	30.5	54.5	28.5	67
Panic	5.8	2.4	3.6	5.0	8
Poor/wrong technique	1.9	-	1.8	0.8	2
Vehicle positioning	4.8	7.3	9.1	4.2	11

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

[a] 13 cases are missing.

To a slightly lesser extent, older and more experienced drivers also most frequently made errors involving inadequate directional control (31%, 29%, respectively) and excessive speed (20%, 20%). However, older and more experienced drivers also frequently made errors of misjudgement of gaps or speed (15%, 12%, respectively) and failed to account for vision obscured by environmental factors (12%, 12%).

Factors contributing to young driver errors in crashes are presented in **Table 4** by age group and driving experience. When comparing the broad categories of driver, environmental and vehicle factors, analyses indicated that there were no statistically significant differences by age group ($X^2(2)=2.48$, $p=.289$) or level of driving experience ($X^2(2)=0.98$, $p=.613$).

Overall, the most common factors contributing to young driver crash involvement 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).

Table 4: Distribution of contributing factors in young driver crashes by age group and driving experience

	Contributing factors	Age group (%)		Driving experience [a] (%)		
		16-19 yrs (N=104)	20-24 yrs (N=82)	P-plates<1 yr (N=55)	P-plates≥1 yr (N=120)	Total (N=186)
Driver	*Physiological state (Total)*	*26.0*	*17.1*	*12.7*	*25.0*	*41*
	Alcohol	7.7	3.7	1.8	7.5	11
	Drugs	4.8	2.4	1.8	4.2	7
	Fatigue	9.6	7.3	5.5	9.2	16
	Medical illness	3.8	3.7	3.6	4.2	7
	Mental state (Total)	*3.8*	*4.9*	*3.6*	*3.3*	*8*
	Mood/emotional distraction	2.9	2.4	3.6	2.5	5
	In a hurry	1.0	1.2	-	-	2
	Suicidal tendencies	-	1.2	-	0.8	1
	Experience (Total)	*18.3*	*15.9*	*18.2*	*16.7*	*32*
	Unfamiliar with road	11.5	7.3	9.1	10.0	18
	Unfamiliar with vehicle	3.8	4.9	3.6	4.2	8
	Unfamiliar with conditions	2.9	3.7	5.5	2.5	6
Environment	*Road geometry (Total)*	*11.5*	*11.0*	*12.7*	*10.8*	*21*
	Layout	5.8	3.7	3.6	5.0	9
	Alignment	5.8	3.7	9.1	3.3	9
	Width	-	3.7	-	2.5	3
	Road infrastructure (Total)	*26.0*	*11.0*	*36.4*	*12.5*	*36*
	Road delineation	2.9	-	1.8	1.7	3
	Signage	5.8	2.4	7.3	2.5	8
	Unsealed shoulder	16.3	8.5	25.5	8.3	24
	Signal sequence	1.0	-	1.8	-	1
	Road maintenance (Total)	*4.8*	*3.7*	*5.5*	*3.3*	*8*
	Debris on road	1.9	3.7	1.8	3.3	5
	Loose gravel	1.9	-	3.6	-	2
	Worn out road markings	1.0	-	-	-	1
	View obstructed (Total)	*11.5*	*15.9*	*9.1*	*15.8*	*25*
	Other traffic	4.8	9.8	1.8	10.0	13
	Parked vehicle	-	1.2	-	-	1
	Sight distance	4.8	2.4	5.5	3.3	7
	Vegetation	1.9	2.4	1.8	2.5	4
	Conditions (Total)	*14.4*	*25.6*	*14.5*	*22.5*	*36*
	Unexpected hazard	4.8	11.0	1.8	10.0	9
	Wet road condition	8.7	11.0	12.7	9.2	18
	Visibility limited	1.0	3.7	-	3.3	4
	Other road users (Total)	*16.3*	*35.4*	*18.2*	*28.3*	*46*
	Unexpected road user behaviour	11.5	34.1	10.9	28.3	40
	Passenger effects	4.8	1.2	7.3	-	6
Vehicle	*Design (Total)*	*5.8*	*2.4*	*1.8*	*5.8*	*8*
	Conspicuity	4.8	1.2	1.8	4.2	6
	High performance vehicle	1.0	-	-	0.8	1
	Tinted windows	-	1.2	-	0.8	1
	Load (Total)	*-*	*1.2*	*-*	*0.8*	*1*
	Shifting, uneven	-	1.2	-	0.8	1
	Mechanical condition (Total)	*5.8*	*8.5*	*9.1*	*6.7*	*13*
	Brakes	1.0	3.7	-	3.3	4
	Tyres	4.8	3.7	9.1	2.5	8
	Poor maintenance	-	1.2	-	0.8	1

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

[a] 13 cases are missing.

