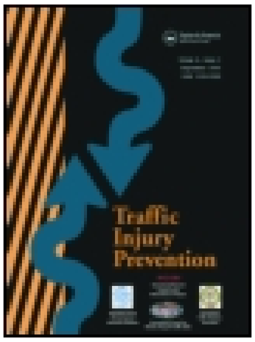

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Near-miss crashes and other predictors of motorcycle crashes: Findings from a population-based survey

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ABSTRACT

Objective: Crash and injury surveillance studies have identified a range of rider-related factors, including age, sex, licensure, training and experience, as being associated with motorcycle crash risk. The aim of this study was to establish whether these previously identified factors were associated with crash involvement in an Australian-based population.

Methods: Data obtained from motorcyclists recruited from road authority licensing offices in a population-based survey design were analyzed. In addition to descriptive analysis, survey logistic regression was used to examine predictors of self-reported motorcycle crashes.

A statewide population prevalence study of motorcyclists in New South Wales, Australia, was conducted using a multistage stratified random sampling plan. Participants ($n = 503$) represented 47% of eligible riders invited to participate. The distribution of responses was weighted to represent the population based on motorcycle registrations as a proxy for active motorcyclists, adjusted for age, sex, and variations in sample size and population density between survey sites.

Results: This analysis investigated factors associated with having crashed in the past 12 months. The key predictors of increased crash risk included frequent near-crash experiences (6–10) in the past year (adjusted odds ratio [OR_{adj}] = 5.3; 95% confidence interval [CI], 1.3–21.8), having 4 or more riding demerit points (OR_{adj} = 4.1; 95% CI, 1.1–14.7), and motorcycle type and riding purpose. Sports (OR_{adj} = 2.8; 95% CI, 1.1–7.3) and commuter motorcycles (OR_{adj} = 4.0; 95% CI, 1.1–15.3) were associated with higher odds of crashes compared to cruiser/touring motorcycles.

Those whose purpose for riding frequently involved commuting, high-speed roads, or motorcycle sports had higher odds of being involved in a crash compared to riders who rarely took part in such activities. Rider age, license type, and time holding a motorcycle license were not predictive of crash involvement when other factors were taken into account.

Conclusions: These findings provide important population-level information and insights about risk exposure for motorcyclists. Taking a more tailored approach to data collection meant that factors associated with crash involvement were identified that are not commonly observed in studies relying on administrative data. In particular, the study highlights the importance of near-crash experiences as warnings to riders and the need to use such experiences as learning opportunities to improve their riding style and safety.

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Crash; motorcycle; near-crash; predictors; population

Introduction

Motorcyclists represent an increasing proportion of road crash casualties globally (Ameratunga et al. 2006). In Australia, motorcycle registrations increased by 93% between 2002 and 2012, compared to 30% for all vehicles (Australian Bureau of Statistics 2012). Motorcycles represent 4% of vehicle registrations in Australia but account for 23% of all serious road crash injuries, with 109 serious injury cases per 10,000 registered motorcycles compared to 13 for car occupants (Bureau of Infrastucture, Transport and Regional Economics 2016).

Crash and injury surveillance studies have identified a range of motorcyclists' rider characteristics and behaviors, including age, sex, licensure, training and experience, conspicuity, motorcycle ownership, alcohol and drug use, and speed and risk-taking behavior (Chang and Yeh 2007; de Rome and Senserrick 2011; Lin and Kraus 2009; Vlahogianni et al. 2012). These findings are commonly observed in administrative data sets (e.g., police, hospital), but such data sets do not capture the full range of road user behaviors or experiences specific to motorcycling. Police, hospital, and coronial data sets are compiled for specific

