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Exposure survey of motorcyclists in New South Wales

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Abstract

This paper reports the results of an exposure survey of 794 registered motorcycle riders, with an average of 18.1 years of riding experience, in the State of New South Wales, Australia. Respondents completed two postal surveys, separated by about 6 months, that included items relating to their crash history, riding patterns, characteristics of their motorcycle, and its odometer reading. Odometer readings indicated that respondents rode a mean of 5208 km each year, and that annual exposure was related to gender, motorcycle type, and dominant riding location, time of week, and purpose. The amount of riding reported for different purposes changed with age, with older riders more likely than younger riders to ride for recreational reasons and on weekends. The mean crash rate (based on self-reported crash involvement) was 0.96 crashes/100,000 km. The crash rate declined with age, was highest in the Sydney metropolitan area, was lowest for motorcycles with large engines, and was highest for trail and dual-use motorcycles. There was a relationship between annual exposure and crash risk such that riders who rode relatively little had higher crash risks (per 100,000 km travelled) than riders who rode more often. A cluster analysis identified three groups of riders with higher-than-average risks of crash involvement.

Keywords: Motorcycle; Exposure; Crash involvement; Survey

1. Introduction

The casualty crash risk of motorcycle riders in countries, such as Australia, Canada, USA, and the United Kingdom is up to 17–20 times that of car occupants, controlling for distance travelled (Nairn, 1993; Presseur et al., 1995). In New South Wales (a State of Australia with a population of 6.6 million) it is estimated that the casualty risk per distance travelled for motorcycle riders is about sixteen times that for occupants of passenger cars and similar vehicles (Roads and Traffic Authority (RTA), 2001).

The pattern of crashes in New South Wales (NSW) is one where motorcycle crash reductions achieved to the mid-1990s have not been sustained in recent years. There was an average annual 4.6% increase in motorcycle fatalities from 1997 to 2002, compared to an average annual decrease of 0.5% in fatalities across all road user types (Australian Transport Safety Bureau (ATSB), 2003).

Consistent with other countries, Australia has had a resurgence of interest in motorcycling—especially amongst older road users who either take up riding as a new activity or who are returning to riding after a period of absence. The number of registered motorcycles in New South Wales increased by about 30% to about 100,000 in the 10 years to 2002, and the average distance ridden by Australian motorcyclists over 55 years of age increased by about 80% between 1991 and 1999 (Christie and Harrison, 2001).

The development of motorcycle safety measures has been hampered by the absence of reliable exposure data. The vehicle-use surveys conducted by the Australian Bureau of Statistics (ABS) are believed to be less reliable for motorcyclists than for other road user groups (Christie and Harrison, 2001). Exposure data disaggregated by rider and motorcycle characteristics, and by trip characteristics and purpose would provide better information about crash risk for different rider, motorcycle, and trip combinations that could

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then be used as the basis for targeting motorcycle safety measures.

The study reported here was funded by the New South Wales Motor Accidents Authority to improve knowledge about exposure patterns amongst riders. It involved two repeated surveys of a sample of owners of registered motorcycles in New South Wales in which one of the items requested odometer readings from the motorcycle. This provided a measure of riding exposure on that motorcycle in the period between surveys that was considered more reliable than a retrospective estimate of riding behaviour. The data collected from the surveys were then used to investigate exposure and crash patterns amongst the sample of riders. While there are a number of sampling problems that make generalisation to the population of riders in New South Wales difficult, the study provides an initial indication of riding activity and crash risk that is expected to be of general interest.

2. Method

2.1. Participants and procedure

The NSW Roads and Traffic Authority (RTA—the licensing and registration authority) assisted in drawing a random sample of 6000 registered motorcycle owners from its database. The sample was stratified to match the motorcycle distribution in NSW with 45% from the Sydney Statistical Division, 20% from the Hunter Statistical Division (including and surrounding the city of Newcastle—a major industrial centre North of Sydney), and the balance (35%) from the rest of New South Wales. The study was conducted in two parts—an initial mail out to this random sample of owners of registered motorcycles, followed 6 months later by a further mailing to those who returned completed survey forms to collect a second odometer reading and information on usage patterns.

Selecting a sample based on registered motorcycles was thought preferable to one based on licensed riders, as many motorcycle licence holders are inactive or dormant. The ratio of licensed riders to registered motorcycles in NSW is about 3:1 (Christie and Harrison, 2001). While it is likely that a currently registered motorcycle is being used on-road and at some risk of crash involvement, it cannot be assumed that a person holding a motorcycle licence is an active rider.

A blind technique was used to protect the privacy of those in the sample such that the researchers did not know the names or addresses of owners drawn for the survey. The RTA's mailing contractor handled the mailing of survey questionnaires, with the surveys being dispatched on 20 January 2002 and again on 11 July 2003. A return period of 3 weeks was allowed for both the first and second stages with participants asked to return their completed surveys in the supplied postage-paid envelopes.

Incentives were offered for participation in both surveys. These were the opportunities to win a full set of motorcycle leathers comprising jacket, trousers, boots, and gloves, together with a premium-brand, full-face motorcycle helmet.

A total of 2226 surveys were returned from the initial mailing (a return rate of about 37%). This formed the database for the follow-up (Stage 2) mail out. The second and final mailing yielded 1010 survey returns (a return rate of about 44%). Of these, 794 follow-up surveys were usable. The remaining 216 participants had either not supplied odometer readings at all, not supplied the second odometer reading, supplied clearly erroneous or illegible readings, not supplied details of their motorcycle, or had purchased a new motorcycle during the study period.

