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Police motorcycle crash casualty reports and their linkage with hospital trauma admissions in the Midland Region of New Zealand, 2012-2016

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Key Findings

- A total of 689 casualties, resulting from on-road motorcycle crashes in the Midland Region of New Zealand, were admitted to hospital as trauma patients during 2012-2016.
- Approximately 56% of trauma admission records could be linked with police records, while an additional 303 patient records could not be linked to any police records.
- Linkage rates were significantly associated with crash severity, patient injury severity, rurality of crash location, age, and self-presentation to hospital.
- Younger motorcycle crash patients, aged under 45 years, were significantly less likely to be linked across datasets, and appear to be under represented among police records.
- This may partly be explained by significantly higher rates of self-presentation to hospital by younger motorcycle casualties.
- A greater understanding of this behaviour may help guide prevention strategies aimed towards younger riders.

Abstract

Police records, held in the Crash Analysis System (CAS) by the New Zealand Transport Agency (NZTA), and hospital admission data held in the Midland Trauma System (MTS) trauma registry, were linked using probabilistic methods. A total of 1,331 casualties resulting from motorcycle crashes on roads in the Midland Region during 2012-2016 were recorded by police. During the same period, and occurring within the same geographical area, a total of 689 on-road motorcycle related crash casualties were admitted to hospital as trauma patients. Linkage of these two datasets revealed substantial under reporting to police of motorcycle crash casualties resulting in hospitalisation. Approximately 56% (386) of hospital trauma admission records could be linked with police CAS records with an additional 303 (44%) patient admission records which could not be linked to any police records. Linkage rates were significantly associated with crash severity as recorded by police, patient injury severity recorded in the trauma registry, patient age, rurality of crash location, and self-presentation to hospital. In particular, younger motorcyclists aged under 45 years were significantly more likely to self-present to hospital with the odds of linkage for self-presenters seventeen times lower than those who did not self-present. The merging of these two datasets has highlighted several sources of bias underlying reporting of motorcycle crashes to police. An understanding of these biases may help to inform policymakers when planning wider preventive strategies designed to reduce the burden of motorcycle crashes in New Zealand.

Keywords

Motorcycle, casualty, trauma, linkage

Introduction

Since the early 2000s there has been an increase in motorcycle deaths and injuries reported to police in New Zealand, an increase which has been comprised almost entirely of those aged over 40 years (Ministry of Transport, 2017). Motorcycle crash casualties have also been identified as an area of concern in the Midland Region of New Zealand, representing approximately 32% of all on-road transport related hospital trauma admissions in the region (Midland Trauma System, 2017). The aim of this study was to use data linkage between motorcycle crash records collected by police in the NZTA Crash Analysis System (CAS) and patient records in the MTS trauma registry to assess a. any under reporting of on road motorcycle crash casualties to police and b. assess the effect of age on linkage rates, and identify any other additional factors within the merged dataset which may affect linkage rates.

During the 1990s there was a marked drop in overall motorcycle deaths and injuries on roads recorded by police in New Zealand (Ministry of Transport, 2017). This drop was most pronounced amongst those aged between 15 to 29 years of age. However, during 2000 to 2010, motorcyclist deaths and injuries increased again and have since plateaued with almost all of this increase comprised of those aged over 40 years. Several data-linkage studies have previously shown that police traffic crash records frequently underestimate the number of road transport accidents which result in hospital admissions (Alsop, 2001; Noor Azreena Kamaluddin, Abd Rahman, & Várhelyi, 2018; Lujic, Finch, Boufous, Hayen, & Dunsmuir, 2008). This is particularly the case for motorcycle crashes which are significantly less likely to be reported to police compared with car crashes (Watson, Watson, & Vallmuur, 2015).

Previous linkage of hospital discharge and police traffic crash records in New Zealand has suggested that only 46% of motorcycle traffic crash hospital admissions during 2000 to 2004 could be linked to police records (Wilson, Begg, D.J., Samaranayaka, A., 2012). This low overall linkage rate was largely attributed to under-reporting of crashes to, or by, police. Furthermore, the degree of linkage was strongly influenced by injury severity with approximately 20% higher linkage rates for serious injuries compared to those with moderate injuries (Wilson, Begg, & Samaranayaka, 2012). However, the linkage study by Wilson et al. (2012) was performed at a time when motorcycle casualty records were at their lowest levels during the 1985 to 2016 period (Ministry of Transport, 2017).