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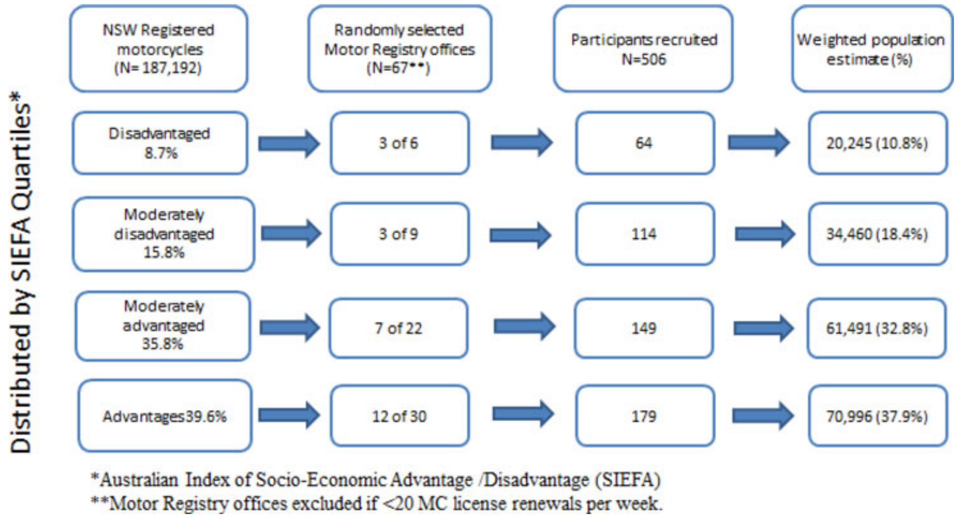

Figure 1 Sampling plan by population strata and weighted population estimate.

administrative purposes, whereas rider preferences and experiential factors are less well documented (International Traffic Safety Data and Analysis Group 2013).

Underreporting is also a limitation of administrative data sets, with data linkage studies indicating that police records may account for less than half of all motorcycle crashes (Lujic et al. 2008; Wilson et al. 2012), particularly those involving single vehicles, unlicensed riders, young riders, nonresidents, and low-severity injuries (Amoros et al. 2006; International Traffic Safety Data and Analysis Group 2013; Ward et al. 2006); in addition, hospital-based surveillance data commonly exclude riders who die at the scene or are treated but not admitted to hospital (de Rome et al. 2011).

The limitations of administrative crash and injury data sets have implications for understanding motorcycle crash risk because they are not representative of all crashes or the wider population of active motorcycle riders (Lin and Kraus 2008). Population-based surveys of motorcyclists are a means of investigating the prevalence of previously identified crash risk factors in the rider population to provide a more reliable basis for identifying safety measures.

The aim of this study was to conduct a population-based survey of active motorcyclists to document the prevalence of previously identified factors associated with crashes and to assess the relevance of these—and potentially other new factors—associated with crashes at the population level.

Method

Study design and sampling plan

A multistage stratified random sampling plan was used to survey the active motorcycle rider population in New South Wales, Australia, over 4 weeks in July 2012. Eligible participants were registered owners of a motorcycle or scooter aged 17 or older. The survey was conducted at government motor registry offices where licensed riders must renew their photo licenses in person. Figure 1 provides a schematic representation of the sampling plan and derivation of population sampling weights.

The sampling plan was based on the geographic distribution of registered motorcycles and stratified by local government area according to the Australian socioeconomic index (SEIFA; Australian Bureau of Statistics 2006). Four strata were constructed using SEIFA quartiles comprising the local government areas with the lowest 25% SEIFA scores (disadvantaged), 26–50% (moderately disadvantaged), 51–75% (moderately advantaged), and 76–100% (advantaged).

The distribution of motorcycle riders in each stratum was estimated using the postcodes of registered motorcycles as a proxy for active riders. The minimum sample to be recruited was calculated proportional to the rider population in each stratum and to achieve estimates with10% precision. Registry offices ($n = 67$) were also classified by strata according to their location. The average number of weekly license renewals per office was used to estimate the number of offices required ($n = 25$) to recruit the required sample. Probability sampling (World Health Organization 2012) was used to select the offices within each stratum to be used as survey sites. Poststratification weighting for over- and undersampling at different sites by sex and age group was used to generate population-level statistics for the population of registered motorcycle owners.

Data collected

Information was collected on rider characteristics previously identified as potential crash risk factors (Langley et al. 2000; Lin and Kraus 2009; Mullin et al. 2000; Sexton et al. 2004; Vlahogianni et al. 2012), including age, license status, motorcycle type, years riding, off-road riding experience, average hours and kilometers ridden per week, number of crashes and near-crash experiences over the past 12 months, traffic violations, and number of demerit points incurred in the past 3 years. Motorcycles were classified by type (e.g., sports, off-road) and whether they were learner approved under the New South Wales graduated licensing scheme (Roads and Traffic Authority 2009).

