

Novice Drivers' Risky Driving Behavior, Risk Perception, and Crash Risk: Findings From the DRIVE Study

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The overrepresentation of youths in crashes involving casualties is a significant public health issue in most high-income countries.^{1,2} As a result, prevention of crashes by novice drivers is a key focus for many jurisdictions, policy-makers, and researchers. The introduction of graduated driver licensing, which gradually introduces full driving privileges for novice drivers, has brought about significant reductions in crashes, particularly in settings where more stringent conditions such as restrictions on passenger numbers and night driving have been introduced.^{3,4} Research on novice drivers' risky behaviors and risk perceptions is crucial to understanding how this initiative can be improved or how complementary interventions can be developed.

There is much to be learned about the impact of novice drivers' risky driving and how it is associated with their increased risk of crash. Recent research confirms that certain risky driving behaviors are more prevalent among younger drivers than older drivers, especially among men.⁵⁻¹² These include high-level speeding and speeding for the thrill of it,^{6,11,13-16} following too closely to the vehicle ahead,⁵ violating traffic rules,⁹ not using seatbelts,¹⁷⁻¹⁹ using mobile phones while driving²⁰⁻²² (including text messaging^{23,24}), driving during high-risk nighttime hours,^{2,25,26} and driving older vehicles.^{14,27,28}

In addition, certain driving behaviors have been demonstrated to be of higher risk for young novice drivers than for experienced adult drivers; these include carrying peer passengers or multiple passengers^{2,29-32} and driving under the influence of alcohol, even at low concentrations.^{26,33,34}

Paradoxically, given higher levels of risk taking, young drivers are often found to be more aware of driving risks than drivers of other age groups, particularly regarding alcohol,^{18,35-39} although young males tend to have poorer perceptions of risk than females.^{6,35,37,39-41}

Objectives. We explored the risky driving behaviors and risk perceptions of a cohort of young novice drivers and sought to determine their associations with crash risk.

Methods. Provisional drivers aged 17 to 24 (n=20822) completed a detailed questionnaire that included measures of risk perception and behaviors; 2 years following recruitment, survey data were linked to licensing and police-reported crash data. Poisson regression models that adjusted for multiple confounders were created to explore crash risk.

Results. High scores on questionnaire items for risky driving were associated with a 50% increased crash risk (adjusted relative risk=1.51; 95% confidence interval=1.25, 1.81). High scores for risk perception (poorer perceptions of safety) were also associated with increased crash risk in univariate and multivariate models; however, significance was not sustained after adjustment for risky driving.

Conclusions. The overrepresentation of youths in crashes involving casualties is a significant public health issue. Risky driving behavior is strongly linked to crash risk among young drivers and overrides the importance of risk perceptions. Systemwide intervention, including licensing reform, is warranted. (*Am J Public Health*. 2009;99:1638-1644. doi:10.2105/AJPH.2008.150367)

Nonetheless, young people who undertake or are exposed to risky driving behaviors tend also to perceive driving risks as low.^{15,35,39,42} In a prevalence study conducted recently in Australia, McEvoy et al. reported that those who reported mobile phone use while driving regarded a range of risky driving practices as significantly less dangerous than those who did not report phone use.⁴³

Young people's risk perceptions, however, can be dependent on context. For example, although speeding per se or under usual conditions is typically viewed as risky,^{6,39} speeding on a clear, dry day is not.⁶ Driving fast because one is in a hurry is considered not as risky as driving fast to test a car's speed, whereas racing other cars ranks among the highest perceived risks.³⁵ Likewise, studies have found that the general public considers only small excess rates of speed (64 km/h in a 60-km/h zone and 105 km/h in a 100-km/h zone) to be acceptable¹⁸ but that high school students of driving age accept higher speeds: in one study, one quarter of students accepted 70 km/h or more in a 60-km/h zone as safe and one quarter accepted

120 km/h or more in a 100-km/h zone as safe if conditions were good.³⁷ In another study, when asked how much over a 60 km/h speed limit a driver would have to be going to be considered "stupid," young drivers reported a significantly higher speed threshold than older drivers, but there were no differences in reported thresholds for a driver to be considered "irresponsible" or "criminal."⁶

Differences in young drivers' perceptions of other risks have also been found. For example, ratings of perceived risk have increased from very low when peer passengers are in the car to higher ratings when passengers have been drinking alcohol, smoking marijuana, or are not wearing seatbelts to highest ratings when passengers are trying to get the driver to speed or are acting wild.³⁵ Regarding driving while using a mobile phone, hands-free use has been considered less risky than manual use^{18,44} and answering a call, dialing, or text messaging as more risky than talking on a phone.^{35,45}

Such findings raise questions about whether risk perception and risky driving behaviors are

strongly related and whether either is directly associated with crashes. Few recent studies of novice drivers have explored these issues, particularly the utility of either risk perception or risky driving behaviors for predicting the risk of a crash. An earlier study conducted in Australia found that self-reported risky driving behaviors were linked to increased risk of crashes in the first year of driving, but this study did not examine the impact of risk perception on crash risk.⁴⁶ Our aim was to explore the risky driving behaviors and risk perceptions of a cohort of young, newly licensed drivers and to determine the associations between these factors and crash risk.

