

## Self-harm and risk of motor vehicle crashes among young drivers: findings from the DRIVE Study

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### ABSTRACT

**Background:** Some motor vehicle crashes, particularly single-vehicle crashes, may result from intentional self-harm. We conducted a prospective cohort study to assess the risk that intentional self-harm poses for motor vehicle crashes among young drivers.

**Methods:** We prospectively linked survey data from newly licensed drivers aged 17–24 years to data on licensing attempts and police-reported motor vehicle crashes during the follow-up period. We investigated the role of recent engagement in self-harm on the risk of a crash. We took into account potential confounders, including number of hours of driving per week, psychological symptoms and substance abuse.

**Results:** We included 18 871 drivers who participated in the DRIVE Study for whom data on self-harm and motor vehicle crashes were available. The mean follow-up was 2 years. Overall, 1495 drivers had 1 or more crashes during the follow-up period. A total of 871 drivers (4.6%) reported that they had engaged in self-harm in the year before the survey. These drivers were at significantly increased risk of a motor vehicle crash compared with drivers who reported no self-harm (relative risk [RR] 1.42, 95% confidence interval [CI] 1.15–1.76). The risk remained significant, even after adjustment for age, sex, average hours of driving per week, previous crash, psychological distress, duration of sleep, risky driving behaviour, substance use, remoteness of residence and socio-economic status (RR 1.37, 95% CI 1.09–1.72). Most of the drivers who reported self-harm and had a subsequent crash were involved in a multiple-vehicle crash (84.1% [74/88]).

**Interpretation:** Engagement in self-harm behaviour was an independent risk factor for subsequent motor vehicle crash among young drivers, with most crashes involving multiple vehicles.

erate injuring of oneself through such methods as superficial cutting, attempted hanging and poisoning.<sup>6</sup> Self-harm is performed most often by people with mental health problems and is a risk factor for suicide and other causes of death.<sup>6–8</sup> Reasons for this behaviour are not well known. They may include coping with feelings of distress, suicidal intent, crying out for attention, addictive self-mutilation, impulsive behaviour, self-loathing and punishment, and attempting to feel in control. A recent study found the rate ratio of self-harm to suicide to be 36 (95% confidence interval [CI] 34.9–37.1).<sup>9</sup>

The rate of death from motor vehicle crashes is hypothesized to be increased among individuals who have previously attempted suicide, and crashes are implicated as a mode of self-harm.<sup>8,10,11</sup> There are several possible reasons for this increased risk of crash-related injury and death. For example, individuals who self-harm may deliberately attempt to injure or kill themselves using a motor vehicle. Alternatively, an increased risk of crash may occur through an indirect association of self-harm with other risk factors associated with crashes. Poor mental health for example is associated with self-harm and has been linked to higher rates of crashes.<sup>8</sup> Common symptoms of poor mental health include depressed or anxious mood, disturbed sleep and poor concentration, all of which may impair cognitive and psychomotor function and thereby impair a person's ability to drive.<sup>12</sup> Self-harm is also commonly associated with alcohol and other substance use, which are also risk factors for motor vehicle crashes.<sup>2,13,14</sup> Finally, developmentally young adults and people who self-harm have poor impulse control, which suggests that they may be particularly vulnerable to a range of health risks, including accidental injury.<sup>6,15,16</sup>

Most studies of motor vehicle crashes among people who self-harm recruited patients seeking health services and used linked data from death registers to examine fatal outcomes. We conducted a prospective study to examine self-harm as a

Globally, poor mental health and injuries (including suicide) are ranked as the first and second highest contributors of lost disability-adjusted life-years among young people.<sup>1</sup> Self-harm and suicide attempts are reported by 5%–17% of people aged 14–25 years and may be increasing in prevalence.<sup>2–5</sup> Self-harm refers to the delib-

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risk factor for nonfatal motor vehicle crashes. We used a cohort of young drivers of whom a subset engaged in self-harm. We also explored the role of associated risk factors, including symptoms of mental disorder and substance use, in explaining any difference in rates of crash.

## Methods

### Study design

The DRIVE Study was a prospective cohort study involving 20 822 newly licensed drivers in the state of New South Wales, Australia. Details about the methods have been reported previously.<sup>17</sup> In brief, all drivers living in New South Wales who were 17–24 years old and received a first-stage provisional licence (allows unsupervised driving) between June 2003 and December 2004 were invited to participate in an online survey. The provisional licence has restrictions on speed and towing and is issued to drivers at least 17 years old following a minimum 12-month period with a “learner” licence (allows supervised driving). Participants gave consent for their survey data to be linked prospectively to data held by the Roads and Traffic Authority of New South Wales, including information about police-reported crashes.

