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Missing cyclists

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METHODOLOGIC ISSUES

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Objectives: (1) For crashes on a public road, to compare serious cyclist crashes involving a motor vehicle with cyclist crashes not involving a motor vehicle, in terms of threat to life and length of stay in hospital. (2) To determine the proportion of all serious crashes involving cyclists on public roads which are recorded by the police. (3) To determine the degree to which under-reporting of serious crashes involving cyclists and motor vehicles on public roads is associated with various demographic, environmental, and injury factors.

Study design: Records for the period 1995–99, of cyclists seriously injured on a public road and hospitalised were linked to the traffic crash report (TCR) database maintained by Land Transport Safety Authority (LTSA).

Results: Of the 2925 cyclist crashes on public roads, only 652 (22%) could be linked to a TCR. Of the crashes involving motor vehicles (n = 1033), only 562 (54%) could be linked to the LTSA database. Age, ethnicity, injury severity, and cumulative length of stay were the only variables that predicted whether hospitalised cycle crash cases were more likely to have a corresponding TCR. There were substantial numbers of cyclist only crashes which typically are not captured in the TCR database. Nine percent of these resulted in serious or worse injury (that is, *International Classification of Diseases*/abbreviated injury scale score of 3+) and 7% resulted in hospital stays greater than seven days.

Conclusion: Greater effort and precision needs to be applied to routinely document the burden of cyclist crashes, especially cyclist only crashes.

New Zealand law requires that any crash involving a moving motor vehicle on a public road where an injury is sustained must be reported to the police. A traffic crash report (TCR) is completed for these crashes and the data are entered in the TCR database. This database is maintained by the Land Transport Safety Authority (LTSA), the organisation with primary responsibility for road safety policy. A recent study has shown that the TCR database substantially underestimated the number of drivers and occupants of cars and motorcyclists seriously injured in crashes that were required to be reported.[1] That study specifically excluded pedestrians and cyclists. Moreover, there have been no other published New Zealand studies that have provided an estimate of under-reporting for these road users. Overseas studies suggest that under-reporting for these road users is likely to be very high.[2–4]

The populations of interest in most studies of under-reporting have been confined to victims of crashes involving a moving motor vehicle. Typically this is because, as is the case in New Zealand, crashes on public roads involving only non-motorised vehicles, mainly bicycles, are rarely reported to the police. Since the amount of bicycle use varies by country, the convention has been for those who contribute data to the International Road and Traffic Accident Database not to include these crashes in the data they submit.

A New Zealand study reported that 1500 cyclists were admitted to hospital in 1988 for the treatment of injury. In 1112 cases (74%) the cyclist was injured on a public road, and of these only 375 (34%) involved a collision with a motor vehicle.[5] While cyclist crashes involving motor vehicles may be more serious in terms of damage to cyclists, the burden of injury for cyclist only crashes, relative to the former, has never been documented.

The aims of this study were:

(1) For crashes on a public road, to compare serious cyclist crashes involving a motor vehicle with cyclist crashes not involving a motor vehicle, in terms of threat to life and length of stay in hospital.

(2) To determine the proportion of all serious crashes involving cyclists on public roads which are recorded by the police.

(3) To determine the degree to which under-reporting of serious crashes involving cyclists and motor vehicles on public roads is affected by various demographic, environmental, and injury factors.

METHODS

For the purpose of this study a serious cyclist crash was defined as any crash which required admission for treatment in a public hospital in New Zealand. Public hospitals provide acute care for the overwhelming majority of admitted injury cases in New Zealand.[6] Cases were selected from the New Zealand Health Information Service (NZHIS) public hospital morbidity data. The NZHIS records data on all public hospital discharges in New Zealand.

To obtain reliable estimates we used five years of national public hospital inpatient data, namely 1995–99.