The proportion of returns from the Sydney statistical district was equal to the proportion in the initial stratified sample (i.e. 45%). However, the proportion for the Hunter statistical district was considerably lower (12.6%) than in the initial stratified sample (i.e. 20%).

When participants who responded to the follow-up survey were compared to those who did not, it was found that older riders were more likely to return the second survey than were younger riders (riders in the oldest age quartile had a response rate of 50%, compared to a response rate of 37% for riders in the youngest age quartile) ($\chi^2_{(3)} = 27.1$, $p < .001$), and that riders who estimated that they rode relatively large amounts each year were more likely to return the second survey (Kruskal–Wallis $H_{(1,2181)} = 19.3$, $p < .001$). Response rates in the second survey were not significantly related to the type of motorcycle, gender, licence type, self-reported accident record, or place of residence.

2.2. Survey content and data analysis

The two surveys were almost identical. They collected identifying information (name, address, and telephone number); information about the respondent's motorcycle (registration number, make, model, year of manufacture, engine size and odometer reading, and the date of the reading); information about the rider (gender, age, licence type, the number of years they have held a motorcyclist licence); information about their riding (estimates of riding distance in the preceding week, month and year, and the percentage of their riding that occurred in different riding contexts, at different times of the week, and for different purposes), and the number of crashes they had been involved in during the preceding 5 years. Where riders owned more than one motorcycle, they were asked to nominate the one they use most often, and to provide information for that motorcycle. Analysis of data derived from items that were repeated in the second survey was based on responses in that survey.

An estimate of riding exposure (distance) was calculated for each rider as the difference between odometer readings multiplied by 365 divided by the number of days that elapsed between the two of the odometer readings. Analysis of the survey data relied on descriptive techniques and parametric statistical tests where possible. Analysis of exposure data was forced to rely on non-parametric tests because of their non-normal distribution.

3. Results

3.1. Description of survey participants

The majority of respondents were males ($n = 738$, 93%). Males were significantly older than females ($t_{(773)} = 2.52$, $p < .05$), with a mean age of 44.2 years compared to 40.1 years. Respondents reported a mean of 18.1 years of riding experience, and males had significantly more time as a licensed rider (mean of 20.2 years) than females (7.4 years)($t_{(773)} = 7.21$, $p < .05$).

Eight makes of motorcycle (out of 22 in the data set) accounted for more than 95% of all motorcycles in the sample (in descending order Honda, 25.1%; Yamaha, 19%; Suzuki, 12.4%; Kawasaki, 13.1%; BMW, 9.9%; Harley–Davidson, 8.7%; Ducati, 3.9%; Triumph, 3.3%). Make and model information provided by respondents was used to allocate each motorcycle to a "type" variable by classifying them against 7 of the 10 basic types based on structure, configuration, and intended use that appeared in National Highway Traffic Safety Administration and Motorcycle Safety Foundation (2000) and are commonly used within the motorcycle industry (i.e. traditional/naked, sports, cruiser, tourer, sports-tourer, trail/dual-purpose, and scooter). Due to their low numbers, trikes and motorcycle–sidecar combinations were not included in the first survey sample. There were also no mopeds/nopeds in the second sample. As only 10 sports-tourer type motorcycles appeared in the sample, these were excluded from any analysis by type.

Sports-style motorcycles were the most common, accounting for almost 40% of motorcycles owned by respondents. This was followed by cruiser-style motorcycles (18.4%), traditional/naked motorcycles (14.1%), and trail/dual use motorcycles (13.1%). The least common were touring-style motorcycles (8.6%) and scooters (3.9%).

Age and time since licensing were both related to the type of motorcycle ridden ($F_{(5,\ 773)} = 17.97$, $p < .05$ and $F_{(5,\ 764)} = 11.36$, $p < .05$, respectively). Sports-style motorcycles tended to have younger, less-experienced riders than other styles, and touring-style motorcycles tended to have older, more-experienced riders. Age and time since licensing were also both related to place of residence ($F_{(5,\ 789)} = 10.37$, $p < .05$; $F_{(5,\ 780)} = 11.30$, $p < .05$ respectively). The youngest and least experienced riders lived in the Sydney area.

3.2. Exposure based on odometer readings

Based on the two of the odometer readings, respondents had a mean annual riding exposure of 5208 km and a median of 3576 km. The distribution was strongly positively skewed. Only 12% of riders had an estimated annual exposure of more than 10,000 km, and 25% of respondents had annual exposure estimates of 1500 km or less.

Annual exposure was related to motorcycle type (Kruskal–Wallis $H_{(6,\ 790)} = 55.7$, $p < .05$). The pattern of results from a series of pairwise analyses indicated that annual riding exposure on sports (median of 4303 km) and touring (median of 5356 km) motorcycles was significantly greater than that on trail/dual use motorcycles (1703 km) and scooters (1780 km). Traditional (3478 km) and cruiser (3366 km) types occupied the middle ground. There were no significant differences between the exposure estimates for the eight most common makes of motorcycle (overall, Kruskal–Wallis $H_{(7,\ 756)} = 12.06$, $p > .05$). Annual exposure was not significantly related to place of residence or age group (where participants were divided into four age groups by quartile: 18–33, 34–42, 43–50, and 51–79 years).

The surveys collected estimates of riding activity on different types of roads, at different times of the week, and for different purposes. These estimates (percentages) were applied to each rider's estimated annual riding exposure based on their odometer reading to provide an estimate of the amount of riding in each context. These are shown in Table 1. The median riding exposure across the sample was greatest for riding on suburban roads or roads in towns, followed closely by riding on rural two-way roads and highways. The median level of riding on freeways was lower, and very little riding occurred on other types of road. Riding exposure was similar on weekdays and weekends, and recreational riding dominated riding exposure, followed by riding for commuting purposes. Riding for work purposes or for other reasons were less common.