The University of Sydney Human Research Committee and the New South Wales Health Ethics Committee approved the study design. All participants gave informed consent. In reporting this study, we have followed the guidelines for observational studies described in the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement.<sup>18</sup>

### Data collection

Participants were asked to complete a baseline questionnaire online. Data was collected on demographic characteristics, driving exposure (number of hours spent driving per week), driver training, use of drugs and alcohol, risky driving behaviour and duration of sleep (number of hours of sleep per day).<sup>17</sup> For risky driving behaviour, participants were asked “How often do you [engage in a particular behaviour]?” Scores were derived from responses to 14 items regarding risky driving behaviours that were adapted from previous research.<sup>19</sup> Summary scores were categorized into tertiles (low, medium and high), with higher scores representing more risky driving behaviour.

Participants were asked to report their engagement in self-harm during the year before the survey in response to questions based on the Beck Suicide Inventory:<sup>20</sup> “In the past 12 months have you deliberately hurt yourself or done anything that you knew might have harmed or even killed you? If yes, what was it that you did?” Qualitative responses about self-harm were coded by 2 research assistants into the following categories: cutting/burning, poisoning, self-battery, risk-taking, other specified harm and other nonspecific harm.<sup>20</sup> All of the responses were also coded according to whether they represented road-related self-harm (yes v. no) and self-harm with lethal intent (yes v. no). The psychiatrist who conducted the initial training of the research assistants coded responses from the first 100 participants and reviewed the

assistants’ coding of the same responses. Analysis of the interrater reliability for a post-training random sample of 20% of these codes resulted in a kappa value of 0.97. All discrepancies were reviewed by the 2 research assistants and the psychiatrist as part of further training before completing the rest of the sample.

The Kessler Psychological Distress Scale was included in the questionnaire to measure the presence of a mental disorder.<sup>21</sup> Participants who had a score of more than 21 were considered to have a mental disorder that warranted clinical attention. In 2004/05, 12% of young adults in Australia aged 18–24 years reported high levels of distress and 19% reported very high levels of distress.<sup>21</sup>

### Outcome measures

Motor vehicle crashes involving participants as the driver were the outcome of interest. We obtained records of crashes for the 10-year period Jan. 1, 1996, to Dec. 31, 2005. We did not include crashes occurring before the baseline survey in the outcome data; however, we did adjust for these crashes as potential confounders in the analysis. In New South Wales, motor vehicle crashes are reported to police when any person is killed or injured; when damage to property is more than A\$500; when the crash is a “hit and run”; when alcohol is involved; or when a vehicle requires towing. For each participant, we recorded whether he or she had either no crash or 1 or more crashes during the follow-up period. The main exposure variable was intentional self-harm.

### Statistical analysis

We analyzed data according to whether participants reported engaging in self-harm in the baseline questionnaire. We used a Poisson regression model to determine relative risks (RR) and 95% confidence intervals (CI) for motor vehicle crash. Poisson regression takes into account “time in the study” as an offset, since entry into and exit from the study would vary among participants. We censored data at the time of first motor vehicle crash or at the end of the follow-up period. Missing values were less than 5% for all variables in the DRIVE Study. Because of the study’s large sample, we undertook list-wise deletion of missing values. Crash outcomes were counted as “yes” whether the crash involved 1 vehicle or multiple vehicles. In the analyses for single-vehicle crashes as an outcome, we compared single-vehicle crashes with crashes involving more than 1 vehicle.

We identified confounding variables from the literature. We included them in the adjusted regression models if they were associated with the outcome measure (crash) and the exposure variable (self-harm). We adjusted all models for crashes that occurred before the baseline questionnaire, as well as exposure to driving; skewed continuous variables were categorized. It was hypothesized from the outset that several potential risk factors may act as confounders or may be a part of the pathway in the risk of crash due to self-harm. Thus, we used incremental modelling to understand better the impact of controlling for covariates sequentially, with self-harm as the primary exposure variable of interest in the model. We examined differences in outcome by sex using

the  $\chi^2$  test. Effect modification by sex and age was examined for each of the main exposures.