The Midland Trauma System (MTS) trauma registry was established in 2010 to coordinate improvements in the quality of trauma care delivery within the Midland Region; comprising Bay of Plenty, Lakes, Tairāwhiti, Taranaki, and Waikato District Health Board catchments (Population 889,541)(MRTS, 2017). The Midland Region is the only region in New Zealand to collect data for both Major (Injury Severity Score, ISS > 12) and Non-major trauma (ISS < 13). Previous studies have relied on ICD10 diagnosis coding which does not readily allow for division into major and non-major trauma. The MTS registry also holds detailed data for trauma patients, such as self presentation, not available in datasets previously used for such linkage studies in New Zealand (Wilson et al., 2012).

In this study, we have applied linkage of trauma-specific registry admission data for motorcycle related injuries in the Midland Region during 2012-2016, together with police reports held within the NZ Transport Agency (NZTA) Crash Analysis System (CAS) database. A similar additional analysis within the CAS dataset will also be undertaken in the future. Given the increase in motorcycle injuries reported to police, and the new demographic underlying it, the linkage of trauma specific hospital admission registry data and police records is considered timely.

Methods

Police CAS and trauma registry datasets

A retrospective review of anonymised, prospectively-collected MTS registry data for the period from 1 January 2012 to 31 December 2016 was conducted to examine how age and other factors such as patient self-presentation and rurality of injury domicile may affect linkage rates. Inclusion criteria for the study were: patients admitted to a Midland base hospital as a result of, and within 7 days of a motorcycle or moped related injury occurring within the Midland region. Data for Tairāwhiti DHB was excluded as it was a more recent addition to the registry. Consistent with trauma registries internationally, patients were excluded if they sustained insufficiency or periprosthetic fractures, exertional injuries, hanging/drowning/asphyxiation without evidence of external force, poisoning, ingested foreign body, injury as a direct result of pre-existing medical conditions or late effects of injury, or the injury occurred more than 7 days prior to admission (Nwomeh, Lowell, Kable, Haley, & Ameh, 2006). Those who died at scene are not collected by the MTS registry. Event episodes (first admission) were the unit of analysis. Length of stay was inclusive of the total days admitted to all hospitals for the index event. Motorcycle riders and passengers who sustained non-fatal (at scene) injuries were identified by an external cause of injury code related to motorcycles and mopeds (ICD-10-AM eCodes V20-V29) and were restricted to those occurring on-road. An extensive review of all trauma registry injury memo descriptions was undertaken prior to the study to ensure that place of injury was correctly coded for the selection of on-road motorcycle crashes only. Variables examined included: patient demographic characteristics, injury event information, in-hospital management, type and severity of injuries, length of stay and rurality of injury and patient residence.

The Injury Severity Score (ISS) numerically describes the overall severity of injury, and is calculated from the three most severely injured body regions as scored by the AIS (Baker, O'Neill, Haddon, & Long, 1974). Non-Major trauma is classified as ISS < 13 and major trauma as ISS > 12 (Palmer, Gabbe, & Cameron, 2016). Ethnicity information was obtained from the patient's unique identifier (National

Health Index number [NHI]) or directly from the patients themselves. Mechanisms of injury were categorised using the International Classification of Disease (ICD-10AM 6th Edition) external cause codes (National Centre for Classification in Health., 2006).

Geographical location of injury and patient residence is recorded for all patients within the trauma registry at an NZ Census Area Unit (CAU) level. Statistics New Zealand classifications were used to classify CAU populations as urban (Main Urban, Satellite Urban, Independent Urban), semirural (Rural with moderate or high urban influence), and rural (Rural with low urban influence, Highly rural/ remote) (2013 NZ Census - normally resident population (Statistics New Zealand, 2014, Wellington).