Table 1 also shows the median levels of riding exposure for each riding context, time, and purpose further disaggregated by gender and age. Statistically significant relationships are shown in boldface, based on the Kruskal–Wallis test and setting the type I error level for each test at .05. Where differences between specific groups are discussed below, they are based on pairwise comparisons.

Males rode significantly more than females in general and on weekdays. There was no overall difference in annual riding exposure between rider age groups (defined in quartiles as noted earlier), but younger riders rode more on roads in cities, towns, or suburbs than did the other age groups; riders in the youngest quartile rode more than riders in the oldest quartile on freeways and multi-lane highways in urban areas; riders in the youngest quartile rode more than riders in the third quartile on weekdays; riding for commuting declined with age; riders in the oldest quartile rode more than riders in the first and second quartiles for pleasure and recreation.

The age data, therefore, suggest that urban commuting declines with age, and that riding for pleasure increases with age. These trends appear to cancel each other—there were no overall differences in exposure between the four age groups.

Table 2 shows the median levels of riding exposure for each riding context, time, and purpose further disaggregated

Table 1
Median annual riding exposure (km) for different riding contexts disaggregated by rider gender and age

	Across sample	Gender		Age quartile			
		Male	Female	1	2	3	4
Annual exposure	3576.9	**3636.9**	**2759.5**	4185.3	3273.5	3665.9	3305.2
Suburban roads	923.1	945.1	715.8	**1336.2**	**861.3**	**783.1**	**833.1**
Rural two-way roads and highways	798.4	810.2	414.9	541.5	700.2	1006.5	960.6
Urban multi-lane (including freeways)	99.2	102.8	13.8	**200.8**	**100.5**	**117.7**	**0.0**
Rural multi-lane (including freeways)	65.1	65.1	67.2	27.5	16.6	104.6	105.4
Other types of road	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riding on weekdays	1136.0	**1232.8**	**440.4**	**1581.4**	**894.8**	**947.1**	**1373.3**
Riding on weekends	1307.1	1316.1	1196.5	1248.5	1300.0	1732.2	1189.5
Commuting	192.5	192.5	161.0	**782.1**	**529.7**	**117.7**	**0.0**
For pleasure or recreation	1591.7	1594.5	1307.0	**1244.5**	**1369.5**	**1708.1**	**2173.2**
Work	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other reasons	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Significant differences in median annual exposure between males and females, or between the four age quartiles (using the Kruskal–Wallis test, $p < .05$) are shown in boldface.

by area of residence. The Illawarra area includes and surrounds the city of Wollongong—another industrial centre south of Sydney. Statistically significant relationships are shown in boldface, as in Table 1.

Total annual exposure was not significantly related to area of residence, but there were differences in the pattern of riding exposure between the four areas. Sydney riders rode more than riders in any other group on roads in cities, towns and suburbs. Riding exposure on two-way roads and highways in rural areas was highest for residents of the rest of the state, and least for residents of Sydney.

Riding exposure on urban freeways and multi-lane roads was highest for Sydney residents, and least for residents of the rest of the state. Although all the median exposure estimates for other road types were all 0.0 km, riders in the rest of the state were significantly more likely to ride on these roads than were riders in the three urban areas. Riders in Sydney had higher levels of exposure for commuting-related riding than those in the other areas.

Table 2
Median annual riding exposure (km) for different riding contexts disaggregated by area of residence

	Area of residence			
	Sydney	Hunter	Illawarra	The rest
Annual exposure	3763.4	2869.6	2966.8	3529.9
Suburban roads	**1491.7**	**705.9**	**728.4**	**492.8**
Rural two-way roads and highways	**496.2**	**673.1**	**609.0**	**1639.0**
Urban multi-lane (including freeways)	**252.4**	**102.8**	**96.7**	**0.0**
Rural multi-lane (including freeways)	96.6	54.6	67.5	21.3
Other types of roads	**0.0**	**0.0**	**0.0**	**0.0**
Riding on weekdays	1394.3	1186.7	995.6	887.2
Riding on weekends	1301.5	1081.7	1219.7	1689.6
Commuting	**426.7**	**27.3**	**112.9**	**86.5**
For pleasure or recreation	1476.8	1615.0	1333.9	1966.3
Work	0.0	0.0	0.0	0.0
Other reasons	0.0	0.0	0.0	0.0

Significant differences in median annual exposure between areas of residence (using the Kruskal–Wallis test, $p < .05$) are shown in boldface.

The residence-related exposure data suggest, unsurprisingly, that riders tend to ride on the road types that are available locally.

Table 3 shows the median levels of riding exposure for each riding context, time, and purpose further disaggregated by type of motorcycle.

The overall exposure pattern for motorcycle type was noted earlier. Exposure on rural two-way roads and highways was lower for trail bikes and scooters than for all other types, and cruisers had significantly higher exposure levels on these roads than traditional-style motorcycles. Trail bikes and scooters had significantly lower levels of exposure on urban freeways and highways than all other types with the exception of traditional motorcycles.

Touring motorcycles had significantly higher exposure on rural freeways and highways than all other motorcycle types with the exception of cruisers, and higher exposure levels on weekdays than cruiser-style motorcycles or trail bikes. Cruiser, sports, and touring-style motorcycles had higher exposure levels on weekends than traditional-style motorcycles, trail bikes, and scooters.