## Results

Of 131 000 eligible new drivers, 20 822 (15.9%) participated in the DRIVE Study. The mean length of follow-up was 2 years. For our analysis, we included 18 871 participants for whom data on self-harm and motor vehicle crashes were available. Of these, 1544 (8.2%) said yes to the question about engaging in self-harm. When the answers to the qualifying question (If yes, what was it that you did?) were coded for true self-harm behaviour, the number fell to 871 (4.6%), comprising 511 (58.7%) females and 360 (41.3%) males.

Table 1 presents the associations of self-harm with demographic characteristics and risk factors for motor vehicle crashes. Self-harm was most common among the youngest drivers (51.9% of those reporting self-harm were 17 years old as compared with 10.9% of those aged 20–24). Those who reported self-harm were also more likely to be female, born in Australia, live in rural or regional areas, drive more hours per week, have higher levels of risky driving behaviour, be more likely to abuse drugs and drink excessive amounts of alcohol, and sleep fewer hours per day on average. In addition, those who engaged in self-harm had higher levels of psychological distress than the rest of the sample.

The majority of self-harm behaviours were coded as cutting or burning ( $n = 431$  [49.5%]). The next most common specified behaviours were self-battering ( $n = 110$  [12.6%]), risk-taking ( $n = 74$  [8.5%]), road-related self-harm ( $n = 68$  [7.8%]), poisoning ( $n = 37$  [4.2%]) and self-harm with lethal intent ( $n = 39$  [4.5%]) (Table 2).

Of the 20 822 participants, 1495 (7.2%) had at least 1 crash as a driver during the follow-up period; 304 (20.3%) of them were involved in single-vehicle crashes. Of the 871 participants who reported self-harm, 88 (10.1%) had at least 1 crash; 14 (15.9%) of them had single-vehicle crashes.

Table 3 presents the results of the multi-variable analyses. In the base model, participants who reported self-harm were at a significantly increased risk of a motor vehi-

**Table 1:** Characteristics of 18 871 young drivers who participated in the DRIVE Study and association with reported engagement in self-harm

Variable	No. of participants $n = 18\,871^*$	No. (%) who engaged in self-harm $n = 871$	$p$ value
<b>Sex</b>			< 0.001
Female	10 381	511 (4.9)	
Male	8 490	360 (4.2)	
<b>Age, yr</b>			< 0.001
17	9 154	452 (4.9)	
18–19	7 010	324 (4.6)	
20–24	2 707	95 (3.5)	
<b>Socio-economic status</b>			0.009
First quartile (highest)	4 763	189 (4.0)	
Second quartile	4 820	234 (4.9)	
Third quartile	4 578	242 (5.3)	
Fourth quartile (lowest)	4 710	206 (4.4)	
<b>Country of birth</b>	$n = 18\,854$		< 0.001
Australia	16 037	780 (4.9)	
United Kingdom, New Zealand	342	22 (6.4)	
Europe	30	1 (3.3)	
Asia	1 058	24 (2.3)	
Other	1 387	44 (3.2)	
<b>Remoteness of residence</b>			< 0.001
Urban	14 059	606 (4.3)	
Regional	3 966	222 (5.6)	
Rural	846	43 (5.1)	
<b>Psychological distress</b>	$n = 18\,818$		< 0.001
Low	5 558	72 (1.3)	
Moderate	7 240	192 (2.7)	
High	4 636	341 (7.4)	
Very high	1 384	264 (19.1)	
<b>Risky driving behaviour†</b>	$n = 18\,753$		< 0.001
Low	6 668	148 (2.2)	
Medium	6 175	283 (4.6)	
High	5 910	438 (7.4)	
<b>Drug use</b>	$n = 18\,799$		< 0.001
Never	17 571	696 (4.0)	
≤ once/month	939	121 (12.9)	
2–4 times/month	208	33 (15.9)	
2–3 times/week	44	9 (20.5)	
≥ 4 times/week	37	8 (21.6)	
<b>Alcohol dependence</b>	$n = 18\,866$		< 0.001
Low (< 7 drinks/week)	16 481	665 (4.0)	
High (≥ 7 drinks/week)	2 385	206 (8.6)	
<b>Duration of sleep, no. of hours/day</b>	$n = 18\,555$		< 0.001
≤ 6	325	51 (15.7)	
6–7	3 067	225 (7.3)	
7–8	5 669	240 (4.2)	
8–9	5 948	198 (3.3)	
≥ 9	3 546	129 (3.6)	
<b>Driving, no. of hours/week</b>	$n = 18\,781$		< 0.001
< 2	3 713	138 (3.7)	
2–5	3 510	154 (4.4)	
5–10	5 557	246 (4.4)	
> 10	6 001	331 (5.5)	

\*Unless indicated otherwise.