The NZTA Crash Analysis System (CAS) is an integrated database system storing road crash and related data from throughout the whole of New Zealand. Data is collected directly at the scene of crashes by NZ Police attending road crashes using a standard Traffic Crash Report (TCR). The collected data is then coded and entered into CAS by NZTA for use in statistics reporting and research by a range of organisations. Both motorcycles and mopeds were included in both datasets as key vehicles. While crash collisions may involve one or more vehicles, and one or more persons, data are presented at an individual person level and identified as linked to the motorcycle party (including pillion) rather than a count of crash collisions. Injuries within the CAS system were recorded as Fatal - including death at scene or within thirty days and as a result of the crash, Serious – serious injuries, including broken bones, concussion, etc, or Minor – minor injuries, including cuts, sprains, bruises etc. Involvement of medical professionals, such as ambulance personnel, in the grading of patient injury severity at scene is not recorded within the police recorded dataset.

Linkage of datasets and Analysis

Data for both Police (CAS) records (includes injured, died, and non-injured persons) and Hospital-admitted (MTS registry) patients were matched temporally using incident (CAS) and injury (MTS) dates spanning from 1 January 2012 – 31 December 2016, and further matched spatially as occurring within the Midland Region encompassing the boundaries of the four DHBs, Bay of Plenty, Lakes,

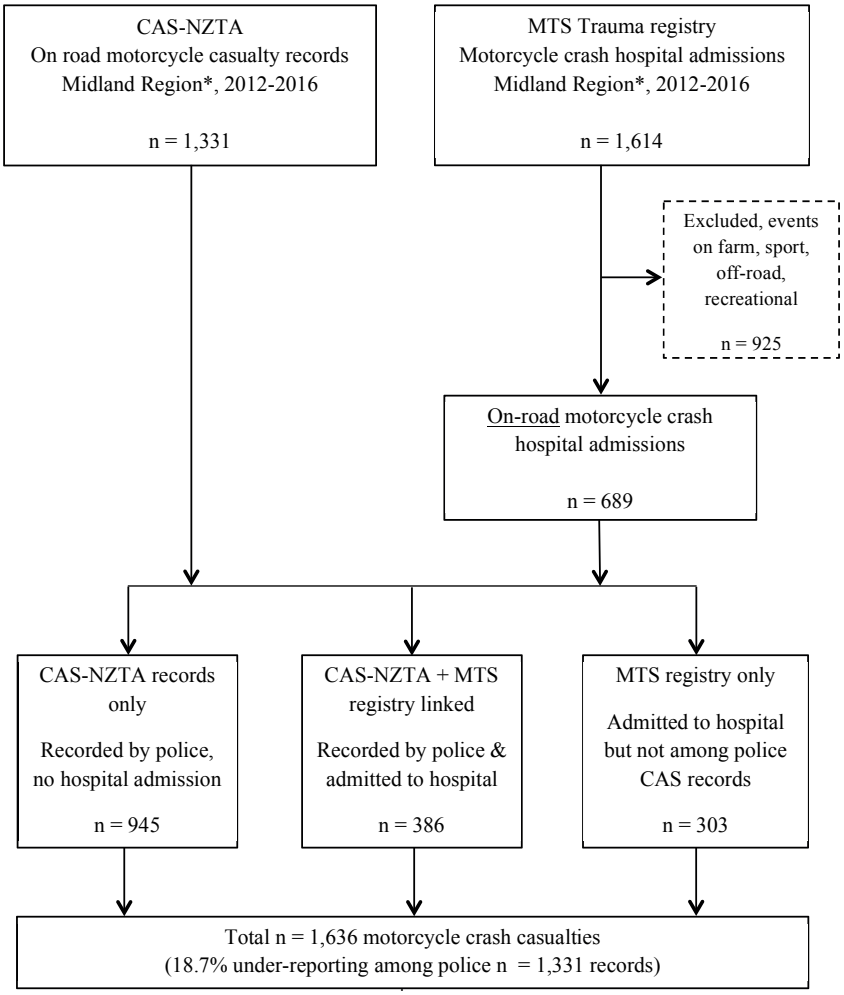

Figure 1. Flow diagram of data selection and linkage between police CAS and MTS trauma registry datasets. All data matched geographically and temporally: crash casualty (CAS) and injury (MTS) both occurring within Midland Region census area units (*Excluding Tairawhiti DHB) and occurring during 2012-2016.