The primary outcome was self-reported crash involvement, defined as “one or more on-road motorcycle crashes including 'minor spills' in the past 12 months," where *minor spills* indicates falls without serious injury or vehicle damage. Categories for responses included none, 1, 2, and 3 or more. For the purposes of the current analysis, responses were then collapsed into a binary factor: None and 1 or more.

Near-crashes were defined as "only just avoiding a crash or near-miss while riding." Categories for near-crash experiences over the past 12 months included none, 1–2, 3–5, 6–10, and 11 or more.

Items from the Motorcycle Rider Behavior Questionnaire relating to exposure, including the frequency of riding for different purposes including riding in different road environments, on high-speed roads, and across different environmental conditions, were included (Sexton et al. 2004).

The reader is referred to the Appendix (see online supplement) for a detailed description of the coding of each of these variables.

Statistical analysis

Analyses were weighted for the stratified survey design to generate population-level estimates for motorcyclists in New South Wales. Univariate analysis screened for any associations between potential explanatory factors (see Appendix A, online supplement, for full list) and self-reported crash involvement (Rao and Scott 1984). The principal analysis used survey logistic regression to examine factors associated with respondents having had any motorcycle crashes in the previous 12 months (Hosmer and Lemeshow 2000). Analysis was performed in Stata Ver. 12 MP.

Ethics approval for this study was obtained from the University of New South Wales Human Research Ethics Committee.

Results

Rider demographics

The mean age of riders was 43.2 years (95% confidence interval [CI], 40.7–45.9): 39.8 years (95% CI, 34.3–45.3) for females (11.5% of sample) and 43.7 years (95% CI, 41.1–46.4) for males (88.5% of sample). Almost 20% were novice riders (leaner or provisional licenses). Novice riders were younger on average (30.02 years; 95% CI, 25.9–34.1) than those fully licensed (44.7 years; 95% CI, 44.6–48.8). There were no age differences between learners or either levels of provisional 1 or 2 licenses. The most commonly ridden motorcycles were sports (36%) and cruisers (29%).

Excluding those on learner licenses, participants reported an average of 16.65 (95% CI, 14.3–19.0) years of on-road riding experience. Where reported (53% of respondents), riders rode on average 1.88 h (95% CI, 1.7–2.1) per week, but learners rode 2.39 h (95% CI, 1.7–3.0), provisional-1 rode 2.13 h (95% CI, 1.3–2.9), provisional-2 2.15 h (95% CI, 1.35–2.96), and fully licensed 1.79 h (95% CI, 1.3–2.9). No significant differences were found in hours ridden per week by license type. Half (49%) rode up to 100 km per week, one quarter (27%) rode 101–300 km, 6% rode between 301 and 400 km, and 15% rode over 400 km per week.

Table 1. Distribution of key rider demographics and crash involvement (population weighted).

	Population estimate	Crash in past 12 months			
		Column%		Row %	
	Column %	No crashes	Crash	No crashes	Crash
Age of rider					
17–25	13.4	12.0	22.9	78.0	22.0^{NS}
26–39	23.3	22.1	31.7	82.4	17.6
40–54	40.6	42.7	26.5	91.6	8.4
55+	22.7	23.3	18.9	89.3	10.7
Sex of rider					
Male	88.5	87.5	95.4	86.1	13.9*
Female	11.5	12.5	4.6	94.8	5.2
License status					
Learner	8.6	8.8	7.2	89.3	10.7^{NS}
Provisional-1	7.4	6.1	16.5	71.3	28.7
Provisional-2	3.6	3.6	3.6	87.1	12.9
Full license	79.4	80.5	71.6	88.4	11.6
Suspended/unknown	0.9	0.94	1.1	85.0	15.0
Motorcycle type**					
Cruiser/tourer	28.9	31.4	11.9	94.7	5.3**
Sport	36.1	32.9	57.9	79.3	20.7
Dual/trail	12.7	13.3	9.1	90.7	9.3
Standard	10.1	9.2	16.0	79.6	20.4
Scooter	12.1	13.2	5.1	94.6	5.4
Learner-approved motorcycle					
Yes	44.4	45.9	32.9	91.5	8.5^{NS}
No, other	55.6	54.2	57.1	86.2	13.8
Time holding a license					
≤6 months	6.4	6.8	6.2	88.2	11.8^{NS}
7–12 months	2.1	2.0	2.4	85.0	15.0
1–3 years	16.2	15.6	20.3	83.8	16.2
4–15 years	34.1	32.5	44.2	83.3	16.7
16–35 years	31.5	33.5	17.9	92.7	7.3
36+ years	9.4	9.5	9.1	87.6	12.4