Sports-style motorcycles had significantly higher exposure for commuting-related riding than cruiser-style motorcycles. Cruiser, sports, and touring-style motorcycles had higher exposure levels for recreation-related riding than traditional-style motorcycles, trail bikes, and scooters.

3.3. Crash rate estimates

Respondents reported the number of crashes of all types in which they were involved as a rider (regardless of severity or fault) in the preceding 5 years. The crash rate was calculated for defined groups of participants by dividing the total number of self-reported crashes/year in that group by the total annual

Table 3
Median annual riding exposure (km) for different riding contexts disaggregated by rider type of motorcycle

	Types of motorcycles					
	Traditional	Cruiser	Sports	Touring	Trail/dual use	Scooter
Annual exposure	**3478.0**	**3366.3**	**4303.1**	**5356.2**	**1703.7**	**1780.2**
Suburban roads	**1106.7**	**798.6**	**1056.6**	**911.9**	**340.3**	**978.5**
Rural two-way roads and highways	**671.3**	**1291.3**	**1004.3**	**1544.2**	**147.7**	**30.4**
Urban multi-lane (including freeways)	**2.3**	**150.1**	**191.7**	**243.0**	**0.0**	**0.0**
Rural multi-lane (including freeways)	**0.0**	**162.7**	**135.4**	**416.9**	**0.0**	**0.0**
Other types of roads	**0.0**	**0.0**	**0.0**	**0.0**	**196.5**	**0.0**
Riding on weekdays	**1945.6**	**759.8**	**1162.8**	**1954.5**	**804.6**	**1341.4**
Riding on weekends	**851.3**	**2066.0**	**1682.2**	**2040.8**	**616.8**	**327.4**
Commuting	**360.5**	**0.0**	**421.5**	**43.3**	**111.0**	**609.0**
For pleasure or recreation	**1139.6**	**2234.1**	**1770.5**	**2766.2**	**674.2**	**395.1**
Work	0.0	0.0	0.0	0.0	0.0	0.0
Other reasons	0.0	0.0	0.0	0.0	0.0	0.0

Significant differences in median annual exposure between motorcycle types (using the Kruskal–Wallis tes, $p < .05$) are shown in boldface.

estimate of kilometres ridden based on odometer readings. The rate was expressed as the number of crashes/100,000 km travelled.

All participants together had 199 crashes in the preceding 5 years, and the total exposure estimate for all participants was 4,135,681 km/annum. This equates to a crash rate of 0.96 crashes/100,000 km across the whole sample. Crash rate estimates are shown for different subgroups of riders in Table 4.

Male and female riders had similar crash rates. Crash rates appear to decline with age, with the crash rate for the youngest quartile being over three times that of members in the oldest quartile. Crash rates in Sydney were at least 50% higher than in other areas of New South Wales, and crash rates were generally inversely related to engine size, although the highest crash rate was for motorcycles with engine capacities between 251 and 500 cc. Trail and dual-use motorcycles had a crash rate that was more than twice the crash rate of sports-style motorcycles, which in turn was at least 50% above that of other types.

Fig. 1a shows crash risk disaggregated by age. Fig. 1b shows the same crash risk estimates, but disaggregated by

Table 4
Crashes, exposure, and crash rate disaggregated by rider and motorcycle characteristics

Variable	Group	*N*	Self-reported crashes in previous 5 years (sum of all reported crashes for group members)	Total of annual exposure estimates (sum of annual estimates for group members)	Crash rate (crashes/100,000 km)
All participants		794	199	4,135,681	0.96
Gender	Male	739	189	3,941,734	0.96
	Female	55	10	194,127	1.03
Age	Youngest quartile	199	97	1,136,010	1.71
	Second quartile	183	28	887,058	0.63
	Third quartile	205	46	1,060,789	0.87
	Oldest quartile	206	25	1,040,291	0.48
Residence	Sydney	358	125	2,002,895	1.25
	Hunter	100	20	503,869	0.79
	Illawarra	69	9	358,088	0.50
	Rest of state	267	45	1,271,008	0.71
Engine size	Up to 250 cc	185	39	659,117	1.18
	251–500 cc	30	14	98,244	2.85
	501–750 cc	188	44	981,737	0.90
	751–1000 cc	193	56	1,183,299	0.95
	1001–1250 cc	119	29	778,868	0.74
	Over 1250 cc	76	17	416,315	0.82
Motorcycle	Traditional	112	18	593,350	0.61
	Cruiser	146	24	753,479	0.64
	Sports	319	95	1,800,613	1.06
	Touring	68	15	490,843	0.61
	Trail/dual use	104	39	331,640	2.35
	Scooter	31	2	100,529	0.40