Table 1. Linkage rates between police-CAS motorcycle crash casualty records and Midland Trauma System (MTS) hospital trauma admission records, Midland health region (Excluding Tairawhiti DHB) New Zealand (2012-2016) and Odds Ratio of record linkage across datasets as determined by logistic regression.

	Total (%)	Un-linked records (%)	Linked records (%)	Odds Ratio (CI) of linkage	P value
MTS Trauma					
Total	689 (100%)	303 (44.0%)	386 (56.0%)		
Injury severity					
Non-Major trauma (ISS*<13)	532 (100%)	258 (48.5%)	274 (51.5%)	Reference	
Major trauma (ISS>12)	157 (100%)	45 (28.7%)	112 (71.3%)	2.30 (1.56-3.44)	< 0.001

**ISS – Injury Severity Score*

Table 2. Concordance between police-CAS injury severity and MTS registry injury severity (Major versus Non-Major) for admitted patients linked between the two datasets, n = 386.

	MTS trauma severity		
Police CAS Crash injury severity	**Non-Major trauma (ISS*< 13)**	**Major trauma (ISS > 12)**	**Total**
Non-injury	-	-	-
Minor	79 (89.8%)	11 (12.2%)	90 (100%)
Serious	193 (68.7%)	88 (31.1%)	281 (100%)
Fatal	2 (13.3%)	13 (86.7%)	15 (100%)
Total	*274 (71.0%)*	*112 (29.0%)*	*386 (100%)*

**ISS – Injury Severity Score*

Taranaki, and Waikato. Tairāwhiti DHB was excluded from the study due to an incomplete data set. Data were matched using multiple fields including crash/injury date, crash/injury CAU, date of birth, and gender. Linkage rates were computed with hospital admitted patients as the primary group divided by the total number of police CAS person records (individual crash persons). All 689 hospital admission records were further checked manually at an individual record level. Microsoft Excel (Excel 2010) and R Statistical software were used for the analyses. The Chi square test was used to detect differences in proportions for non-normal distributions. P values were used to determine the result significance. Where significant differences in linkage rate were identified, the extent of concordance was assessed using multivariate logistic regression, with the response variable being 'linked' or 'not linked' and predictor variables being the factor categories and reference categories selected as high volume or representative of a baseline. Ethical approval was not required for this study as the analyses involved the use of anonymised secondary data. The study adhered to the MTS Data Use Policy and access to the trauma registry data was approved by the MTS Strategic Group.

Results

Figure 1 shows a flowchart of the linkage process. During 2012-2016, a total of 1,331 motorcycle casualties occurring on roads within the Midland Region (excluding Tairāwhiti DHB) were reported to police and recorded in the Crash Analysis System (CAS) held by the New Zealand Transport Agency (NZTA). Of these, 774 were classified by police as minor crashes, 433 serious crashes, 74 fatal crashes, and 50 as non-injury crashes. During the same period, and occurring within the same geographical area, the Midland Trauma System trauma registry recorded 1,614 motorcycle-related patient admissions. Of these, 689 occurred on-road, with the remaining 925 occurring on farm, during sport, or in the countryside being excluded from data linkage. A total of 386 records were linked between the two datasets equating to 29% of police recorded CAS records, and 56% of trauma hospital admitted patient records. There were 947 records in the police CAS dataset only, and an additional 303 records in the MTS trauma registry dataset only (Figure 1).

Table 1 shows a comparison of linkage rates according to police CAS crash severity classification and MTS trauma injury severity (Major trauma - ISS > 12, and non-major trauma - ISS < 13) for the 386 patients linked between the two datasets.

A higher rate of linkage (71%, 112/157) was seen among major trauma (ISS>12) patients compared with 52% (275/532) linkage among non-major (ISS < 13) admitted patients. Major trauma patients were 2.3 times more likely to be linked to police records compared to Non-Major trauma patients; however, a total of 45 major trauma patients could not be linked to police records (Table 1).