$^{*}P \le .05$; $^{**}P \le .001$. NS = Non significant.

Crash outcomes

Overall, 12.9% had been involved in one or more motorcycle crash in the past 12 months, with the majority reporting one crash (77%); this includes crashes of all severities, with approximately 16% being police-reported casualty crashes. Table 1 shows the estimated population distribution of crash involvement by key rider demographics. Crashed riders included 13.9% of males and 5.2% of females ($P = .01$). Sports (21%) and commuter (20%) riders reported higher crash involvement than riders with other motorcycle types ($P \le .001$). No significant associations were found between crash involvement and either age, license status, learner-approved motorcycle, or time holding a motorcycle license.

Table 2 shows the estimated population distribution of crash involvement by measures of riding exposure. Three quarters (76%) of respondents reported a near-crash experience, including 31% who reported 3 or more near-crashes. Most riders (89.5%) reported no demerit points incurred while riding in the past 3 years but 5% had 1–3 demerit points and 5.5% had 4 or more. The proportion of riders reporting crashes was higher for those who often rode for

Table 2. Distribution of riding exposure and association with crash involvement (population weighted).

	Population estimate	Crash in past 12 months			
		Column%		Row %	
	Column %	No crashes	Crash	No crashes	Crash
Number of crashes last 12 months					
None	87.1	100	—	100	—
1	9.9	—	76.8	—	100
2	1.8	—	14.4	—	100
3	0.4	—	2.7	—	100
More than 3	0.8	—	6.1	—	100
Number of kilometers ridden, on average, per week in past 12 months					
Up to 100	48.5	47.5	55.4	85.3	14.7[NS]
101–300	27.1	27.8	22.4	89.3	10.7
301–400	6.3	5.8	9.2	81.1	18.9
401+	15.1	15.9	9.4	91.9	8.1
Unknown	3.0	2.9	3.5	84.8	15.2
Number of times just avoided a crash in past 12 months (near-crash)					
No near-crashes	24.1	25.2	16.4	91.2	8.8***
1 or 2 times	44.4	46.4	31.6	90.8	9.2
3 to 5 times	17.8	17.6	19.5	85.9	14.1
6 to 10 times	7.3	5.2	21.5	62.0	38.0
>10 times	6.3	5.6	10.9	77.5	22.5
Demerit points lost as a rider in past 3 years[a]					
None	89.5	90.6	82.2	88.2	11.8*
1–3 points	5.0	5.0	5.1	86.9	13.1
4+ points	5.5	4.4	12.7	69.9	30.1
Ride for commuting					
Rarely	46.4	49.9	22.8	93.6	6.4***
Often	53.6	50.1	77.2	81.4	18.6
Ride on motorways/dual carriageways with 110 km/h limit					
Rarely	61.3	65.0	36.3	92.4	7.6***
Often	38.7	35.0	63.7	78.7	21.3
Ride for sporting purposes (i.e., motor-cross, enduro)					
Rarely	91.3	93.1	79.3	88.8	11.2***
Often	8.7	6.9	20.7	69.3	30.7
Ride off-road					
Rarely	60.2	61.1	53.7	88.5	11.5[NS]
Often	39.8	38.9	46.3	85.0	15.0
Built-up areas					
Rarely	25.1	26.3	17.5	91.1	8.9[NS]
Often	74.9	73.7	82.5	85.8	14.2
Rural road					
Rarely	56.9	59.1	42.0	90.5	9.5**
Often	43.1	40.9	58.0	82.6	17.4
Rider training in past 5 years					
No	62.9	63.2	61.1	87.4	12.5[NS]
Yes	37.1	36.8	38.9	86.4	13.5
Wears fluorescent clothing (conspicuity)[b]					
Yes, always	15.8	16.0	14.7	88.1	11.9[NS]
No, never	75.0	74.3	76.9	86.8	13.2
Sometimes	0.09	0.09	0.08	87.1	12.9