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 inexperience (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, and environmental conditions (26%), predominantly unexpected hazards and wet road conditions.

Similar to the youngest drivers, the most common factors contributing to crash involvement for less experienced drivers included road infrastructure (36%), particularly unsealed shoulders, and driver inexperience (18%) such as unfamiliarity with the road. In contrast, the most common contributing factors for more experienced drivers were other road user behaviour (28%) particularly unexpected behaviour, driver physiological state (25%), and environmental conditions (22%) such as unexpected hazards.

4. Discussion

4.1. Characteristics of young drivers and their crashes

Consistent with previous findings, the crashes of younger and less experienced drivers were more likely to involve a single vehicle and occur in rural areas, on roads with higher speed limits and on undivided roads than the crashes of slightly older and more experienced young drivers (e.g. Clarke, Ward, Bartle, & Truman, 2006). Drivers aged 16-19 years were also more likely to be involved in crashes on weekends and to be driving older vehicles compared to drivers aged 20-24 years.

There are a number of system-wide measures that could reduce the incidence of young driver crashes due to both age and inexperience. 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 could potentially prevent some loss of control crashes and also mitigate the consequences of such crashes (see Doecke & Woolley, 2010). Young drivers should also be encouraged to drive newer vehicles with the latest safety features that can prevent crashes (e.g. electronic stability control, collision avoidance systems) or reduce the severity of a crash (e.g. airbags).

Of interest, both younger and less experienced 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). Peer passenger restrictions are part of graduated licensing systems in other countries where they have been associated with a 5-38% reduction in young driver crashes. Passenger restrictions have also been introduced in some Australian jurisdictions 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 only recorded in South Australian police reports if they are injured. Consequently findings from this study provide one of the best estimates of the number of young driver crashes involving peer passengers. While this study is not comprised of 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

Around 73% of young drivers were assigned a driver error independent of legal culpability for the crash. This finding is consistent with other studies that 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). Collectively, these findings imply young driver over-involvement in errors leading to 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 period. Findings from this study failed to identify any differences in driver errors by age group, consistent with McKnight and McKnight's (2003) study. However, separating 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 (e.g. Catchpole, Macdonald, & Cairney, 1998; Kloeden, 2008). 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). Electronic stability control (ESC) and lane departure warning devices are potential technological solutions to mitigate vehicle operation errors.

In comparison to other research investigating young driver crashes, a higher prevalence of speeding was identified. This was most likely because the in-depth data assisted in determining many travelling speeds via computer reconstructions. Studies relying purely on the incidence of 'excessive speed' in police reports or self-disclosure of speeding behaviour during interviews are likely to result in an underestimate of the true level of speeding. 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.

In terms of contributing factors, analyses by the broad categories of driver, environment and vehicle factors indicated that there were no significant differences by age group or level of driving experience. Consequently, measures targeting the most common factors contributing to young driver crashes identified in this paper might be beneficial for all young drivers regardless of age or experience. 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, is consistent with the findings of an earlier study using Victorian casualty crash data (Catchpole et al., 1998). Both studies 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. More detailed analysis of the driver errors associated with these specific crashes in this 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 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 the environment. In 17 cases the difficulty was attributable to decision making in response to the conflict. For eight of these cases the driver was travelling at excessive speed so there was probably insufficient time to respond, for six cases the driver misjudged either the time or space needed to avoid the conflict and for 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 of impairment and was reported more frequently as a contributing factor in the present study (8.6%) compared

to similar studies investigating young driver behaviour (i.e. Braitman, et al, 2008: 3%; McKnight and McKnight, 2003: 1.7%). The higher prevalence of impairment by fatigue might be attributable to the detailed information collected during in-depth crash investigation and self-disclosure during interviews. In contrast, few drivers are likely to admit they were fatigued to police, resulting in the likely underestimation of fatigue in police reported data. Nevertheless, findings from this study are consistent with research that suggests fatigue is a significant risk factor for all young drivers regardless of their age and level of skills (Lam, 2003), possibly due to lifestyle factors (see Groeger, 2006). While night time driving restrictions have the potential to address fatigue at night, it is not clear how daytime fatigue might be addressed by a graduated licensing system (Ferguson, 2003). An alternative solution is vigilance monitoring systems that provide a warning if drivers' eyes are off the road for too long.

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

5. Conclusions

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 driver age and level of experience. 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.

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).

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