Table 3. Demographic characteristics of 689 motorcycle-related trauma patient hospital admissions in the Midland Region (Excl. Tairāwhiti DHB), 2012-2016, by linkage with police-CAS records and Odds Ratio of record linkage determined by logistic regression.

	Total admitted	MTS registry only, n (%)	Police-CAS/ MTS linked, n (%)	Odds Ratio (CI) of linkage	P value
Total	689	303 (44%)	386 (56%)		
Gender					
Female	96	41 (43%)	55 (57%)	Reference	
Male	593	262 (44%)	331 (56%)	0.94 (0.61-1.46)	0.83
Ethnicity*					
European	489	201 (41%)	288 (59%)	Reference	
Māori	177	92 (52%)	85 (48%)	0.64 (0.46-0.91)	0.013
Other/PI	21	9 (43%)	12 (57%)	0.93 (0.38-2.24)	1.00
Not stated	2	1 (50%)	1 (50%)		
Age (Years)					
0-14	20	16 (80%)	4 (20%)	0.17 (0.05-0.55)	< 0.002
15-19	61	36 (59%)	25 (41%)	0.49 (0.27-0.89)	0.02
20-24	84	35 (42%)	49 (58%)	0.98 (0.58-1.69)	1.0
25-34	122	63 (52%)	59 (48%)	0.66 (0.41-1.06)	0.09
35-44	109	45 (41%)	64 (59%)	1.00 (0.61-1.65)	1.0
45-54	157	65 (41%)	92 (59%)	Reference	
55-64	99	32 (32%)	67 (68%)	1.48 (087-2.5)	0.15
65+	37	11 (30%)	26 (70%)	1.67 (0.77-3.62)	0.3
Place of Injury					
Urban	316	134 (42%)	182 (58%)	Reference	
Semi-Rural	123	47 (38%)	76 (62%)	1.19 (0.78-1.83)	0.43
Rural	250	122 (49%)	128 (51%)	0.74 (0.51-1.07)	0.11
Patient domicile.**					
Urban	304	133 (44%)	171 (56%)	Reference	
Semi-Rural	125	53 (42%)	72 (58%)	1.06 (0.69-1.61)	0.80
Rural	172	86 (50%)	86 (50%)	0.77 (0.55-1.07)	0.19
Self-presenting***					
No	534	171 (32%)	363 (68%)	Reference	
Yes	145	129 (89%)	16 (11%)	0.06 (0.03-0.10)	< 0.001
Pillion passenger					
All	26	18 (69.3%)	8 (30.7%)	n/a	
Female	20	14 (70.0%)	6 (30.0%)		
Male	6	4 (66.6%)	2 (33.3%)		

*Where ethnicity and employment status was 'not stated', data were excluded from statistical tests. **Excludes 88 undetermined,***excludes 10 unknown.

Table 2 presents concordance rates between police recorded crash severity and patient trauma severity among the 386 linked records. There was a statistically significant association between record linkage and minor, serious, and fatal crash classification made by police ($\chi^2 = 328$, $P < 0.001$). Highest linkage rates were found among crashes classified by police as serious (59%, 281/473) with odds of record linkage 11 times higher than those classified by police as minor. At least 90 persons classified as being in a minor crash by police were still admitted to hospital. Similarly, there was a significant association between record linkage and trauma injury severity ($\chi^2 = 19$, $P < 0.001$). Highest concordance was found between crash casualties classified as minor by police and admitted to hospital as non-major patients (n = 79). 31% of casualties classified by police as serious were admitted as major trauma patients,

Table 4. Motorcycle injured trauma patients admitted (Midland Region, excluding Tairāwhiti DHB, 2012-2016), linkage rates by age under 45 years and older: patient demographic factors, place of injury, and self-presentation to hospital (ISS – Injury Severity Score)