[a]Most traffic infringements incur a minimum penalty of 3 demerit points, which are current for 3 years. A license is suspended if 12 demerit points are incurred.
[b]Unknown for 21 riders.
$^*P \le .1$; $^{**}P \le .05$; $^{***}P \le .001$. NS = Non significant.

commuting, on high-speed motorways, for sport, and on rural roads ($P < .05$), whereas no univariate associations were observed between crash involvement and riding often in built-up areas or off-road or participation in rider training or wearing fluorescent striped clothing as an aid to conspicuity.

Factors associated with crash involvement

Near-crashes, motorcycle type ridden, demerit points, riding purpose (i.e., commuting or sport), and riding on motorways were all associated with having had a crash in the previous 12 months (Table 3).

The odds of having had a crash were 5.3 times higher for those reporting 6–10 near-crashes (adjusted odds ratio [OR_{adj}] = 5.3; 95% CI, 1.29–21.88) compared to those with no near-crash experiences. There was, however, no observed association between the highest near-crash category (10 or more), likely due to the small number of riders reporting this number of near-miss events.

Compared to cruiser riders, sports bike riders had 2.8 times (OR_{adj} = 2.84; 95% CI, 1.11–7.30) and standard bikes had 4 times (OR_{adj} = 4.02; 95% CI, 1.05–15.33) higher odds of having crashed in the past 12 months. There was no difference between sports or standard bike riders in having had a crash ($P = .5$), whereas the adjusted odds of a crash among riders of standard bikes was 1.91 times that of riders of dual/trail bikes, but this was not statistically significant (OR_{adj} = 1.91; 95% CI, 0.55–6.67; $P = .09$).

Riders with 4 or more demerit points had 4 times higher odds of having had a crash (OR_{adj} = 4.09; 95% CI, 1.14–14.74) than those with none and 2.6 higher odds than those with 1–3 demerit points, although this latter comparison was not statistically significant (OR_{adj} = 2.6; 95% CI, 0.65–10.68; $P = .2$).

Riders who often rode for commuting (OR_{adj} = 2.25; 95% CI, 1.09–4.65), for sport (OR_{adj} = 4.39; 95% CI, 1.29–14.88), or on motorways/dual carriageways signed 110 km/h (OR_{adj} = 3.40; 95% CI, 1.59–7.24) had higher odds of having crashed compared to those who rarely rode for those purposes.

There was no association between age or length of time licensed and crashes in the past year, nor was there any interaction between age and license.

Discussion

This study examined the associations between rider characteristics, rider experience, and self-reported crash involvement among the active motorcycling population in New South Wales, Australia. The methodology enabled the identification of factors that are not commonly observed in studies relying on administrative data. The findings highlight the value of population-based approaches to road safety research.

The results identified some motorcycle types (sports and standard) and riding exposures (motorcycle sports, commuting, high-speed roads), a history of near-crash experiences, and traffic violations as being associated with crash involvement. There was no evidence that rider characteristics (i.e., age, license status or length of time licensed, engine size, clothing conspicuity, or rider training) were associated with crash involvement. The lack of association between age or license status and crash involvement is consistent with findings that such factors cease to be predictive when experience and other factors are taken into account (Mullin et al. 2000). Our findings suggest that many of the commonly identified rider-related demographic and exposure factors may be less critical contributors to crashes when viewed across the population.