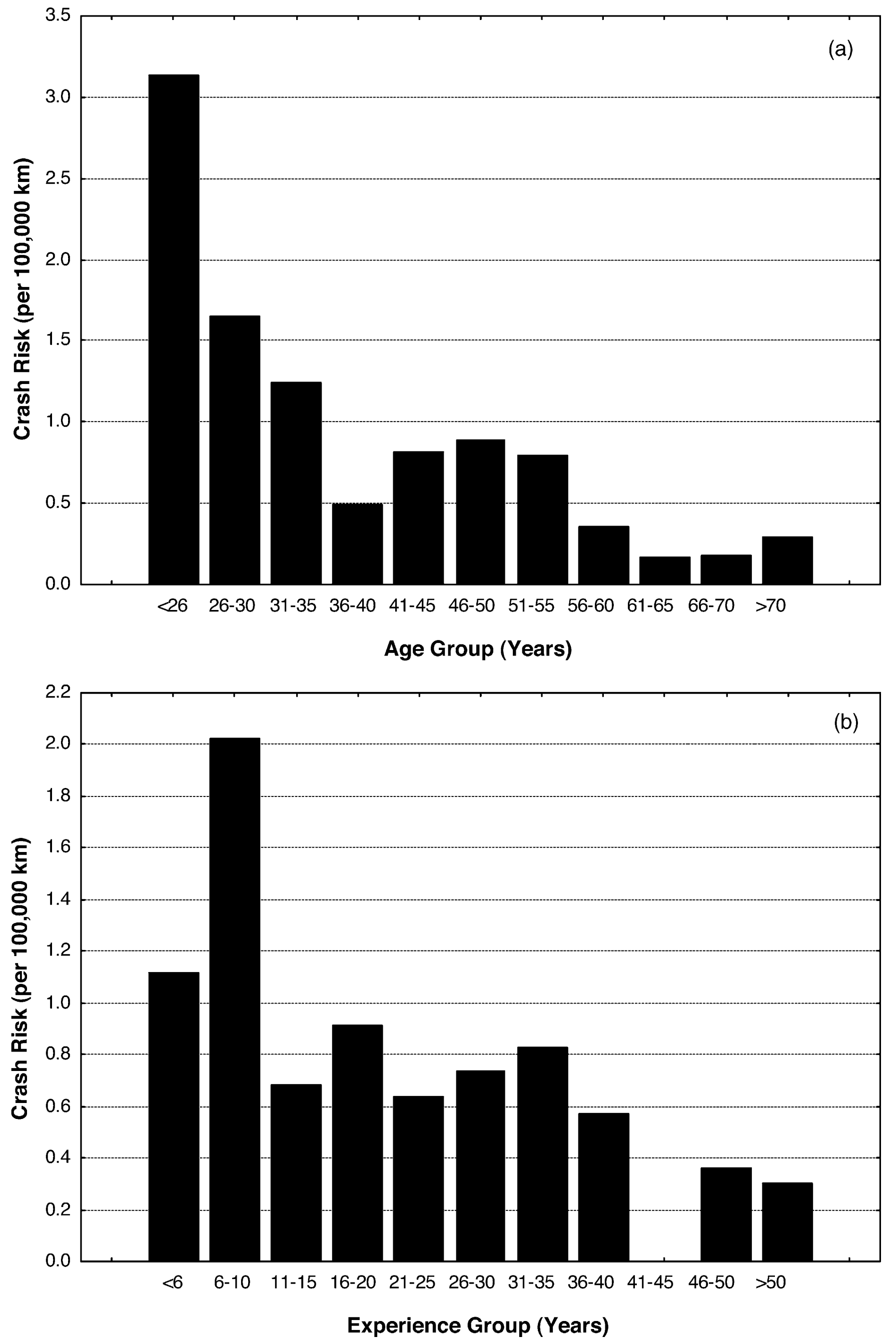

Fig. 1. Crash risk (crashes/100,000 km) by rider age (a) and years of riding experience (b).

experience. Younger and less experienced riders had a much higher risk than older and more experienced riders, although there is a peak in crash risk for riders in their forties and fifties. Crash risk continues to decline afterwards, so this peak in crash risk is unlikely to result from an age-related decline in riding skill. It may be the result of an increase in the number of novice riders (as new riders commence riding in their forties and fifties), who have a higher crash risk than more experienced riders, or it may the result of riders returning to riding after an absence of some time—during which their skill level may have declined through a lack of riding experience.

The relationship between exposure level and crash risk is shown in Fig. 2. The data in this graph represent the crash rate (per 100,000 km) for groups of riders with annual exposures of less than 1000, 1001–2000, 2001–3000 km, and so on in 1000 km intervals. The crash risks were plotted at the mean exposure level for each group, and the fitted curve is a power function. Fig. 2 suggests that riders who ride fewer kilometres have higher risks of crash involvement on per kilometre basis.

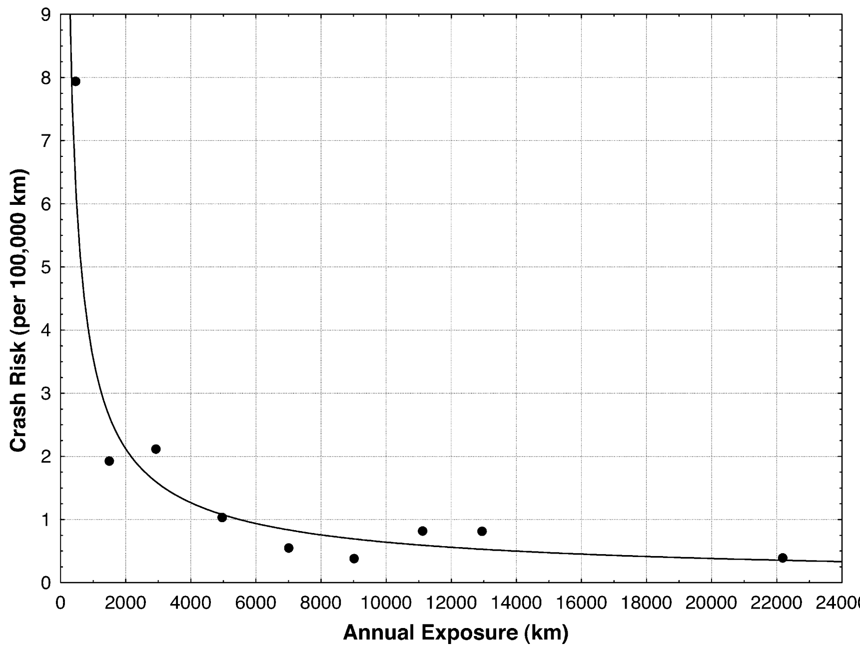

Fig. 2. Crash risk (crashes/100,000 km) by riding exposure (km ridden/year, based on odometer readings).