	Age < 45 Years			**Age ≥ 45 Years**		
	MTS Registry (N)	Linked (%)	*P* value	MTS Registry (N)	Linked (%)	*P* value
Overall	396	51		293	63	
Injury severity			0.07			< 0.001
Non-Major (ISS<13)	326	48		206	56	
Major (ISS>12)	70	61		87	79	
Gender			0.27			0.37
Female	58	61		38	55	
Male	338	48		255	64	
Ethnicity*			< 0.02			0.89
European	258	56		230	63	
Māori	118	39		58	66	
Other/PI	18	56		5	66	
Place of injury			0.78			0.71
Urban	126	59		125	38	
Semi-Rural	66	58		56	68	
Rural	204	55		112	63	
Patient domicile**			0.21			0.96
Urban	109	43		63	62	
Semi-Rural	70	53		55	70	
Rural	178	53		124	61	
Self-presenting			< 0.001			< 0.001
No	293	64		242	73	
Yes	103	10		41	12	
Unknown	9	57		1	0	

*Exclude 2 cases ethnicity not stated, **Excludes cases where domicile unknown, P value from Chi-square test for independence (test of whether linkage is independent between categories of the variables.

and a further 11 patients admitted to hospital as major trauma cases had been in a crash classified by police as being minor.

Table 3 shows a comparison of admitted patient factors and demographics for CAS linked and non-linked patient records and odd ratios of linkage as determined by logistic regression. 86% (593/689) of all hospital admissions were male while the proportion of linked versus unlinked records was very similar between males and females (Table 3).

There was a significant association between ethnicity and linkage with significantly lower odds ratio of linkage noted among Māori compared to Europeans, as well as a significant association between age and linkage rates. Odds of linkage increased significantly with age, with a steeper increase in odds of linkage occurring among those aged 55 years and older. Hospital admission records for patients who were injured in a rural location were less likely (OR 0.74) to be linked with police CAS records compared to those injured in an urban area although this was not statistically significant. There were no significant variations in odds of linkage rates by rurality of patient domicile. Linkage rates varied significantly with patient self-presentation to hospital, patients who self-presented were almost 95 percent less likely to be linked to police CAS records (Table 3).

At least 26 admitted patients were pillion passengers, 69% (18/26) of these hospital records could not be linked with police records. A majority of pillion passengers were female (77%, 20/26), and constituted 78% of all pillion passenger patients who could not be linked with police records.

Table 4 shows a comparison of patient factors for those aged 0-44 years or 45 years and over. Significant relationships were found between ethnicity, rurality of place of injury, and self-presentation to hospital emergency department for those aged under 45 years.. Almost two-thirds of patient records which could not be linked to police CAS records involved patients aged under 45 years. Furthermore, only

Table 5. Motorcycle injured trauma patients admitted (Midland Region, excluding Tairawhiti DHB, 2012-2016), linkage rates by self-presentation to hospital: patient demographic factors, place of injury, and patient domicile rurality (ISS – Injury Severity Score).

	Non self-presenting				**Self-presenting**		
	MTS Registry (N)	Linked (%)	*P* value		MTS Registry (N)	Linked (%)	*P* value
Overall*	535	68			144	11	
Injury severity			0.11				1.00
Non-Major (ISS<13)	383	66			139	12	
Major (ISS>12)	152	74			5	0	
Gender			0.94				0.06
Female	73	67			21	24	
Male	462	68			123	9	
Age			0.02				1.00
0-44	293	64			94	11	
45+	242	75			50	12	
Ethnicity**			0.39				0.19
European	389	69			93	15	
Māori	129	64			45	5	
Other/PI	16	75			5	0	
Place of injury			0.01				0.36
Urban	229	74			83	11	
Semi-Rural	106	69			14	21	
Rural	200	60			47	9	
Patient domicile***			0.07				0.93
Urban	222	72			74	9	
Semi-Rural	101	70			24	8	
Rural	134	60			36	11	

*Excludes 10 cases means of presentation unknown, **Excludes cases where domicile unknown, P value from Chi-square test for independence (test of whether linkage is independent between categories of the variables.

fifty one percent of these younger motorcyclists could be linked across both datasets. For patients aged over 45 years, significant relationships were found for linkage rates with severity and with self-presentation. Gender did not appear to be related to age group while patients identifying as Māori or other/Pacific Islander had a significantly lower representation among those 45 years of age, suggesting a bias towards European representation among those aged over 45 years. No effect of rurality of patient domicile was found between the two age groups.