The circumstances of injury are coded according to the "Supplementary Classification of External Cause of Injury and Poisoning" (E code) of the *International Classification of Diseases* (ICD).[7] The E codes permit the identification and enumeration of victims classified under a variety of categories relating to "environmental events, circumstances and conditions". Only admissions with a primary diagnosis of injury were included in the analysis. Readmissions for the treatment of the same injury, were excluded. The rationale for case selection is provided elsewhere.[8]

Abbreviations: AIS, abbreviated injury scale; ICD, *International Classification of Diseases*; LTSA, Land Transport Safety Authority; NZHIS, New Zealand Health Information Service; TCR, traffic crash report

Table 1 Distribution of severity for motor vehicle involved crashes and cyclist only crashes 1995–99

	AIS					
	1	2	3	4	9*	Total
Motor vehicle						
Linked	86	281	86	31	78	562
%	46	51	69	78	57	54
Unlinked	101	265	38	9	58	471
%	54	49	31	23	43	46
Subtotal	187	546	124	40	136	1033
%	100	100	100	100	100	100
Cyclist only						
Linked	21	49	13	1	6	90
%	5	5	9	7	2	5
Unlinked	388	1028	135	14	237	1802
%	95	95	91	93	98	95
Subtotal	409	1077	148	15	243	1892
%	100	100	100	100	100	100
Total	596	1623	272	55	379	2925

*Includes 0, 9 and missing values.

The potential population of interest was identified by two strategies. All crashes that involved a motor vehicle and occurred on a public road are coded in the range E810–E819: ''Motor vehicle traffic accidents''. For these cases we identified all the cyclists by reference to the fourth digit of the E code which identifies the type of road user.

All crashes that involve other road vehicles and which may be on a public road are coded in the range E826–E829: ''Other road vehicle accidents''. For these cases we also identified all the cyclists by reference to the fourth digit of the E code. We then sought to identify the subpopulation of incidents that occurred on a public road by reference to the place of occurrence code.

Injury severity in terms of threat to life was measured according to the abbreviated injury scale (AIS), an anatomical scale ranging from minor (1) to virtually unsurvivable (6).[9] Scores were derived from the first four diagnoses using ICDMAP-90.[10] We used the convention of ICD/AIS for referring to the indirectly derived scores.

For the purposes of estimating cumulative length of stay we traced each inpatient discharge for a period of 12 months. Initial investigations on tracing a population of cyclists injured in 1995 for six years revealed that all readmissions for further treatment occurred within a 12 month period. We used data from 2000 for calculating cumulative length of stay for the 1999 cases

Records of cyclists seriously injured on a public road where there was a motor vehicle involved were linked to the TCR database. The two datasets were linked on a variety of common fields (for example, surname, initials, gender, age, date of injury) using the probabilistic record linkage software AUTOMATCH[11] with a manual review of a sample of matched pairs and manual linkage of unlinked or ''orphaned'' records.

In summary we sought to identify three categories of crashes involving cyclists:

(1) Involving a motor vehicle linked to a TCR.

(2) Involving a motor vehicle not linked to a TCR.

(3) Cyclist only (that is, where a motor vehicle was not involved).

The degree to which under-reporting of serious crashes involving motor vehicles was associated with various demographic, environmental, and injury factors was examined by using univariate and multivariate logistic regression analyses, similar to those employed by Alsop and Langley.[1] Based on this earlier work we sought to determine the effects of age, gender, ethnicity, threat to life, cumulative length of stay, region, day, month, and year of injury on the probability of a crash being recorded in the TCR database. For ethnicity the population was classified as Maori (the indigenous people of New Zealand) or non-Maori. The age groups we used in our analysis are based on those given in the New Zealand Travel Survey with those groups covering the 25–39 age range combined into one due to relatively low exposure for the age groups within this range.[12]

RESULTS

For the period 1995–99 there were 1033 cases identified from the hospital records as ''motor vehicle traffic accidents'' (E810–E819). There were an additional 5462 cycle crashes identified as ''other road vehicle accidents'' (E826–E829). Of the latter group 1892 were positively identified as having occurred on a public road (hereafter referred to as cyclist only crashes). A further 896 were positively identified as having occurred off a public road. For the remaining 2674 it was not possible to determine the location. In summary we were able to identify 2925 cyclist crashes on public roads, 35% of which involved motor vehicles. This estimate is conservative given the large number of cyclist-involved crashes in which the location of the crash was unspecified.

Of the cyclist only crashes there were 163 cases (9%) with an injury of ICD/AIS of 3+. The comparable number of crashes involving a motor vehicle was 164 (16%) (table 1). Table 2 shows that cyclist only crashes comprised 46% of cumulative length of stay for all cyclists injured on a public road. The average length of stay, for cyclist only crashes was approximately half that for motor vehicle involved cyclist crashes. Similarly crashes involving a motor vehicle were approximately three times more likely to result in hospital stays of more than seven days. Nevertheless victims of cyclist only crashes accounted for 39% of these longer stays.