†Summary scores for responses about how often participants engaged in risky driving behaviours were categorized into tertiles, with higher scores representing more risky driving behaviour.<sup>19</sup>

cle crash compared with those who reported no self-harm (RR 1.42, 95% CI 1.15–1.76;  $p = 0.001$ ). The risk associated with self-harm remained significant in all of the multivariable models, including the final model in which we controlled for age, sex, average hours of driving per week, previous crash, psychological distress, duration of sleep, risky driving behaviour, use of drugs or alcohol, remoteness of residence and socioeconomic status (RR 1.37, 95% CI 1.09–1.72;  $p = 0.007$ ). The absolute difference in risk between those who reported engaging in self-harm and those who did not was 2.3%.

## Interpretation

In this prospective study involving a large cohort of newly licensed young drivers, we found that drivers who reported having engaged in self-harm in the year before the survey were at significantly increased risk of motor vehicle crash during the follow-up period. This risk remained even after we controlled for psychological distress and substance abuse. This finding suggests that self-harm is an independent risk factor for motor vehicle crash rather than a manifestation of these factors. We were unable to investigate the association between self-harm and single-vehicle crashes because of small numbers.

Previous studies have found that suicidal ideation, anxiety and depression are significant risk factors for motor vehicle crash.<sup>22,23</sup> However, in these studies, mental health status was determined after the crash, which may have resulted in report-

ing bias. A prospective study that explored mental illness and risk of crash did not find a significant effect of depression.<sup>22</sup>

Annually, up to 4700 people in Australia aged 18–24 years are admitted to hospital because of crash-related injuries. Up to 24 087 in this age group are admitted because of self-harm (115 per 100 000 population).<sup>24</sup> In a 2002 survey of grade 10 and 11 students (approximate age 15–16 years) in Queensland, Australia, 12% reported that they had engaged in self-harm at some point in their lives.<sup>24</sup> In a longitudinal study in Canada, the prevalence rate of nonsuicidal self-harm was 16.9% among 568 youth aged 14–21.<sup>4</sup> The prevalence of self-harm in our study (8.2% overall [4.6% when responses were coded as true self-harm behaviour]) was similar to the prevalence of 5%–17% reported worldwide<sup>6</sup> and of 4%–6% and 12% in Australian reports.<sup>11,20</sup>

Given that self-harm was found to be an independent risk factor for motor vehicle crash among young drivers who engaged in self-harm, effective interventions to address self-harm would be beneficial in this group. A study of the long-term follow-up effects of a school-based program for the prevention of drug abuse had the added advantage of reducing risky driving behaviours.<sup>25</sup>

For practising clinicians, a discussion about self-harm and driving behaviours as well as other self-harm involving a motor vehicle may be useful when other potential risky behaviour is being considered. Our study's findings can also

**Table 2:** Categories of self-harm behaviours described by 871 participants who reported having engaged in self-harm in the year before the DRIVE Study

Category	No. (%) of participants <i>n</i> = 871*	Examples of responses
Cutting/ burning	431 (49.5)	"Blew my hand up on purpose"; "slit wrists"
Poisoning	37 (4.2)	"Overdosed on sleeping pills"
Self-battering	110 (12.6)	"Bashed my head due to frustration"
Risk-taking	74 (8.5)	"Jumped off two-story building"; "dangerous speeding"
Other (specified action)	21 (2.4)	"Hung myself"; "tried to suffocate"
Other (nonspecified action)	272 (31.2)	"Tried to commit suicide"
Road-related†	68 (7.8)	"Drove into tree"; "dangerous speeding"; "tried to cause a crash"; "ran out in front of a car"
Lethal intent†	39 (4.5)	"Tried to commit suicide"; "hung myself"

\*Numbers total more than 871 because some participants reported more than 1 method of self-harm.

†Some actions of self-harm that were classified in the first 6 categories were also included in 1 or both of the last 2 categories.