METHODS

The DRIVE Study is a prospective, Web-based cohort study of young drivers in the state of New South Wales, Australia, for which detailed methods have been previously reported.⁴⁷ Briefly, all drivers resident in New South Wales aged 17 to 24 holding a first-stage provisional motor vehicle license between June 2003 and December 2004 were invited to participate in the study. This provisional license is the first license allowing unsupervised driving. At the time of the study, drivers holding this license could have no alcohol in the bloodstream and could drive no faster than 90 km/h, and all New South Wales drivers were restricted from manual use of mobile phones. All respondents gave consent for their survey data to be linked prospectively to data held by the state jurisdictional authority, the Roads and Traffic Authority of New South Wales, including information about licensing test attempts and police-reported crashes.

Crash records were obtained for the 10-year period from January 1, 1996 to December 31, 2005. In New South Wales, according to the Road Transport Act 1999, a crash must be reported to police when any person is killed or injured, when there is damage of over Aust\$500 to property other than the vehicles concerned, when drivers involved in the crash do not exchange insurance and contact information, when one or more of the drivers is reported to be driving under the influence of alcohol, or if a vehicle involved in the crash is towed away.

The DRIVE Study questionnaire contained questions on demographic information, driving

experience and training on the provisional license, self-ratings of driving ability, and average weekly driving hours (the main measure of driving exposure).⁴⁷ The questionnaire also included 14 items regarding risky driving behaviors (Table 1) and 10 items regarding risk perceptions (Table 2) that were adapted from previous research.^{48,49} For risky behavior items, participants were asked, "How often do you [engage in a particular behavior]?" possible responses and corresponding scores were: very often=4, often=3, sometimes=2, hardly ever=1, and never=0; the total score range was 0 to 56. For risk perception items, participants were asked, "When you are driving, how safe do you think the following are?", with response options and scores as follows: always safe=3, mostly safe=2, sometimes safe=1, and rarely safe=0; the total score range was 0 to 30. Higher scores on the scales thus represent more risky driving behavior and more risky perception (poorer perceptions of safety). The summative scores for risky driving behaviors and risk perception were categorized into tertiles (low, medium, and high).

Participants were assured that all information was confidential and that identifying information would not be stored or used in conjunction with the questionnaire responses.

Statistical Analyses

The primary outcome variable, a driver's number of police-reported crashes, was categorized as 0 or as 1 or more crashes during follow-up. Exposure variables were risky driving behaviors and risk perceptions. The number and proportion of participants who reported that they "very often" or "often" undertook each risky driving behavior were calculated. A similar approach was used to determine number and proportion of responses to each risk perception as "always safe" or "mostly safe." Differences by gender for each factor in risky driving behavior and risk perception scales were examined with the χ^2 test.

We analyzed data by using summative scores for risky driving behaviors and risk perception categorized into tertiles (low, medium, and high) and applying a Poisson regression model to determine relative risks (RRs) and 95% confidence intervals (CIs), including stratification by gender. Relative risks were preferred because of

the prospective design and because other methods did not improve the fit of the data. An offset for time in the study was included to account for the different periods between the time a participant entered the study and the end date of crash data analyzed (i.e., crashes through December 31, 2005 were analyzed for all participants irrespective of when they joined the study). Poisson models were found to fit data appropriately ($P=0.9$, by the χ^2 test for goodness-of-fit for adjusted model with all covariates). All analyses were conducted with SAS version 9.1 (SAS Institute Inc, Cary, North Carolina).

Confounding variables were identified from the literature and included in the adjusted regression models if they were significantly ($P<.2$) associated with the outcome measure (a crash) after adjustment for age and gender. Factors adjusted for were age, gender, country of birth, socioeconomic status, remoteness of residential postcode, hours of professionally and privately supervised driving on a learner license, months on a learner license, number of attempts to pass driving tests, self-rated driving ability, average weekly driving hours, months between provisional license and study entry, and previous crashes (prior to study participation). Effect modification by gender and age was examined for each of the main exposures.

A spline curve (not shown) was fitted to the scatterplot of summative scores for risky driving and risk perception scales and showed that the general smoothed relationship approximated a straight line. The Pearson correlation coefficient was therefore calculated to quantify the association between risky driving and risk perception.

RESULTS

In total, 20 822 young drivers completed the baseline survey (with 95% completed online) and gave consent for data linkage. The majority (74.6%) of the study population was aged 17 to 18 years; 54.6% were female. During an average follow-up of 2 years, 92.8% had no police-recorded crashes as a driver, 6.8% had 1 such crash, 0.3% had 2 crashes, and 0.01% had 3 crashes. Of the 20 822 participants, 2.7% had crashes recorded prior to joining the study.