Rider behaviors such as speeding, alcohol use, and riding unlicensed have previously been associated with crash and

Table 3. Factors associated with having crashed in the past 12 months.[a]

	Univariate (unadjusted)			Multivariable (adjusted)		
Motorcycle crash in past 12 months	Odds ratio (univariate)	95% CI	*P*-value	Odds ratio (adjusted)	95% CI	*P*-value
Number of times just avoided a crash in past 12 months (near-crash)						
No near-crashes	Reference			Reference		
1 or 2 times	1.04	0.38–2.88	0.9	0.72	0.27–1.91	0.5
3 to 5 times	1.70	0.54–5.33	0.3	1.07	0.40–2.90	0.9
6 to 10 times	6.33	1.67–23.97	0.01	5.31	1.29–21.88	0.02
>10 times	3.00	0.69–13.05	0.1	1.2	0.32–4.44	0.8
Motorcycle type						
Cruiser/tourer	Reference			Reference		
Sport	4.64	1.76–12.18	0.003	2.84	1.11–7.30	0.03
Dual/trail	1.81	0.54–6.06	0.3	2.1	0.49–8.99	0.3
Standard	4.57	1.17–17.84	0.03	4.02	1.05–15.33	0.04
Scooter	1.01	0.18–5.69	0.9	0.91	0.15–5.66	0.9
Demerit points lost as a rider in past 3 years						
None	Reference			Reference		
1–3 points	1.12	0.32–3.95	0.9	1.62	0.36–7.26	0.5
4+ points	3.2	0.72–14.31	0.1	4.09	1.14–14.74	0.03
Ride for commuting						
Rarely	Reference			Reference		
Often	3.36	1.60–7.05	0.003	2.25	1.09–4.65	0.03
Ride on motorways/dual carriageways with 110 km/h limit						
Rarely	Reference			Reference		
Often	3.27	1.61–6.62	0.002	3.40	1.59–7.24	0.003
Ride for sporting purposes (i.e., motor-cross, enduro)						
Rarely	Reference			Reference		
Often	3.52	1.41–8.79	0.01	4.39	1.29–14.88	0.02
Time holding a license						
Up to 6 months	Reference			Reference		
7–12 months	1.31	0.14–11.94	0.8	0.62	0.05–7.13	0.7
1–3 years	1.43	0.26–7.89	0.7	1.23	0.20–7.56	0.8
4–15 years	1.5	0.28–8.13	0.6	1.22	0.21–6.98	0.8
16–35 years	0.59	0.09–3.67	0.6	0.51	0.06–4.12	0.5
36+ years	1.05	0.18–6.28	0.9	2.17	0.21–22.40	0.5
Age of rider						
17–25	Reference			Reference		
26–39	0.75	0.32–1.75	0.5	0.72	0.31–1.65	0.4
40+	0.36	0.16–0.80	0.01	0.69	0.22–2.15	0.5
Number of kilometers ridden, on average, per week in past 12 months						
Up to 100	Reference			Reference		
100–300	0.69	0.27–1.74	0.4	0.48	0.21–1.11	0.1
301–400	1.35	0.30–6.07	0.7	0.73	0.19–2.79	0.6
400+	0.51	0.16–1.57	0.2	0.31	0.07–1.39	0.1
Unknown/n.s.	1.04	0.22–4.90	0.9	1.28	0.17–9.43	0.8

[a]Rarely = monthly or never; often = daily or weekly.

injury risk (Elliott et al. 2007; Lin et al. 2003). This is supported by our findings of an association between traffic violations and crash history, particularly because 4 or more demerit points indicates that more than one violation had been committed in the reference period.

The association between frequent riding on high-speed roads (motorways/dual carriageways zoned at 110km/h) and a crash history is more difficult to interpret. Higher speeds are known to be associated with increased risk of crashes, but there is less evidence of increased crash risk for motorcycles associated with high-speed roads per se (Lin and Kraus 2009). It may be that riders who feel more comfortable riding in those environments have overall higher levels or types of exposure. Further work is required to explain this result.

Riders who reported riding for sport were also more likely to have a crash history, which is consistent with evidence that riders whose motivations are driven by performance-related criteria have a higher propensity to crash than other riders (Christmas et al. 2009). The association between sports bikes and crashes is also consistent with a performance orientation and confirmed by other evidence that sports bike riders have a higher crash rate per registered motorcycle than other motorcycle classes (de Rome and Senserrick 2011). The association between standard bikes and crashes is also consistent with previous findings that standard bikes have relatively high crash rates (247) per 10,000 registered motorcycles, compared to sports-unclad (248), scooters (262), and super sports (285; de Rome and Senserrick 2011).

