The Austroads in-depth study of motorcycle crashes in NSW: Causal relationship findings

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Introduction

Motorcyclists represent 16% of fatalities and 22% of serious casualties on Australian roads each year (ATC, 2011), with little change in casualty numbers over the last decade (Transport NSW, 2012). To develop effective countermeasures, there is a need for detailed understanding of risk factors influencing motorcycle crashes. In-depth investigation is the best method for collecting high levels of detail about crashes. The last Australian in-depth study occurred in 1997 (Haworth, 1997) and a number of significant motorcycle interventions have been implemented since that time (e.g., graduated licence schemes, numerous education and awareness campaigns). To identify risk factors for crashes emerging since then, the Australian road and transport agencies commissioned a new in-depth study of motorcycle crashes. The aims of this study were to: 1. Examine causal relationships between human, vehicle, road and other environmental factors and motorcyclists in serious injury crashes, and 2. examine the influence of the total system on the injuries sustained by seriously injured motorcyclists. This paper summarises the causal relationship findings from this study.

Method

To achieve these aims, this study used a case-control in-depth investigation approach coupled with expert multidisciplinary review of crashes. Case riders were motorcyclists aged 16 years or older who were admitted to a study hospital following a crash on a public road between August 2012 and July 2014. Study hospitals included three major trauma hospitals, two in urban Sydney and one in regional NSW. For inclusion, the crash had to have occurred within a four hour drive of Sydney and the rider must have sustained at least one injury that was able to be coded to the Abbreviated Injury Severity Scale (AIS) (AAAM, 2005). Data recruitment and collection followed ANCIS protocols. In short, participating riders were interviewed, their medical records reviewed, and injuries coded to the AIS. The crash scene, motorcycles and equipment used were inspected and photographed, usually within 2 weeks of the crash. Crash scene inspections included a video drive through from both the case and opposing direction perspectives. Collected data was entered into an electronic database, and 4 page summaries of each case were prepared. Case summaries, including the full set of photographs and video drive through were then presented to a multidisciplinary expert review panel. The panel consisted of NeuRA researchers and engineers, a leading trauma forensic pathologist, road engineering and motorcycling experts from the NSW Centre for Road Safety, motorcycle safety research and crash investigation experts and behavioural scientists. Using their combined expertise, the panel identified key contributory factors in each crash and injury outcome using the Haddon Matrix as a framework (Haddon Jr 1972).

Controls were riders who had ridden the same road where the crash occurred but had not crashed at this location. A minimum of one control per crash location was sought but there was no limit placed on the maximum numbers of controls per case. Recruitment occurred via a study website that invited riders to participate and listed sites for which controls were needed. The website was promoted through motorcycle community organisations and the NSW Roads and Maritimes Services website. Riders who registered on-line received a unique link to the control rider survey by email. Riders were also encouraged to visit the web site using study brochures that were attached to parked motorcycles and by advertisements placed in newspapers local to the crash locations. The control survey was completed on-line and consisted of all the questions asked of case riders with the exception of questions about the crash.

The case–control analysis tested the hypothesis that rider and/or trip characteristics will differ between motorcyclists who are involved in a crash at a particular location and those who are not. To test this hypothesis while controlling potential confounders, conditional logistic regression accounting for the 'one:many' control sample design was used to perform the case control analysis. The outcome variable was whether or not the rider belonged to the case or control sample. Due to the large number of potential variables, model building was done in two steps. In Step 1, rider characteristic variables with a significant association ($p<0.05$) with the outcome were used in a backwards stepwise selection procedure as described by Hosmer and Lemeshow (2000) with entry to the model set at $p=0.25$ and exit set at $p=0.15$. Variables remaining in the final model were seen as 'important' rider characteristics and were used in Step 2 of the modelling process. In Step 2, trip characteristic variables with a significant association ($p<0.05$) with the outcome were used together with the 'important' rider characteristics in a second backwards stepwise selection procedure with entry to the model also set at $p=0.25$ and exit set at $p=0.15$. Potential interactions between all variables included in the final model were then explored and the assumption of linearity checked for any remaining continuous variables. Odds ratios and 95% confidence limits for the variables included in the final model were also calculated.

Data generated during the panel reviews and information in the final cases summaries were used to conduct a qualitative analysis of crash and injury causation factors. This involved content analysis conducted by a single researcher in consultation with other investigators achieved by reading and sorting of ideas thematically to describe contributory factors using the Haddon Matrix as a framework. For this analysis, the themes and content generated by this qualitative analysis, relevant to the variables included in the final model generated above were reviewed to provide additional meaning to the quantitative results.