Table 1 presents the number and proportion of participants (total sample and by

TABLE 1—Number and Proportion of Participants Aged 17–24 Years Reporting Undertaking Risky Driving Behaviors Very Often or Often, by Gender: The DRIVE Study, New South Wales, Australia, June 2003–December 2004

Risky Driving Behavior	Total Sample		Men		Women	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Drive with 2 or more passengers	9910	47.6 (46.9, 48.3)	4598	48.6 (47.6, 49.6)	5312	46.7 (45.8, 47.7)
Drive while listening to loud music	8805	42.3 (41.6, 43.0)	4244	44.9 (43.9, 45.9)	4561	40.1 (39.2, 41.0)
Drive about 70 km/h in a 60-km/h zone	4404	21.2 (20.6, 21.7)	2385	25.2 (24.3, 26.1)	2019	17.8 (17.1, 18.5)
Drive fast just for the thrill of it	1492	7.2 (6.8, 7.5)	1032	10.9 (10.3, 11.5)	460	4.0 (3.7, 4.4)
Follow very close behind slower drivers	1107	5.3 (5.0, 5.6)	641	6.8 (6.3, 7.3)	466	4.1 (3.7, 4.5)
Speed up if someone is trying to pass	816	3.9 (3.7, 4.2)	513	5.4 (5.0, 5.9)	303	2.7 (2.4, 3.0)
Take some risks when driving because it makes driving more fun	774	3.7 (3.5, 4.0)	587	6.2 (5.7, 6.7)	187	1.6 (1.4, 1.9)
Make rude gestures at other drivers	780	3.7 (3.5, 4.0)	504	5.3 (4.9, 5.8)	276	2.4 (2.1, 2.7)
Honk your horn or flash your lights in anger at other drivers	669	3.4 (3.1, 3.6)	443	4.7 (4.3, 5.1)	256	2.3 (2.0, 2.5)
Do burnouts, donuts, or skids just for the fun of it	697	3.3 (3.1, 3.6)	610	6.5 (6.0, 6.9)	87	0.8 (0.6, 0.9)
Race or drag race for the fun of it	619	3.0 (2.7, 3.2)	495	5.2 (4.8, 5.7)	124	1.1 (0.9, 1.3)
Drive while using SMS ^a on a mobile phone	575	2.8 (2.5, 3.0)	232	2.5 (2.1, 2.8)	343	3.0 (2.7, 3.3)
Drive while talking on a mobile phone	534	2.6 (2.3, 2.8)	267	2.8 (2.5, 3.2)	267	2.3 (2.1, 2.6)
Drive without wearing a seatbelt	91	0.4 (0.3, 0.5)	64	0.7 (0.5, 0.8)	27	0.2 (0.1, 0.3)

Note. SMS = short message service; CI = confidence interval.

^aA text-messaging service.

gender) who reported “very often” or “often” partaking in risky driving behaviors; the most commonly reported were driving with multiple passengers (almost half of respondents), driving while listening to loud music (two fifths), and driving at 70 km/h in a 60-km/h zone (one fifth). Least common was driving without a seatbelt (<1%). With the exception of driving while text messaging, which was reported by more women than men ($P=.01$), more men than women reported frequent undertaking of the risky behaviors ($P<.01$), although differences were less marked for talking on mobile phones ($P=.03$) or for driving with multiple passengers ($P=.07$).

Corresponding results for perceptions of risky driving behaviors as “always safe” or “mostly safe” are reported in Table 2. The vast majority of the sample (90%) perceived driving with multiple passengers as safe or mostly safe. Over half the sample had poor risk perceptions of late-night driving and about one third for driving 10 km/h over the posted limit, both in a 60-km/h zone and in a 100-km/h zone. Men reported significantly poorer risk perception than women for all items ($P<.002$),

with the greatest discrepancies for driving 70 km/h in a 60-km/h zone and late-night driving.

Composite scores were calculated and correlated for those who responded to all risky driving behavior and risk perception items ($n=19\,569$). There was a positive but weak association between risky driving behaviors and risk perception ($r=0.05$; $P<.001$).

Table 3 presents the results of the regression analyses exploring the associations between summative scores of risky driving and of risk perception and the likelihood of a crash, stratified by gender. Univariate analyses showed that drivers with both medium and high scores on the risky driving measure were significantly more likely to have a crash than those with low scores. This relationship remained after adjustment for multiple confounders. Further controlling for risk perception did not significantly alter the results. The key finding, therefore, was that high scores for risky driving were associated with a 50% increased crash risk (adjusted RR=1.51; 95% CI=1.25, 1.81).

Further exploration confirmed that each risky driving item was significantly independently associated with increased crash risk at $P<.05$,

with the exception of nonuse of seatbelts ($P=.24$).

A high score compared with a low score on the risk perception measure (poorer perception of safety) was also associated with increased crash risk in univariate and multivariate models; however, this significant association was not sustained after adjustment for risky driving behavior.

There were no significant differences in risk estimates by gender. Although the effect size for risky driving behaviors was higher for women than men (for women, RR=1.68; 95% CI=1.30, 2.17; for men, RR=1.41; 95% CI=1.08, 1.84), the difference was not significant. There was, similarly, no difference by gender in the effect of risk perception on crashes (Table 3). Likewise, there was no effect modification by age for either risky driving behaviors or risk perception.