Perhaps the most useful finding is in relation to near-crash experiences. As predictors of a crash history, near-crash experience(s) may be indicative of a riding style that is inattentive or more risky. Three quarters of the respondents reported having at least one near-crash in the past 12 months. The relationship to crash risk was strongest with higher numbers of near-crash experiences. Although infrequent (~10%) in this sample, violations of speed and errors related to control of the motorcycle were found to be associated with an increased the risk of near-crashes, which is consistent with other research (Elliott et al. 2007; Sakashita et al. 2014).

Further research is necessary to clarify whether numbers of near-crashes are predictive of crashing or the experience of a crash increases recall of previous incidents. If the predictive value is confirmed, this may provide evidence for rider training programs to encourage riders to develop the habit of reflecting on their riding to identify what they could have done better, particularly in cases of near-crashes. Building personal competence and resilience by learning from experience has been effective in reducing driving offenses and crash involvement for young novice drivers and may prove useful for novice riders (Griffin et al. 2004; Senserrick et al. 2009).

The robust sampling frame was the key strength of the study. This achieved a representative sample with demographic details, riding characteristics, riding experiences, and self-reported crashes linked, allowing estimation of the population at risk of future crash involvement. Unlike many other large-scale studies, we sampled across the population of riders rather than inviting volunteers, thereby overcoming the limitations of cross-sectional samples that cannot be generalized to the whole population (Ciol et al. 2006). The system of mandatory photographic licenses was a further advantage because it requires all individuals to attend a motor registry in person to renew their licenses. This gives every rider an equal chance of being recruited for the study and was cost effective, allowing the survey to be conducted at a number of registries simultaneously.

There were some limitations to the study. As a survey, data were based on self-reports, with the inherent risk of participants presenting more favorable than accurate responses, and may have underestimated the actual prevalence of unlawful riding in this population. However, there is little evidence of social desirability bias in the literature on self-reported risky behavior (Lajunen and Summala 2003; Sullman and Taylor 2010), and high levels of accuracy have been found in young drivers' self-reports of police-recorded car crashes (Begg et al. 1999; Boufous et al. 2010). Noting this limitation, we acknowledge that in-depth crash investigation and naturalistic studies offer alternative ways to explore factors associated with crashes but are known to be expensive and take considerable time and hence they are relatively few in number (Allen et al. 2013; Day et al. 2013; Haworth et al. 1997; see Shinar [2017] for review). With the population-based sampling method and use of survey logistic regression as appropriate for the survey design, we assert the findings to be robust and of value.

With respect to generalizability of observed factors associated with crashes, we note the use of a broad definition of crashes. In addition to police-reported casualty crashes, the adopted definition included minor spills. This was intended to encompass all crashes including those that would not have been reported to the police. This strategy resulted in 12% of participants reporting crash involvement, whereas less than 2% would have been expected if limited to police-reported crashes. Due to time limitations in the administration of the survey questionnaire, detailed data for these crashes and associated treatment for injuries were not collected; however, future studies would be well served to do so.

In addition, motor registries servicing rural and remote areas with low population density were excluded for reasons of efficiency. However, the proportion of registered motorcycle owners living in those regions was used to determine the required sample sizes for those quartiles. Nonrespondents are also a potential source of bias. Though it was not possible to determine whether participants were different from nonparticipants in terms of the data collected, the distribution of the preweighted sample was relatively closely aligned with the New South Wales motorcycle registrations database in terms of age and sex.

These results provide important population-level information about motorcyclists' risk exposure. It identified factors not commonly observed in studies relying on administrative data, highlighting the value of the population-based survey approach. Perhaps most important, the study highlights the significance of multiple near-crash experiences as being associated with crash involvement. That near-miss crashes are associated with crashes, including police-reported casualty crashes, is perhaps unsurprising. Whether these near-miss events are associated solely with the riders' own behaviors, that of other road users, or route-based environmental factors should be examined in future studies. Regardless of the underlying reasons, it is suggested that riders use such experiences as learning opportunities to improve their personal safety, and policymakers can use this same information to develop targeted programs focused on improving the safety of the motorcycle community.

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