Results

The final case-control sample included 99 crashed riders and 336 control riders. Results from Step 1 and Step 2 of the conditional logistic regression analysis are presented Table 1 and Table 2.

Table 1: Step 1-Final logistic regression model, 'important' rider characteristics (* denotes variables significantly associated with the outcome variable)

Variable	**Category**	**N (%)**		**Univariate**			**Multivariate**			
		Case	**Control**	**p value**	**OR**	**95%CI**	**p value**	**OR**	**95%CI**	
Bike Type*	Other	45(46)	266(79)	-			-			
	Sports	53(54)	70 (21)	0.001	4.65	2.58-8.37	0.001	19.73	3.26	119.43
Bike Familiarity*	Very Familiar	63(71)	296(89)	-			-			
	Other	26(29)	37(11)	0.0005	3.32	1.69-6.52	0.038	11.25	1.14	110.91
Off road riding	Yes	36(41)	201(62)	-			-			
	No	52(59)	125(38)	0.021	1.87	1.10-3.19	0.079	4.39	0.84	22.86
Protective Clothing*	*Continuous*	Mean 0.44, SD0.50	Mean 0.83 SD0.37	<0.001	0.45	0.34-0.60	0.002	0.23	0.09	0.59

Table 2: Step 2Final logistic regression model (shading and * denotes variables significantly associated with the outcome variable)

Variable	**Category**	**N (%)**		**Univariate**			**Multivariate**			
		Case	**Control**	**p value**		**95%CI**	**p value**	**OR**	**95%CI**	
Bike Type*	Other	45(46)	266(79)	-			-			
	Sports	53(54)	70 (21)	0.001	4.65	2.58-8.37	0.001	19.70	3.30	119.40
Bike Familiarity*	Very Familiar	63(71)	296(89)	-			-			
	Other	26(29)	37(11)	0.0005	3.32	1.69-6.52	0.004	10.29	2.13	49.66
Age*	*Continuous*	Mean 37.3 SD15.2	Mean 50.1 SD13.9	<0.001	0.95	0.93-0.97	0.001	0.92	0.88	0.97
Protective clothing*	*Continuous*	Mean 0.44, SD0.50	Mean 0.83 SD0.37	<0.001	0.45	0.34-0.60	0.008	0.50	0.30	0.84
Heavy traffic*	No	82(93)	194(58)	-			-			
	Yes	6(7)	142(42)	<0.001	0.05	0.02-0.16	<0.001	0.03	0.004	0.16
Fast but boring*	No	82(93)	237(71)	-			-			
	Yes	6(7)	99(30)	0.0005	0.21	0.08-0.50	0.002	0.08	0.02	0.37
Trip Familiarity*	Other	41(48)	287(89)	-			-			
	Daily	45(52)	34(11)	<0.0001	11.0	4.45-26.94	0.008	5.50	1.55	19.51
Trip Purpose*	Recreation	33(36)	189(59)	-			-			
	Commuting/Transport*	34(37)	69(22)	0.052	2.22	0.99-4.98	0.049	0.19	0.04	0.99
	Other	25(27)	63(20)	0.347	1.48	0.67-3.33	0.813	1.26	0.19	8.24

Potential interactions between the variables in the final model were explored and a significant interaction between age and bike type was identified (see Figure 1).