DISCUSSION

We found that self-reported risky driving behaviors among novice drivers were linked to a 50% increased risk of a crash after control for

TABLE 2—Number and Proportion of Participants Aged 17–24 Years Rating Risk Perception Items as Always Safe or Mostly Safe, by Gender: The DRIVE Study, New South Wales, Australia, June 2003–December 2004

Rates the Following as Always Safe or Mostly Safe	Total Sample		Men		Women	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Driving with 2 or more passengers	18 694	89.8 (89.4, 90.2)	8589	90.8 (90.2, 91.4)	10 105	88.9 (88.3, 89.5)
Driving between midnight and 6 AM	11 018	52.9 (52.2, 53.6)	5747	60.8 (59.8, 61.8)	5271	46.4 (45.5, 47.3)
Driving at 110 km/h in a 100-km/h zone	7552	36.3 (35.6, 36.9)	4262	45.1 (44.1, 46.1)	3290	28.9 (28.1, 29.8)
Driving at 70 km/h in a 60-km/h zone	6412	30.8 (30.2, 31.4)	3432	36.3 (35.3, 37.3)	2980	26.2 (25.4, 27.0)
Driving while talking on a mobile phone	2017	9.7 (9.3, 10.1)	1172	12.4 (11.7, 13.1)	845	7.4 (7.0, 7.9)
Driving a poorly maintained car	1368	6.6 (6.2, 6.9)	871	9.2 (8.6, 9.8)	497	4.4 (4.0, 4.7)
Driving with a blood alcohol level just over the legal limit	1180	5.7 (5.4, 6.0)	749	7.9 (7.4, 8.5)	431	3.8 (3.4, 4.1)
Driving while using SMS on a mobile phone	1048	5.0 (4.7, 5.3)	555	5.9 (5.4, 6.3)	493	4.3 (4.0, 4.7)
Driving after smoking marijuana	922	4.4 (4.1, 4.7)	537	5.7 (5.2, 6.1)	385	3.4 (3.1, 3.7)
Going through a red light	593	2.8 (2.6, 3.1)	313	3.3 (2.9, 3.7)	280	2.5 (2.2, 2.7)

Note. SMS=short message service; CI=confidence interval.

multiple confounders. However, whereas perception of risk was associated with crash risk (those who regarded potentially dangerous situations as safe having a higher risk of crash), it was not found to be an important crash predictor after accounting for reported risky driving behaviors. Measures of risky driving and risk perception were only weakly correlated (although this correlation was statistically significant), probably because of the large sample size.

These findings confirm and strengthen those from recent international studies. Earlier Australian research found an increased risk of crashes in the first year of driving for young drivers who reported risky driving.⁴⁶ A recent British cohort study of young drivers also showed that risk of a self-reported crash was higher in the first year of licensure among participants reporting intentional violations of traffic laws.⁵⁰ In Finland, researchers found that, although risk-taking attitudes had a substantial direct effect on risky driving, risk perceptions did not.⁴² Earlier US research also found that risk perception was not a good predictor of reported seatbelt use.⁵¹ Generally, young people who undertake, or are exposed to, risky driving behaviors also perceive driving risks as low, and those perceiving risk as high are less likely to undertake the behavior.^{15,35,39,42} Nonetheless, studies have also shown that young people who

perceive driving risks as high can still report engaging in these behaviors.^{18,37}

The need for interventions targeting risky driving behavior, independent of risk perception, is clear and offers some explanation as to why drivers' education programs that focus on increasing awareness and knowledge of driving risks without seeking behavior change have generally not succeeded in reducing crashes.^{52,53} Research suggests that licensing reform has an important role in effecting behavior change among novice drivers.^{3,4,54–56} Enforcement regimes can effectively deter risky driving behavior without requiring improvements in risk perceptions, both through issuance of sanctions (specific deterrence) and through highly visible programs that appear ubiquitous (general deterrence).⁵⁷

As highlighted in this research, novice drivers ranked 2 known risk behaviors—driving with multiple passengers and driving late at night—lowest on the risk perception scale. Driving with multiple passengers was also the most commonly reported risky driving behavior for both genders (almost half of the sample). Research has shown that implementing graduated driver licensing restrictions to limit passengers and restrict late-night driving among new drivers has reduced crashes.^{54–56} These findings suggest that such licensing reforms are warranted.

Most risky driving behaviors reported by study participants were not common—generally, they were reported to be undertaken very often or often by fewer than 5% of participants. However, in addition to the high level of driving with multiple passengers, over 40% of participants reported driving while listening to loud music and one quarter of men and one fifth of women reported very often or often driving at about 10 km/h over the speed limit in a 60-km/h zone. Risks associated with driving with loud music are not well understood and have not been a specific focus of safety campaigns; however, loud music can act as a distraction, and research suggests that listening attentively to the radio can worsen driving performance, particularly lane keeping, as much as a mobile phone conversation.⁵⁸ In comparison, the risks of speeding have been well documented and widely targeted in statewide campaigns in the study location.⁵⁹ Although this level of speeding can be viewed as commonplace among other driver groups and acceptable within the driving community,⁶⁰ it remains a dangerous practice: the risk of a crash when driving at 70 km/h is 4 times the risk at 60 km/h.⁶¹

Current licensing countermeasures to address speeding behavior among young novice drivers include reduced demerit point thresholds and more severe penalties for

TABLE 3—Crude and Adjusted Relative Risks (RR) for Associations Between Risky Driving Behavior, Risk Perception, and Likelihood of Crash Among Young Drivers Aged 17–24 Years, by Gender: The DRIVE Study, New South Wales, Australia, June 2003–December 2004