Of the 2925 crashes, 652 (22%) were linked to a TCR (table 1). Of the crashes involving motor vehicles ($n = 1033$), 562 (54%), could be linked to the LTSA database. Ninety (5%) of the 1892 cyclist only crashes linked.

There were significant univariate associations between the probability of being recorded in the LTSA database and gender, ethnicity (table 3), ICD/AIS ($\chi^2 = 26.252$, $p<0.001$), and cumulative length of stay ($\chi^2 = 34.006$, $p<0.001$). There were no significant variations in reporting rates by day, month, or year of injury, region, or age.

Following the recommendation of Hosmer and Lemeshow,[13] all factors moderately significant from the univariate analyses were included in the multivariate logistic

Table 2 Distribution of length of stay for motor vehicle involved crashes and cyclist only crashes 1995–99

	Total cases	No with >1 admission	Cumulative day stay	Average day stay	Cumulative day stay (No of cases)						
					0	1	2	3–4	5–7	8–14	15+
Motor vehicle											
Linked	562	42	3590	6.4	31	164	85	90	71	72	49
%	54	69	63	116	38	48	49	66	61	66	65
Unlinked	471	19	2076	4.4	51	175	89	47	46	37	26
%	46	31	37	80	62	52	51	34	39	34	35
Subtotal	1033	61	5666	5.5	82	339	174	137	117	109	75
%	100	100	100	100	100	100	100	100	100	100	100
Cyclist only											
Linked	90	4	357	4.0	13	25	25	8	11	5	3
%	5	8	7	155	5	3	8	4	9	6	9
Unlinked	1802	49	4493	2.5	246	814	303	220	110	77	32
%	95	92	93	97	95	97	92	96	91	94	91
Subtotal	1892	53	4850	2.6	259	839	328	228	121	82	35
%	100	100	100	100	100	100	100	100	100	100	100
Total	2925	114	10516	3.6	341	1178	502	365	238	191	110

regression model. The model provided an adequate fit to the data, indicated by the Hosmer and Lemeshow goodness-of-fit test statistic ($\chi^2 = 4.97$ with 8 df, $p = 0.76$).[13] With the exception of age the results from the multiple logistic regression were consistent with those found in univariate analyses (table 4).

DISCUSSION

In this study the NZHIS hospital discharge classification served as our gold standard. This database is likely to contain some coding errors. For example, 90 of the cyclist only crashes linked to the LTSA database. By definition these crashes were subject to a detailed crash report by a police officer, they are thus likely to have been incorrectly coded in the NZHIS database as non-motor vehicle traffic crashes. Similarly, while in law it may be clear what is classified as a public road crash, victims may adopt a more liberal definition of what is a road and what is public in their reports to police. Finally, the ICD coding instructions state: "A motor vehicle accident is assumed to have occurred on the highway unless another place is specified, except in the case of accidents involving only off-road motor vehicles, which are classified as non-traffic accidents unless the contrary is stated". Consequently, hospital derived estimates may over-state the incidence of motor vehicle crashes on a public road, and under-state the incidence of off-road crashes and on-road crashes not involving a motor vehicle. We are unable to arrive at an estimate of the size of these respective errors, however,

Table 4 Summary of fitted logistic regression model

Factor	Odds ratio*	95% CI*	χ^2, p value
Age (years)			12.21, p=0.03
0–9	1	–	
10–14	1.12	0.72 to 1.75	
15–19	0.56	0.33 to 0.95	
20–24	0.70	0.40 to 1.21	
25–39	0.67	0.42 to 1.08	
40+	0.82	0.50 to 1.33	
Ethnicity			6.14, p=0.01
Maori	1	–	
Non-Maori	1.67	1.12 to 2.51	
ICD/AIS			14.04, p=0.01
AIS 1	1	–	
AIS 2	1.15	0.81 to 1.65	
AIS 3	1.90	1.11 to 3.27	
AIS 4+	3.15	1.40 to 7.68	
AIS 9	1.71	1.06 to 2.77	
Length of stay (days)			20.44, p=0.00
0	1	–	
1	1.62	0.97 to 2.75	
2	1.66	0.95 to 2.93	
3–4	3.16	1.74 to 5.83	
5–7	2.48	1.33 to 4.66	
8–14	2.86	1.51 to 5.49	
15+	2.41	1.20 to 4.92	
Region			29.62, p=0.10
Day injured			8.18, p=0.23

*Only shown for factors that were significant at a 5% level. CI, confidence interval.