3.4. Cluster analysis

A cluster analysis was undertaken to group riders with similar exposure characteristics. If these groups also had different levels of crash risk, this information would be valuable in the development of public education programs to increase rider safety.

Exploratory cluster analysis was undertaken to estimate the number of clusters of participants using Ward's amalgamation rule and squared Euclidean distance as a measure of similarity. The variables included in the analysis were age, years of experience, the percentage of riding that took place in different contexts, on different road types, and at different times of the week, and annual exposure (derived from odometer readings). All variables were included as *z*-scores to eliminate the effect of differences in measurement scales on the distance estimates. The amalgamation schedule suggested a solution with either eight or nine clusters, and examination of the tree diagram suggested that a solution with nine clusters was appropriate. Data were then subjected to *K*-means cluster analysis specifying the same variables and a nine-cluster solution.

Table 5
Descriptive statistics for clusters of motorcycle riders

	Clusters								
	1	2	3	4	5	6	7	8	9
N	104	89	30	187	73	46	46	159	27
Age	44.9	44.1	52.8	44.1	49.4	35.4	38.5	39.9	43.9
Years of experience	20.3	17.2	27.2	18.3	26.4	9.8	17.1	14.4	18.8
Exposure on suburban roads	1831	1226	1443	595	620	2836	184	4134	7521
Exposure on rural two-way roads	367	1156	1073	2923	3979	761	351	725	9295
Exposure on urban freeways and multi-lane highways	131	1001	544	161	113	2441	58	304	4101
Exposure on rural freeways and multi-lane highways	128	747	2998	354	204	559	108	214	4805
Exposure on other road types	52	148	256	136	155	123	1852	62	724
Exposure on weekdays	995	1225	3642	676	3976	5042	885	4412	15677
Exposure on weekends	1515	3054	2673	3494	1098	1681	1669	1029	10771
Exposure for commuting	304	356	2306	133	2373	4968	86	4480	10823
Exposure for recreation	2057	3677	3736	3956	2300	1606	2090	809	14150
Exposure for work	94	180	222	6	213	118	341	75	826
Exposure for other reasons	54	65	50	74	187	47	36	77	647
Crash risk (per 100,000 km)	1.38	1.47	0.42	0.85	0.43	1.03	3.23	1.06	0.39

Age and experience are measured in years, the exposure measures are odometer-based estimates of annual kilometres ridden, and crash risk is expressed in crashes/100,000 km ridden.

Table 5 shows the outcome of the cluster analysis for variables included in the analysis, and includes crash risk estimates for each cluster. Differences between clusters on all the variables included in the analysis were statistically significant. The crash risk estimates in Table 5 suggest that three of the (Clusters 1, 2, and 7) had relatively high crash risks, and that three had relatively low risks (clusters 3, 5, and 9). The three high-risk clusters appear to have a similar mean age, and about the same experience level, as the sample as a whole.

The highest-risk cluster – Cluster 7 – had a crash risk of 3.23 crashes/100,000 km. It comprised 6% of the sample, but accounted for 10% of the crashes reported by participants. Members of Cluster 7 rode relatively less often than other riders in all contexts other than “on other roads” (these were almost always off-road situations), and were biased towards weekend riding and riding for pleasure rather than riding for commuting; 35 of the 46 riders in this cluster (76%) rode trail or dual-use motorcycles.

Riders in Cluster 2 had a crash risk of 1.47 crashes/100,000 km. They comprised 11.7% of the sample and accounted for 15.1% of the crashes reported by respondents. Participants in Cluster 2 appear to have a bias towards riding on urban and rural freeways and multi-lane highways, riding on weekends, and riding for pleasure rather than for commuting. Sports-style motorcycles were over-represented in this group, with 46% of riders in this cluster riding this type of motorcycle compared to 40% of the whole sample.

Riders in Cluster 1 had a crash risk of 1.37 crashes/100,000 km, comprised 13.7% of the sample and accounted for 9.8% of the crashes reported by respondents. Compared to the whole sample, riders in Cluster 1 appear to have slightly less riding exposure, a larger percentage of riding on roads in cities, towns, or suburbs, less riding in other contexts, a bias towards weekend riding, less riding for commuting, and more riding for recreation or pleasure. Traditional-style motorcycles were over-represented in this cluster, with 23% of riders in this cluster riding this type of motorcycle compared to 14% across the whole sample.

4. Discussion

This study collected information from motorcycle riders to investigate their riding exposure and crash risk. Data of this type have been unavailable in Australia, or have been estimated based on population surveys relying on retrospective data collection or self-reported estimates of riding behaviour. The key strength of this study was its use of a repeated-measures design—in which respondents provided odometer information from their motorcycle at two points in time. These were used to estimate the annual riding exposure for survey participants.

4.1. Riding patterns

Riding patterns were not surprising. In general, motorcyclists reported riding activity that matched their place of residence, their type of motorcycle, and their age (and the likely motivational needs satisfied by their riding).

It might be possible to use information about the relationship between riding patterns and motorcycle type in the development of public education programs to target specific subgroups of high-risk riders. Advertising/advisory materials could be made more relevant by making use of content or role models, based on high-risk sub-groups of riders and riding patterns. Based on the results reported here, for example, public education material targeting safety issues for younger riders in urban areas would be more relevant if it depicted riders on sports-style motorcycles or on trail bikes.