Measure and Value	Crude RR (95% CI)	Risky Driving Behavior, Adjusted RR ^a (95% CI)	Risk Perception, Adjusted RR ^a (95% CI)	Risky Driving Behavior and Risk Perception, Adjusted RR ^a (95% CI)
All participants				
Risky driving behavior				
High	1.70 (1.50, 1.94)	1.58 (1.34, 1.85)	...	1.51 (1.25, 1.81)
Medium	1.25 (1.09, 1.44)	1.32 (1.12, 1.55)	...	1.30 (1.10, 1.54)
Low (Ref)	1.00	1.00	...	1.00
Risk perception				
High	1.39 (1.22, 1.57)	...	1.31 (1.13, 1.53)	1.09 (0.92, 1.29)
Medium	1.04 (0.90, 1.20)	...	1.11 (0.94, 1.30)	1.00 (0.84, 1.18)
Low (Ref)	1.00	...	1.00	1.00
Male participants				
Risky driving behavior				
High	1.56 (1.29, 1.89)	1.48 (1.17, 1.88)	...	1.41 (1.08, 1.84)
Medium	1.27 (1.03, 1.56)	1.40 (1.10, 1.79)	...	1.39 (1.08, 1.79)
Low (Ref)	1.00	1.00	...	1.00
Risk perception				
High	1.25 (1.04, 1.51)	...	1.24 (0.99, 1.55)	1.08 (0.84, 1.38)
Medium	0.90 (0.73, 1.12)	...	0.99 (0.77, 1.27)	0.91 (0.70, 1.17)
Low (Ref)	1.00	...	1.00	1.00
Female participants				
Risky driving behavior				
High	1.74 (1.45, 2.08)	1.75 (1.40, 2.18)	...	1.68 (1.30, 2.17)
Medium	1.20 (1.00, 1.45)	1.26 (1.01, 1.57)	...	1.23 (0.98, 1.55)
Low (Ref)	1.00	1.00	...	1.00
Risk perception				
High	1.36 (1.13, 1.63)	...	1.38 (1.12, 1.71)	1.08 (0.85, 1.38)
Medium	1.11 (0.92, 1.34)	...	1.20 (0.97, 1.48)	1.06 (0.85, 1.33)
Low (Ref)	1.00	...	1.00	1.00

Note. CI = confidence interval. Crude RRs were from univariate analysis; adjusted RRs were from multivariate analysis.
^aAdjusted for age, gender (for total sample analysis), country of birth, socioeconomic status, remoteness of residential postcode, months on learner license, professional supervised driving hours on learner license, private supervised driving hours on learner license, number of attempts at driving tests, self-rated driving ability, average weekly driving hours, months between provisional license and study entry, and previous crash.

offenses.^{62,63} However, research in Europe has found mixed results regarding the impact of such initiatives on crashes.¹ Alternatively, in some jurisdictions, novice drivers must pass a “good behavior” period—free of any offenses such as speeding—before they can progress to the next stage of licensing.^{63,64} Some research also suggests that these initiatives have an important role in motivating behavior change and reducing crashes^{64,65}; however, this is not a well-researched countermeasure. Further, speeding remains a significant contributing factor to

crashes by novice drivers^{11,14,66}; this is true in our study location, where 40% of fatal crashes involving 17- to 25-year-old drivers involve speeding.⁶⁷ At the time of recruitment, the state already had a reduced demerit point threshold for newly licensed drivers, but it has since introduced more severe penalties for speeding as part of a “zero tolerance” campaign on speeding.⁶⁷ Any serious speeding offense now leads to suspension of license. The present findings suggest that targeted initiatives such as these are warranted.

The finding that men reported more frequently engaging in several risky driving behaviors and had poorer risk perceptions than women supports findings of previous studies.^{5–12} Although young men have been identified as a particular target for interventions to reduce risky driving, the association between risky driving and the risk of crash did not differ by gender in the current study; that is, whether male or female, those who reported undertaking a high level of risky driving behaviors had an increased risk of crash. This reinforces the need to include the entire young driver population in targeted interventions.

Limitations

As the young drivers included in this research were volunteers and not a representative sample of the general population, estimates of the population prevalence of exposures or outcomes were not calculated. However, the study population represented a broad cross-section of the young driver population and substantial heterogeneity in the distribution of potential risk factors for crashes was achieved, making it possible to explore the associations of interest.⁴⁷

The measures of risky driving behaviors and risk perception were obtained via self-report, and the possibility of socially desirable responses cannot be excluded. Therefore, the magnitude of association between risk perception, risky behaviors, and crashes may be underestimated. However, questionnaire items were based on previous studies and a wide distribution in responses was found. Moreover, several risky driving and crash-based studies have confirmed the accuracy and reliability of self-reports in this field.⁶⁸ Nonetheless, the use of response scales applied in this research has been questioned, particularly regarding risk perceptions and in rating several items as a measure of overall risk perception.⁶⁹ Questionnaire-based measures of risk perception have also not compared directly with other measures, such as identifying risks in videos of driving scenarios.⁷⁰ In addition, given that young people have reported context-dependent perceptions of risk,^{6,35} the findings relating to risk perception need further investigation. It is possible that the current measure was not sensitive enough to determine stronger associations between risk perception and crash risk.