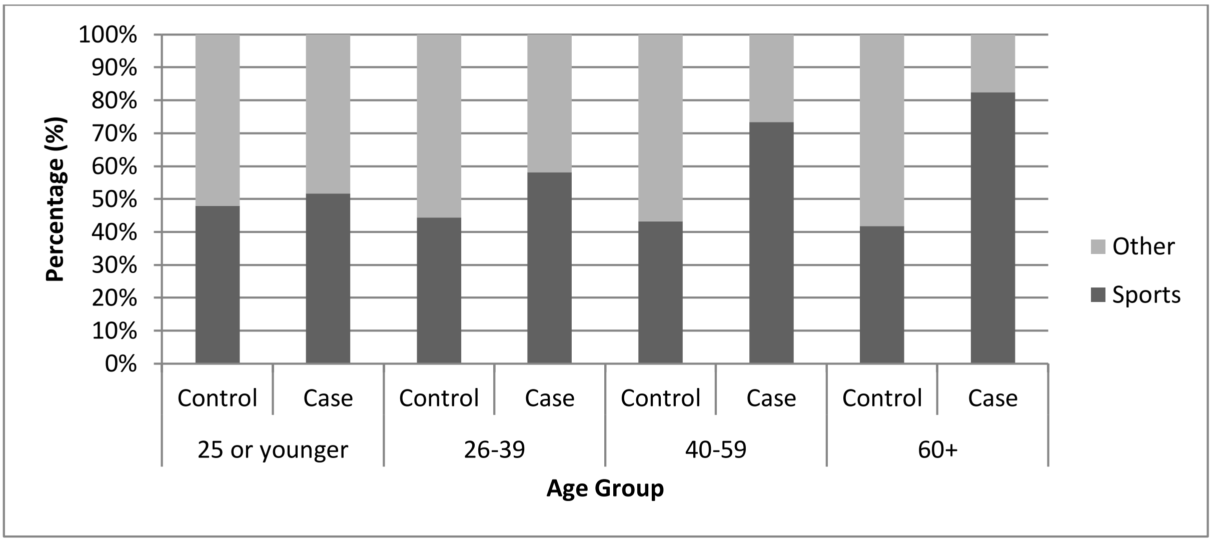

Figure 1: Variation in relationship between motorcycle type and being in crash sample by age

From the qualitative analysis, familiarity with the route was raised as a potential factor in a number of crashes. Route unfamiliarity was discussed as a factor in crashes involving cornering errors. However, route familiarity was also raised in crashes where the rider failed to stop in time. Unfamiliarity with the motorcycle being ridden was discussed as a factor in a number of crashes and manifested in inexperienced riders riding new bikes, and experienced riders moving from one motorcycle type to another.

Discussion

The findings of this study indicate that the type of motorcycle being ridden, the rider's familiarity with the motorcycle being ridden, familiarity with the crash location, the rider's use of protective equipment and age of the rider are key indicators of motorcycle crash risk. Differences in the nature of the trip between riders who crashed (cases) and those who did not (controls) might also be important. Interestingly, the elevated crash risk associated with sports bikes was more prominent among older riders.

Importantly, it may not be the type of motorcycle that increases risk, but rather characteristics of riders and/or the riding activities undertaken on the different motorcycle types. Motorcycle unfamiliarity as a risk factor is consistent with a New Zealand population based case-control analysis (Mullin et al, 2000) and observations made by Haworth et al (1997). Interestingly this also aligned with observations in the qualitative study. Route familiarity as a crash factor appears to be an uncommon finding among motorcycle crash risk literature, but is consistent with road user behaviour theories that suggest familiarity might lead to automatic behaviour, reduced attention and increased reckless behaviour (Rosenbloom et al, 2007). However, as the control recruitment method relies on the self-report of the control rider's actually riding through the crash location, and exposure to high risk roads was not controlled, this finding needs further confirmation. Unfamiliarity with the route being ridden was also identified as a contributory factor in the qualitative analysis. Together, these findings suggest a possible non-linear relationship between route familiarity and crash risk.

The protective effect observed with commuting or general transport compared to recreational purposes aligns with observations by Haworth et al (1997) who reported an increase in risk associated with non-work-related trips compared to work related trips. More recently Moskal et al (2012) also identified a protective effect for commuting riding compared to recreational riding. Coupled with our findings related to differences in the type of riding between case and control riders, this suggests further study of mechanisms (such as rider mindset/attitude) underlying these associations might be worthwhile.

Finally, the observed inverse association between the use of protective clothing – as measured by number of items worn, and being involved in a crash ought not to be construed to mean protective clothing provides any benefit in terms of crash avoidance. Rather, it it is likely that there is something intrinsically different, such as attitudes to riding and/or risk taking behaviour associated with the use of protective clothing that is also associated with a reduced likelihood of crashing. Further analysis will be undertaken to examine the nature of clothing worn by different rider-motorcycle type combinations, as well as other demographic factors. It may also be the case that this association is amplified by the crash sample representing a serious injury sample, as non-use of protective clothing has been shown to be associated with an increased likelihood of hospitalisation after a motorcycle crash due to injuries sustained (de Rome et al, 2011).

Among the limitations of this work is the fact that the control sample may not be drawn from the same population of riders included as cases. To minimise this limitation, we re-ran the model used to identify 'important rider characteristics' in the case-control analysis using data collected during a population referenced survey of motorcycle riders across NSW, and all variables remained significantly associated with the outcome of being in the crash sample. For more details on this population sample of riders see de Rome et al (2013).

Concluding comment

The findings presented here present a number of novel findings but also reinforce previous research that has found motorcycle type, for instance, is significantly associated with crash risk. These data can be used to communicate to all road users the risk and protective factors for motorcycles, and programs can be tailored to focus on these areas as a means to improving the safety of motorcyclists.

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