The differences between older and younger riders are of some interest given the changing pattern of crash risk with age. Older riders were likely to engage in recreational riding on weekends in rural areas and younger riders were likely to use their motorcycle for commuting and in an off-road context. It is not possible to determine (from these data) if this reflects a changing pattern of motorcycle use as riders become older, or a changing pattern of motorcycle use over time. Although it is likely that riders change their pattern of riding as they age, it is also possible that the older riders in the sample have always preferred recreational, weekend motorcycle use, and that the younger cohort of riders represented in the sample will continue to prefer commuting as their main type of riding as they age.

4.2. Crash risk

It was not possible to estimate crash risk for individual riders because of the low frequency of crashes. Instead, the crash risk for specific groups was calculated by summing the self-reported numbers of crashes and the odometer-based estimates of annual exposure and expressing the rate for the group as the number of crashes/100,000 km. This made detailed analysis of crash risk data impossible.

It is not possible to compare the crash rates reported here and the official crash data. Official crash data in Australia are generally unreliable for low-severity crashes, and respondents were asked to report any crashes. ATSB (2004) reported that the motorcycle crash rates for Australia in 2002 were 123.9 seriously injured riders or pillion passengers/10,000 motorcycles, and 300.3/100 million km travelled. The crash rates reported here, which include less serious crashes, were equivalent to 504/10,000 motorcycles and 960/100 million km.

The crash risk for riders in their forties and fifties was higher than expected. One possibility is that this is related, in part, to older riders returning to riding after an absence. The data reported here do not allow definite conclusions to be drawn about this, but it seems reasonable to suggest that a period of absence from riding might result in a decline in safety-related motorcycle skills. Somewhat more speculatively, this may be especially so if the returning rider has been driving other vehicles in the non-riding period, where they will have developed hazard-perception and decision-making skills that could be more appropriate to driving than to riding. It is also possible that the higher crash rate for this age group could reflect a shift towards larger motorcycles and different types of riding activity as riders have more disposable income and different riding motivations. It was not possible to assess this with the current data set, but could be an important focus for future research.

The relationship between crash risk and current riding exposure is interesting. The rate of crash involvement (on per kilometre-travelled basis) appears to decline as a function of current riding exposure. This suggests a potential countermeasure—just as novice drivers are encouraged to accrue as much practice as possible in a range of safe conditions, the same may help riders. Those who currently ride only rarely may not ride a sufficient amount, in enough different contexts, to preserve their riding skill. The problem with this, however, is that motorcycling is less safe than other forms of transportation, and any increase in riding activity will result in additional crashes. The balance between the declining crash rate and increasing exposure would need to be assessed. A better alternative may be to use this group as a target group for a public education program. They could be informed about the extra risk and could be encouraged to take additional care when riding.

This pattern, whereby high exposure appears to moderate crash risk, has been reported elsewhere in the literature in respect of car drivers (Hakamies-Blomqvist, 2003), and to some extent, highly exposed truck drivers (Bureau of Transport Economics, 2000). As ABS usage surveys over the last decade suggest that exposure (annual distance travelled) is falling for motorcycles (ABS, 2003), and other research suggests that recreational motorcycle use (e.g. on weekends only) is rising (Christie and Newland, 2001); one could speculate that the size of the low-exposure, high crash risk group will increase.

The shape of the function itself is interesting. Skill acquisition and learning in general proceed according to a power function (Swezey and Llaneras, 1997)—a curve in which the rate of change in skill declines with experience or learning trials. The similarity between learning curves and the power function fitted to the exposure-crash risk data suggests that exposure to riding may have an ongoing effect on crash risk that is similar to the effect of learning. It would be interesting to compare the effect of riding experience with the effect of driving in the same sample; one possibility is that exposure to driving and riding result in skill acquisition that is specific to each behavioural context, and that these skill sets are not completely compatible. One might speculate that incompatibilities between the hazard-detection and decision-making skills required for driving and riding could result in a higher crash risk for low-exposure riders, who may drive more often than they ride. Unfortunately, the current survey did not include items relating to driving.

Riders of trail and dual use bikes are a specific high-risk group—with low exposure levels and very high crash rates on per kilometre-travelled basis. The high risk associated with trail bike riding most likely reflects a number of factors, including low exposure levels as riders and related limited opportunities to acquire safety-related skills, and the focus on off-road riding. This is likely to be less safe because of the proximity of potential hazards and the low friction coefficient of the riding surface, the tendency towards younger riders in this group, the likely low level of familiarity with the riding environment, and the possible instability of this style of motorcycle, with its relatively high centre of gravity and differences in tyre tread/profile.

4.3. Groups of riders

An important outcome of this study was the identification of three high-risk groups of riders. Riders identified in the three clusters comprised about 32% of the sample, and each group represents a potential target group for road safety measures or public education programs. The highest-risk cluster was composed of riders who tended to ride trail bikes off-road on weekends. The high risk associated with trail bike riders was discussed above, but it would be useful to know the circumstances of their crashes, if they crash in traffic situations the problem for this group may reflect their limited exposure to riding on normal roads, but if they crash when riding off-road, the high crash risk may relate to the riding context.

The next high-risk cluster was composed of riders, who rode relatively often on urban and rural multi-lane highways and freeways on weekends for recreational reasons, who lived in the Sydney area, and who were likely to ride sports-style motorcycles. This suggests that this group rides as a hobby and that their riding patterns include long weekend rides. As a substantial amount of their riding exposure is on freeways and highways (41% compared to 21% for the whole sample), their high crash risk may result in part from relatively little exposure to (and unfamiliarity with) urban traffic conditions. It would be interesting to know, whether this cluster has its crashes in urban traffic or when riding long distances.