The driving exposure measure was also a self-report measure and was based on average weekly driving hours at the time of the survey. This may not be sensitive enough to detect differences in actual mileage driven or variations in driving exposure over time, both of which alter the level of crash exposure. The possible influence of this limitation on the results is unknown, but this measure is widely used in this field when it is the best available option.^{48,71}

Given the large sample size needed to generate sufficient power to produce reliable estimates of factors associated with the risk of crash, a relatively rare outcome, there have been few studies that have examined associations between risky driving and crash risk. Further, there have been few large-scale observational studies of novice drivers worldwide that have had the capacity to link detailed questionnaire data to routinely collected data sources. This study therefore has some significant strengths, including 100% consent from participants to access data on crashes from police reports. The breadth of the questionnaire data allows adjustment for multiple confounding variables, crucial in an observational study but rare in large-scale studies of novice drivers that use routinely collected data from jurisdictional licensing and crash data sources.

Conclusions

This study has highlighted that self-reported risky driving is associated with a 50% increased risk of crashes but that the effect of risk perception, although an independent predictor of crashes, is attenuated once risky driving is accounted for. A detailed understanding of the associations between risky driving behaviors and the risk of crash is useful in determining enhancements to current interventions and further developments, including the types of novice driver policies that need strengthening. The findings suggest that the introduction of restrictions on the number and age of passengers and on nighttime driving, as well as additional measures to address speeding, are warranted, and that both male and female novice drivers must be targeted in such intervention. However, a system-wide approach that more broadly targets risky driving as an unacceptable behavior can improve effectiveness and

provide additional benefits by engaging the wider driving community.^{5,60,72} ■

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This article was accepted December 8, 2008.

Contributors

R. Ivers, M. Stevenson, M. Woodward, and R. Norton conceptualized the study and R. Ivers supervised all aspects of its implementation. R. Ivers and T. Senserrick led the writing. S. Boufous, H.-Y. Chen, and M. Woodward conducted the analyses. All authors contributed to the interpretation of the findings and the writing.

Acknowledgements

The DRIVE Study was funded by the National Health and Medical Research Council of Australia, Roads and Traffic Authority of New South Wales, National Roads and Motorists' Association (NRMA) Motoring and Services, NRMA-Australian Capital Territory Road Safety Trust, New South Wales Health, and the Motor Accidents Authority of New South Wales. R. Ivers, T. Senserrick, S. Boufous, and M. Stevenson receive salary funding from the National Health and Medical Research Council of Australia.

Human Participant Protection

This study was approved by the University of Sydney Human Research Ethics Committee and the New South Wales Department of Health Ethics Committee. Participants provided consent online or in writing.

References

- Twisk DAM, Stacey C. Trends in young driver risk and countermeasures in European countries. *J Safety Res.* 2007;38:245–257.
- Williams AF. Teenage drivers: patterns of risk. *J Safety Res.* 2003;34:5–15.
- Baker SP, Chen L-H, Li G. *National Evaluation of Graduated Driver Licensing Programs.* Washington, DC: National Highway Transportation Safety Administration; 2006. NHTSA technical report DOT HS 810 614.
- Baker SP, Chen L-H, Li G. *Nationwide Review of Graduated Driver Licensing.* Washington, DC: AAA Foundation for Traffic Safety; 2007.
- Fergusson D, Swain-Campbell N, Horwood J. Risky driving behaviour in young people: prevalence, personal characteristics and traffic accidents. *Aust N Z J Public Health.* 2003;27:337–342.
- Hatfield J, Job RFS. *Beliefs and Attitudes About Speeding and Its Countermeasures.* Sydney: Australian

Transport Safety Bureau; 2006. ATSB report B2001/0342.

- Laapotti S, Keskinen E. Has the difference in accident patterns between male and female drivers changed between 1984 and 2000? *Accid Anal Prev.* 2004;36:577–584.
- Mathijssen R, Houwing S. *The Prevalence and Relative Risk of Drink and Drug Driving in the Netherlands: A Case Control Study in the Tilburg Police District. Research in the Framework of the European Research Programme, IMMORTAL R-2005-9.* Leidschendam, Netherlands: Institute for Road Safety Research (SWOV); 2005.
- Maycock G. *Novice Driver Accidents and the Driving Test.* Crowthorne, UK: Transportation Research Laboratory; 2002. TRL report TRL527.
- Olteidal S, Rundmo T. The effects of personality and gender on risky driving behaviour and accident involvement. *Saf Sci.* 2006;44:621–628.
- Sakashita C, Graham A, de Roos M, Croft S, Elliott M. Comparing provisional and unrestricted licence holders on speeding offences and crash rates. Paper presented at: Australasian Road Safety Research Policing and Education Conference; October 17–19, 2007; Melbourne, Australia.
- Turner C, McClure R. Age and gender differences in risk-taking behaviour as an explanation for high incidence of motor vehicle crashes as a driver in young males. *Inj Control Saf Promot.* 2003;10:123–131.
- Blows S, Ameratunga S, Ivers RQ, Lo SK, Norton R. Risky driving habits and motor vehicle driver injury. *Accid Anal Prev.* 2005;37:619–624.
- Gonzales MM, Dickinson LM, DiGuseppi C, Lowenstein SR. Student drivers: a study of fatal motor vehicle crashes involving 16-year-old drivers. *Ann Emerg Med.* 2005;45:140–146.
- Ryb GE, Dischinger PC, Kufera JA, Read KM. Risk perception and impulsivity: association with risky behaviors and substance abuse disorders. *Accid Anal Prev.* 2006;38:567–573.
- Sabel JC, Bensley LS, Van Eenwyk J. Associations between adolescent drinking and driving involvement and self-reported risk and protective factors in students in public schools in Washington State. *J Stud Alcohol.* 2004;65:213–216.
- Fell JC, Baker TK, McKnight AS, et al. *Increasing Teen Safety Belt Use: A Program and Literature Review.* Calverton, MD: National Highway Traffic Safety Administration; 2005. NHTSA report DOT HS 809 899.
- Pennay D. *Community Attitudes to Road Safety—Wave 19, 2006.* Canberra: Australian Transport Safety Bureau; 2006. ATSB report CR 229.
- Vivoda JM, Eby DW, Louis RM, Kostyniuk LP. A direct observation study of nighttime safety belt use in Indiana. *J Safety Res.* 2007;38:423–429.
- Broughton J, Hill J. *Mobile Phone Use by Drivers, 2000–03.* Wokingham, UK: Road Safety Strategy Division, Department for Transport, TRL Limited; 2005. TRL report TRL634.
- Glassbrenner D. *Driver Cell Phone Use in 2005: Overall Results.* Washington, DC: National Highway Traffic Safety Administration; 2005. NHTSA report DOT HS 809 967.
- Driving Around Melbourne.* Kew, Australia: Vic-roads; 2003.