**Table 3:** Risk of subsequent motor vehicle crash among participants who reported having engaged in self-harm\*

Model†	Risk of motor vehicle crash, risk ratio (95% CI)	<i>p</i> value
<b>Base model</b>	1.42 (1.15–1.76)	0.001
<b>Incremental adjustments</b>		
Psychological distress	1.44 (1.15–1.80)	0.001
Risk-taking	1.31 (1.06–1.64)	0.01
Psychological distress and risk-taking	1.37 (1.10–1.72)	0.005
Drug/alcohol use	1.35 (1.08–1.68)	0.008
Duration of sleep	1.41 (1.14–1.76)	0.002
Psychological distress and drug/alcohol use	1.39 (1.11–1.75)	0.004
Psychological distress and duration of sleep	1.43 (1.14–1.79)	0.002
Psychological distress, duration of sleep and risk-taking	1.37 (1.09–1.71)	0.007
Psychological distress, duration of sleep, risk-taking and drug/alcohol use	1.34 (1.07–1.69)	0.01
Psychological distress, duration of sleep, risk-taking, drug/alcohol use, residence and socio-economic status	1.37 (1.09–1.72)	0.007

Note: CI = confidence interval.

\*Participants who reported no self-harm formed the reference group.

†All of the models were adjusted for age, sex, average hours of driving per week and previous crash.



help inform discussions about fitness to drive and decisions to suspend licences of drivers who have symptoms of poor mental health. It has been argued that these decisions have been previously made solely on subjective data.<sup>26</sup>

Our findings have implications not only for those who engage in self-harm but potentially for the wider population as well, since a high proportion of the crashes in our study involved multiple vehicles.

### Strengths and limitations

The main strength of our study is its design as a large prospective cohort study with a rich data set of detailed information on multiple potential confounders. There was minimal loss to follow-up because we used routinely collected data on motor vehicle crashes. Being a prospective study ensured that neither recall bias nor differential misclassification played a role. Minimization of recall bias is particularly important for studies of self-harm. First, self-harm behaviours may change or be reported differently after a crash. Second, gathering information on self-harm behaviours from a proxy in the case of a crash-related death is less likely to be accurate because most youth who engage in self-harm hide their behaviours from others.<sup>11</sup>

A further advantage of our study was our ability to adjust for multiple risk factors such as risky driving behaviours, substance use, short sleep duration and psychological distress. Nonetheless, models that adjust for multiple factors can over-adjust for multi-collinear, highly related factors that may be intervening variables on the causal pathway for crashes. One might argue that models should not adjust for factors such as risky driving behaviours that may be a manifestation of self-harm behaviour. We therefore chose to present findings from an unadjusted model and from models in which we adjusted for several combinations of risk factors to show the unique contributions of each variable in predicting motor vehicle crash. Given that the adjusted models had little impact on the unadjusted relative risk, our findings show that self-harm is a robust, independent risk factor for crash.

Our study has limitations. Converse to the benefits of the prospective design, a limitation arises from our use of information collected before a crash, since characteristics may change over time. However, the variables we used have previously been shown to be relatively stable.<sup>27</sup> Another limitation was that data on prior suicide attempts and history of mental illness were not available. Also, data on crashes were available only for individuals with a valid New South Wales driver's licence and who crashed in New South Wales. However, loss of data owing to individuals moving out of state or having a crash while travelling out of state would have been minimal. New South Wales experiences a net migration gain of people aged 15–24 years because of job and university opportunities. Also, crashes that involve residents of New South Wales during short-term travel out of state are estimated by the Roads and Traffic Authority of New South Wales to account for about 3% of crashes (unpublished data). Another limitation was that the DRIVE Study was not designed to be generalizable. However, a heterogeneous population was enrolled, which provides confidence that the general population of young drivers was represented in the study.

### Conclusion

We found a significantly increased risk of motor vehicle crash among newly licensed drivers who had engaged in self-harm in the year before participating in the DRIVE Study. However, we were unable to discern whether a crash was due to the intention to injure or kill oneself. This aspect needs further study. The success of interventions to manage driving risk will depend on the reason for the elevated prevalence of crashes among those who engage in self-harm. Research into single-vehicle crashes will contribute valuable data on this topic. Evaluating whether strategies for improving driving skills, impulse and emotional control while driving will prevent intentional crashes may also be useful. Finally, defining target groups for interventions should be the subject of further research, since less than 1 in 40 youth who engage in self-harm seek assistance for their behaviour.<sup>11</sup>

This article has been peer reviewed.

**Competing interests:** None declared.

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