In both age groups, there was a very strong relationship between self-presenting behaviour and linkage rates. However, older patients aged over 45 years were less likely to self-present to hospital compared to those aged under 45 years, almost twice as many under 45 year olds self-presented compared to those aged over 45 years (Table 4).

Approximately 21% (144/689) of all hospital admissions were patients known to have self-presented to hospital. Approximately 89 percent ((129/144) of all self-presenting patient records could not be linked to police CAS records. Table 5 shows a comparison of linkage rates for patients who either self-presented to hospital or did not by injury severity, various demographic factors and injury circumstances. Linkage rates were associated with rurality of injury location for those patients who did not self-present. Lowest linkage rates for those who did not self-present had been injured in a rural location. Notably, at least five patients who self-presented were major trauma patients who could not be linked to police CAS records. For patients who did self-present to hospital, there were no apparent associations with any variable considered in our study.

While gender was not found to be a significant factor in self-presentation, 21 self-presenting patients were female, and approximately two thirds (14/21) of these self-presenting females had been pillion passengers..

Discussion

This study has shown that in the Midland Region of New Zealand, police records continue to underestimate motorcycle crash casualties resulting in hospital admission. Approximately 56% of admitted patient records within the MTS trauma registry could be linked with police CAS records for on-road motorcycle crash casualties in the Midland Region (2012-2016). This is higher than the 46% linkage rate previously found between NZ Ministry of Transport Traffic Crash Reports (TCRs) and NZ NMDS (National Minimum Dataset) hospital discharge records for on-road motorcycle crash casualties during 2000-2004 (Wilson et al., 2012).

A number of reasons may contribute to this difference in linkage rates. The MTS trauma registry holds detailed information regarding the circumstances of injuries, including injury descriptions provided directly by patients. This may allow more accurate ICD-10 coding and identification of patients with motorcycle related injuries than the more generalized hospital discharge records which contribute to the NMDS discharge dataset. Furthermore, the linkage study reported by Wilson et al. (2012) covered a period of time (2000-2004) when motorcycle crash casualties reported to police were at their lowest levels during the period 1985 to 2016 (Ministry of Transport, 2017). Such differences aside, the present study again confirms substantial under reporting of motorcycle crash casualties to police.

Previous studies have shown the increase in motorcycle crash casualties reported to police since the early 2000s was almost entirely among those aged over 40 years. Our study suggested a significantly higher probability of data linkage for older motorcyclists aged over 45 years. The general pattern of higher linkage rates with increasing age found in this study also agrees well with that previously reported for motorcycle casualties (Wilson et al., 2012). The combination of higher numbers of older motorcycle casualties, together with higher odds of linkage among older riders, may thus contribute to the higher linkage rate seen in this study compared to that seen during 2000-2004 (Wilson et al., 2012).

An association between injury severity and linkage rates has previously been noted in other studies and may reflect a higher rate of attendance by police at more serious crashes, as well as more often involving another vehicle increasing the likelihood of reporting (Kamaluddin, Abd Rahman, & Varhelyi, 2018; Watson et al., 2015; Wilson et al., 2012). In the current study, older riders aged incurring major trauma, had significantly higher linkage rates with police CAS records. The current study might therefore suggest a more complex interrelationship involving age, severity, and odds of data linkage, which may partly be related to circumstances of patient presentation to hospital, specifically self-presentation to hospital. The observation of eleven patients recorded as minor injuries in the police records, but recorded as major trauma in the hospital record is concerning. This may suggest a need for further training of police in injury severity assessment at scene. Similarly, the extent of medical professional involvement in such assessments at scene are currently not recorded, thus making any biases in linkage across regions or demography difficult to understand.

Patients are recorded in the MTS trauma registry as "self-presenting" if the patient arrived at the emergency department of their first presenting hospital without prior assistance from emergency services. A novel finding of this study was the significant number (21%, 144/689) of motorcycle related hospital admissions who had self-presented to hospital. Furthermore, and perhaps unsurprisingly, the odds of linkage with police CAS records for such self-presenting patient records are significantly lower. Linkage rates were almost 95% lower for patients who self-presented than for those who did not self-present across all demographic factors we examined. At least 129 (42.6%) of the 303 MTS trauma registry only patients had self-presented to hospital compared with only 16 (4.1%) self-presenting admissions linked with police CAS records.