Table 3 Percent of motor vehicle involved crashes reported by personal characteristics

	Frequency of crashes	% Reported	95% CI	χ^2, p value
Age (years)				
0–9	139	55	46 to 63	
10–14	260	59	53 to 65	
15–19	124	47	38 to 56	9.03, p=0.108
20–24	114	50	41 to 59	
25–39	203	51	44 to 58	
40+	193	59	52 to 66	
Gender				
Female	244	55	51 to 63	0.03
Male	789	54	51 to 58	p=0.854
Ethnicity				
Maori	147	46	39 to 55	4.55
Non-Maori	886	56	52 to 59	p=0.033

CI, confidence interval.

our estimates for the cyclist only crashes are likely to be conservative given the large number of events (n = 2674) for which place of occurrence could not be ascertained. The size of this category is cause for concern, since it seems likely that a significant portion of these cases may have occurred on a public road. Accordingly our estimate of 22% reporting for all cyclist crashes on public roads is likely to be low.

While the extent of under-reporting of motor vehicle crashes on public roads in New Zealand has been documented for users of motor vehicles,[1] this report represents the first attempt to determine the extent for cyclists in New Zealand. The under-reporting is substantial at 46% for cyclist crashes involving a motor vehicle but is within the range previously reported for other road users. Alsop and Langley demonstrated that under-reporting ranged from a high of 59% for motor cyclists injured in single vehicle crashes to a low of 21% for passengers injured in multiple vehicle crashes.[1]

A large proportion of serious motor vehicle involved cases were linked to TCRs, however, relatively large numbers of the non-reported cases were also serious in terms of threat to life and cumulative length of stay in hospital. Furthermore, there was significant variation in reporting by age, severity, ethnicity, and length of stay. Consequently LTSA estimates cannot be corrected by a simple adjustment.

The relatively large number of cyclist only crashes that are not recorded in the TCR database was not unexpected but it is nevertheless cause for concern, given that a significant proportion of them resulted in serious threat to life and length of stay in hospital. There are a number of possible reasons why the public do not report such crashes to the police. First, by law they are not required to do so. Secondly, in most cases only the cyclist was injured, and many may consider that they would be inviting a prosecution for illegal road behaviour by reporting an incident. Thirdly, in contrast to motor vehicle crashes, property damage is usually not significant in absolute terms and consequently there is no incentive to report to comply with insurance requirements. While the law could be changed to make reporting mandatory, we believe this is unlikely to result in a significant improvement in reporting. We endorse the recommendation of Hvoslef that crashes involving non-motorised vehicle road users should be extracted from hospital records,[14] as we have done here for cyclists, and published separately. Failure to do this runs the risk of these important crashes not receiving prevention resources commensurate with the size of the problem.

The LTSA has sought to address the generic issue of under-reporting in its annual publication *Motor accidents in New Zealand* by providing an estimate of crashes resulting in hospital inpatient treatment. The relevant section of the report typically contains estimates for cyclists. Unfortunately the estimates are for all non-motor vehicle crashes irrespective of whether they occurred on the road. As the results presented here demonstrate, this approach results in an over estimation of the size of the problem, since many of these incidents would have occurred off-road.

In summary, we estimated that each year there were an average of 584 cyclist crashes on public roads which require public hospital inpatient treatment. LTSA has records for only: 22% of these crashes, 40% of the most life threatening cases (those with ICD/AIS 3+), and 43% of the most costly cases requiring a length of stay in hospital of 7+ days. Greater effort and precision needs to be applied by LTSA to documenting the burden of cyclist-involved crashes, especially cyclist only crashes. This would be greatly facilitated if NZHIS sought to encourage hospitals to improve the place of occurrence coding for the non-motor vehicle incidents resulting in inpatient treatment. Hospital admission data, however, cannot provide the information on the circumstances surrounding a crash which is found in the typical TCR. Since this information is critical to the development of effective countermeasures LTSA should be actively seeking to obtain it for cycle only crashes, since the circumstances of crashes are different to those involving cars and as such different prevention strategies may be required.

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