23. *Crash Index: Annual Road Safety Index*. Melbourne, Australia: AAMI Ltd; 2005.
24. Baker S, Spina K. Drivers' attitudes, awareness and knowledge of driver distractions: research from two central Sydney communities. Paper presented at: International Conference on Driver Distraction; June 2–3, 2005; Sydney, Australia.
25. Cavallo A, Catchpole J. Accidents of first year drivers: what can we learn about skill development? Paper presented at: Australasian Road Safety Research Policing and Education Conference; October 17–19, 2007; Melbourne, Australia.
26. Keall MD, Frith WJ, Patterson TL. The influence of alcohol, age and number of passengers on the night-time risk of driver fatal injury in New Zealand. *Accid Anal Prev*. 2004;36:49–61.
27. Engström I, Gregersen NP, Hertnetkoski K, Keskinen E, Nyberg A. Young Novice Drivers, Driver Education, and Training: Literature Review. Borlänge, Sweden: Swedish National Road and Transport Research Institute; 2003.
28. Williams AF, Leaf WA, Simons-Morton BG, Hartos JL. Vehicles driven by teenagers in their first year of licensure. *Traffic Inj Prev*. 2006;7:23–30.
29. Cavallo A. Analysis of novice and young driver crashes in Victoria. Paper presented at: Australasian Road Safety Research, Policing and Education Conference; September 24–26, 2003; Sydney, Australia.
30. Chen L-H, Baker SP, Braver ER, Li G. Carrying passengers as a risk factor for crashes fatal to 16–17 year old drivers. *JAMA*. 2000;283:1578–1582.
31. Lam LT, Norton R, Woodward M, Connor J, Ameratunga S. Passenger carriage and car crash injury: a comparison between younger and older drivers. *Accid Anal Prev*. 2003;35:861–867.
32. Vollrath M, Meilinger T, Kruger H-P. How the presence of passengers influences the risk of a collision with another vehicle. *Accid Anal Prev*. 2002;34:649–654.
33. Bell NS, Amoroso PJ. Self-reported risk-taking behaviors and hospitalization for motor vehicle injury among active duty army personnel. *Am J Prev Med*. 2000;18(suppl 3):85–95.
34. Palamara PG, Legge M, Stevenson MR. *An Investigation of the Relationship Between Years of Licensing, Traffic Offences, and Crash Involvement: A Comparison of First Year Drivers With Drivers Licensed for Ten Years and Five Years*. Crawley, Australia: Injury Research Centre, University of Western Australia; 2001. IRC report RR117.
35. Ginsburg KR, Winston FK, Senserrick TM, et al. National Young Driver Survey: teen perspective and experience with factors that affect driving safety. *Pediatrics*. 2008;121:e1391–e1403.
36. Greening L, Stoppelbein L. Young drivers' health attitudes and intentions to drink and drive. *J Adolesc Health*. 2000;27:94–101.
37. Harre N, Brandt T, Dawe M. The development of risky driving in adolescence. *J Safety Res*. 2000;31:185–194.
38. Patton D, Brown D, Broszeit B, Dhaliwal J. *Substance Use Among Manitoba High School Students*. Winnipeg: Addictions Research Foundation of Manitoba; 2001.
39. Sarkar S, Andreas M. Acceptance of and engagement in risky driving behaviors by teenagers. *Adolescence*. 2004;39:687–700.
40. Whissell RB, Bigelow BJ. The Speeding Attitude Scale and the role of sensation seeking in profiling young drivers at risk. *Risk Anal*. 2003;23:811–820.
41. Wundersitz LN, Hutchinson TP. *South Australia's Driver Intervention Program: Participant Characteristics Best Practice Discussion, and Literature Review*. Adelaide, Australia: Center for Automotive Safety Research, University of Adelaide; 2006. Case report series CASR 021.
42. Ulleberg P, Rundmo T. Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Saf Sci*. 2003;41:427–443.
43. McEvoy SP, Stevenson MR, Woodward M. Phone use and crashes while driving: a representative survey of drivers in two Australian states. *Med J Aust*. 2006;185:630–634.
44. White MP, Eiser JR, Harris PR. Risk perceptions of mobile phone use while driving. *Risk Anal*. 2004;24:323–334.
45. Lerner N, Boyd S. *On-Road Study of Willingness to Engage in Distracting Tasks*. Washington, DC: National Highway Transportation Safety Administration; 2005. NHTSA technical report DOT HS 809 863.
46. Stevenson MR, Palamara P. Behavioural factors as predictors of motor vehicle crashes: differentials between young urban and rural drivers. *Aust N Z J Public Health*. 2001;25:245–249.