The final high-risk cluster was composed of riders who tended to ride less each year than others in the sample, and who reported relatively more of their riding on urban roads in Sydney, on weekends, and on traditional-style motorcycles for recreational reasons. This group of riders may use a car or public transport for commuting, and then use their motorcycle for transport on weekends. Traditional-style motorcycles were the oldest motorcycles in the sample – the median year of manufacture was 1984, compared to 1997 for the sample as a whole – suggesting that riders in this group may see riding as an alternative form of recreational transport or as a hobby, rather than as an important part of their day-to-day lives. The high crash risk of this group may relate to their limited exposure as riders, and their weekend exposure in complex, high-traffic urban areas.

It is of some interest that the three high-risk clusters were all more likely to ride for pleasure or recreation rather than for commuting or work—consistent with findings that driving for non-transport motivations is predictive of crash involvement (e.g. Gregersen and Berg, 1994).

There is a need to understand more about the circumstances of crash involvement for high-risk riders. In two of the high risk clusters described above, for example, crash involvement may related to the riding context in which they spend most of their time, or it may relate to riding in a context (in both cases in complex urban traffic situations), where they have relatively little experience, and therefore, lower levels of safety-related skill. The data collected in the current study did not allow investigation of this issue.

4.4. Problems with the study

It is likely that those who responded to the surveys were relatively frequent or enthusiastic motorcyclists. Although the original sample of riders was drawn from the RTA registration database, it cannot be assumed that the participants who returned completed surveys were a random sample of riders in New South Wales. The response rate for the first survey was about 37%, but it was not possible to assess potential differences between the respondents and non-respondents because privacy laws necessitated discarding information about the latter. It is reasonable to expect, however, that riders who responded to the first survey would be more motivated about motorcycling issues than those who did not.

It was possible to compare riders who returned and did not return the second survey. There was significant bias towards older riders, more-active riders, and rural residents. It is reasonable to assume that these biases were also present in the first survey in addition to any other biases that could not be assessed. The consequence of this is that the current sample will not be a fully representative one, and in particular, the results are best understood as reflecting the riding patterns and crash involvement of riders who are relatively motivated about riding.

There is an additional concern about the data used to estimate annual exposure that was addressed only in part. It will be recalled that some surveys in the second round had to be excluded from analysis, because the odometer readings were incorrect. The most common problem was that the odometer reading in the second survey was lower than that provided in the first, when the motorcycle information in the two surveys matched. Other errors that were not obvious would not have been detected—and any errors in odometer readings in the first survey could not be detected. It is possible that the total exposure estimates across riders may have been less reliable than expected. While there is no reason to believe that errors in odometer readings would have biased the exposure estimates upwards or downwards, it is important to be aware that some of the variability in exposure estimates may relate to this.

It should also be noted that the period between the second and first surveys excluded most of the Christmas/new year holiday period, included late summer, but also includes the cooler, wetter weather expected in autumn and early winter. It is uncertain how this affected the exposure estimates.

Another potential problem relating to the use of a 6-month period for calculating crash risk is that respondents reported crashes in the preceding 5 years (as crash frequencies are low), and the rate was calculated with an implicit assumption that the 6-month exposure data could be extrapolated over the 5 years. This is problematic because there is evidence that riding activity levels have been changing and that they have been changing at different rates for different groups of riders – total exposure levels for all riders have not changed substantially, but there is strong evidence on an increase in average distances ridden for older riders and a similar decline for younger riders (Christie and Harrison, 2001). The result of these changes might be such that the crash rates reported here overestimate the crash risk for younger riders and overestimate the crash risk for older riders.

The crash risk estimates will have been influenced by a number of factors. The likely sampling bias towards riders who ride more and who are older may have resulted in a lower overall estimate of crash rate and lower estimates for subgroups defined by variables other than age and exposure, as the survey results suggest that crash rate declines with age and exposure. There are also some problems with using estimates that rely on self-reports of crash involvement, although this should be less of a problem amongst riders, compared to drivers, as their crashes are likely to be more severe and, therefore, less likely to be forgotten. One way to counter the problems associated with self-reports would have been to make use of official motorcycle crash data. It was considered inappropriate to do this, however, as the official crash data represent crash involvement across the population of all riders in New South Wales (including unlicensed and unregistered riders), whereas the survey data provide exposure information from a biased sample of registered motorcycle owners. As the two data sets are based on different populations, and as one set (the survey) is likely to be a biased sample of its population, crash risk estimates based on a combination of the two are likely to be inaccurate.

5. Conclusions

The pattern of results reported is largely consistent with that reported elsewhere. The high crash risk associated with trail/dual use motorcycles is of concern, as the actual exposure of this type is the lowest of all those examined. From a severity perspective, however, Christie (2002) showed that injury severity levels from trail bike crashes were lower relative to those resulting from sports machine crashes and cost less in respect of individual insurance claims. This may suggest, while both groups are of interest, that sports type crashes may be a more productive target for countermeasure attention in terms of severity and cost reduction.

The identification of three high-risk clusters of motorcyclists provides an opportunity to develop targeted road safety measures or public education programs. In particular, the similar, high level of recreational riding apparent in the three clusters and the apparent importance of low exposure levels as a predictor of high crash rates lead to a suggestion that recreational riding and riders who ride relatively less often than others be targeted.

Further research is needed to understand the relationship between exposure and crash risk with a view to making recommendations about the potential value of an increase in exposure for low-exposure riders. There is also likely to be some potential value in additional research to understand the circumstances in which riders in the three high-risk clusters crash as a further guide to the development of appropriate countermeasures.

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