There were twice as many patients who self-presented in the under 45 year old age group compared to those age 45 years and older. Significantly higher self-presentation rates by younger riders, and the high proportion of such self-presenting patients having non-major trauma (96.5%, 139/144 self-presenting patients), has a marked effect on linkage rates. In particular, motorcycle injury among younger riders appears to be under reported in police CAS statistics and the contribution of such self-presenting behaviour requires further study.

We also found that older motorcyclists who did not self-present were significantly more likely to be linked to police records. The effect of severity, and significantly greater linkage rates among older riders with major trauma among those who did not self-present warrants further study. Of concern was the observation that at least five of those patients who self-presented were admitted as major trauma patients, and of which none could be linked to police CAS records. In addition, several hospital admissions not linked to police CAS records were pillion passengers, particularly females, suggesting that police records fail to capture the full extent of motorcycle injuries, partly by under-recording of pillion passenger casualties.

In the present study, the linkage rates between police and hospital datasets was also associated with the rurality of injury location. Our finding of lower linkage amongst those injured in a rural location agrees with a similar study in Australia which found lower linkage rates for road crash casualties occurring in rural and remote locations (Watson et al., 2015). Although the Australian study included other road users such as cars and cyclists, the authors and those of other studies have suggested that this may be due to under-reporting to police in rural locations (Boufous, 2003; Langley, Stephenson & Cryer, 2003; Watson et al., 2015).

Almost two thirds of hospital admissions involving patients who were injured in an urban location were younger motorcyclists. The nature of motorcycling activity

and crash rurality in these two age groups, and whether older riders are more commonly injured in rural areas during recreational riding, while younger riders, often injured in urban areas, may be more work or commute related, requires further study. It is also possible that the significantly lower linkage rates of self-presentation among those injured in rural and semi-rural areas is linked to either the greater proportion of riders injured rurally tending to be older riders and who are overall less likely to self-present, or crash and injury severity may be higher on open roads in rural areas. Similarly, greater rates of self-presentation for those injured in urban areas may simply be a function of proximity to major hospitals, or linked to the lower average age of motorcycle riders injured in such urban areas.

Some limitations of this study include the fact that that not all road crash casualties may be reported to police, motorcycle casualties who attended an emergency department but were not admitted for more than 24 hrs, or died at scene, are not captured in the trauma registry, and our study does not include motorcycle crash casualties who may have been treated in primary care. A further potential concern is the quality of data linkage, however, the availability of multiple linkage fields and our extensive manual checks provide us with confidence that any such effects are likely to be very minimal. Despite these limitations, this study has uncovered new insights concerning the wider extent of motorcycle injuries resulting in hospital admission and factors underlying variations in linkage with police records. In particular, age, rurality of injury, and self-presentation to hospital appear to be inter-related, an understanding of which is valuable given recent shifts in motorcycle crash demographics reported to police.

Conclusions

Across all motorcycle-related hospital admissions in the Midland Region, only 56% of records could be linked with reports collected by police. Significantly higher linkage rates were found for patients involved in crashes classified as serious by police, patients admitted with major trauma, patients aged over 45 years. Significantly lower linkage rates were found for those patients who were injured in a rural or semi-rural area, or who self-presented to hospital. Pillion passengers who were admitted to hospital, especially females, were also found to be under reported among police CAS records. Approximately 21% of all motorcycle-related hospital trauma admissions were self-presenting patients, arriving at their first presenting hospital without prior assistance from emergency services. Younger motorcycle crash casualties, under 45 years of age, were significantly more likely to self-present than older motorcyclists. Across all ages, only approximately 11% of self-presenting patients could be linked to police CAS records. This combination of factors may help to explain the overall higher linkage rates for older riders over 45 years. The merging of hospital admission and police records provides a greater understanding of the wider extent of motorcycle crash casualties and where biases may exist in reporting to police. In particular, the high rate of self-presentation to hospital by younger motorcycle riders warrants further study. Such wider studies should include such factors as insurance, work related motorcycling activity, alcohol or drug status, and any other behavioural risk factors.

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