47. Ivers RQ, Blows SR, Stevenson MR, et al. A cohort study of 20 822 young drivers: the DRIVE study methods and population. *Inj Prev*. 2006;12:385–389.
48. Begg DJ, Brookland R, Hope J, Langley J, Broughton J. New Zealand drivers study: developing a methodology for conducting a follow-up study of newly licensed drivers. *J Safety Res*. 2003;34:329–336.
49. Donovan J, Jessor R. *Young Adult Driving Questionnaire*. Boulder: Colorado Institute of Behavioral Science; 1992.
50. Wells P, Tong S, Genderton B, Grayson G, Jones E. *Cohort II: A Study of Learner and New Drivers Volume 1—Main Report*. London, UK: Transport Research Laboratory, Department for Transport; 2008. Road Safety Research Report No. 81.
51. Calisir F, Lehto MR. Young drivers' decision making and safety belt use. *Accid Anal Prev*. 2002;34:793–805.
52. Ker K, Roberts I, Collier T, Beyer F, Bunn F, Frost C. Post-licence driver education for the prevention of road traffic crashes: a systematic review of randomised controlled trials. *Accid Anal Prev*. 2005;37:305–313.
53. Mayhew DR. Driver education and graduated licensing in North America: past, present, and future. *J Safety Res*. 2007;38:229–235.
54. Ferguson SA, Teoh ER, McCart AT. Progress in teenage crash risk during the last decade. *J Safety Res*. 2007;38:137–145.
55. Gillan JS. Legislative advocacy is key to addressing teen driving deaths. *Inj Prev*. 2006;12(suppl 1):i44–i48.
56. Williams AF. Contribution of the components of graduated licensing to crash reductions. *J Safety Res*. 2007;38:177–184.
57. Homel R. *Policing and Punishing the Drinking Driver: A Study of General and Specific Deterrence*. New York, NY: Springer-Verlag; 1988.
58. Parliament of Victoria Road Safety Commission. *Inquiry Into Driver Distraction*. Melbourne, Australia: Victorian Government Printer; August 2006. Parliamentary Paper No. 209, Session 2003–2006.
59. Roads and Traffic Authority of New South Wales. Advertising campaigns. 2008. Available at: <http://www.rta.nsw.gov.au/roadsafety/speedandspeedcameras/campaigns/index.html>. Accessed May 14, 2008.
60. Redshaw S. Changing driving behaviour—a cultural approach. *Aust J Soc Issues*. 2001;36:315–331.
61. Roads and Traffic Authority of New South Wales. Speeding. 2008. Available at: <http://www.rta.nsw.gov.au/roadsafety/speedandspeedcameras/index.html>. Accessed May 14, 2008.
62. Ferguson SA. Other high-risk factors for young drivers—how graduated licensing does, doesn't, or could address them. *J Safety Res*. 2003;34:71–77.
63. Senserrick T, Whelan M. *Graduated Driver Licensing: Effectiveness of Systems and Individual Components*. Clayton, Australia: Monash University Accident Research Centre; 2003. MUARC report 209.
64. McKnight AJ, Peck RC. Graduated driver licensing and safer driving. *J Safety Res*. 2003;34:85–89.
65. Tannahill J, Smith M. State's experience with inexperienced drivers: update on status of provisional licensing. *Traffic Saf*. 1990;21:18–21.
66. Lam LT. Factors associated with young drivers' car crash injury: comparisons among learner, provisional, and full licensees. *Accid Anal Prev*. 2003;35:913–920.
67. Roads and Traffic Authority of New South Wales. Speeding—provisional drivers and riders. 2008. Available at: <http://www.rta.nsw.gov.au/roadsafety/speedandspeedcameras/speedingprovisional.html>. Accessed May 14, 2008.
68. Hatakka M, Keskinen E, Katila A, Laapotti S. Self-reported driving habits are valid predictors of violations and accidents. In: Rothengatter T, Carbonell Vaya E, eds. *Traffic and Transport Psychology: Theory and Application*. Oxford, UK: Pergamon; 1997:295–303.
69. French DP, Marteau TM, Sutton S, Kinmonth AL. Different measures of risk perceptions yield different patterns of interaction for combinations of hazards: smoking, family history and cardiac events. *J Behav Decis Making*. 2004;17:381–393.
70. Farrand P, McKenna F. Risk perception in novice drivers: the relationship between questionnaire measures and response latency. *Transp Res F Traffic Psychol Behav*. 2001;4:201–212.
71. Clarke WL, Cox DJ, Gonder-Frederick LA, Kovatchev B. Hypoglycemia and the decision to drive a motor vehicle by persons with diabetes. *JAMA*. 1999;282:750–754.
72. Williams AF. Young driver risk factors: successful and unsuccessful approaches for dealing with them and an agenda for the future. *Inj Prev*. 2006;12(suppl 1):i4–i8.