

Peer-reviewed papers

Measuring non-fatal road trauma: using police-reported and hospital admission-based data to monitor trends and inform policy

by Rebecca J Mitchell¹, Mike R Bambach¹, Raphael H Grzebieta¹ and Ann M Williamson¹

¹Transport and Road Safety (TARS) Research, University of New South Wales, Australia

Corresponding author: Rebecca Mitchell (r.mitchell@unsw.edu.au)

Transport and Road Safety (TARS) Research, University of New South Wales, Old Main Building, Sydney, NSW 2052, Australia, Tel: +61 2 9385 7555

Abstract

Road trauma identified using hospital admission records or police-reported crashes are susceptible to changes in policy and resourcing. This research compares temporal trends in police, hospital and linked police-hospital records for non-fatal road trauma for road users by injury severity during 2001 to 2009 in New South Wales, Australia. Hospital records showed significantly increasing injury trends for motorcyclists and pedal cyclists (6.3% and 5.5%) and significantly decreasing trends for motor vehicle occupants and pedestrians (1.7% and 2.2%) per year whereas, for police-reported crashes, there were significant decreases for pedal cycle, motor vehicle and pedestrian casualties (1.5%, 3.8% and 5.2%), and a significant increase for motorcyclists (1.8%) per year. Differences in the annual percent change over time between hospital and police-reported crashes are evident which may influence policymaking. Policy makers should endeavour to review road casualty trends from a range of data collections to inform policy development regarding road safety.

Keywords

Road trauma, Data linkage, Policy, Injury severity, Police data, Hospital data

Introduction

Police reports of road traffic crashes are commonly used to measure performance in reducing road trauma-related mortality and morbidity in many countries, including Australia [1-4]. While reducing the number of fatalities on the road has been a focus in Australia, policy initiatives are also aiming to reduce the incidence of serious injuries

following road trauma [5]. To be able to monitor trends of serious injury over time, mechanisms to monitor the incidence of serious injury are required. Previous research has shown that only monitoring police-reported road crashes can under-enumerate the number of road crashes [2, 6-8], particularly for certain crash types, such as vehicle-cyclist collisions [9]. In addition, when attempting to identify individuals who have been seriously injured in a road traffic crash, police have been found to misclassify injury severity [1, 7, 10].

Other data collections, such as hospital admission or trauma registries, can provide information on injuries following road traffic crashes [2, 4, 11], including information on those crashes that are not captured by police, but these data collections contain little to no detail regarding the crash circumstance. Injury severity estimates can be calculated from hospital administrative data collections [12, 13], negating the need to solely rely on police-identified injury severity estimates.

In addition to monitoring temporal trends in road trauma, information on the number, incidence and circumstances of road traffic crashes are used by policy makers to determine the magnitude of road trauma, to identify the causal and contributory factors involved in road crashes, and to identify priorities for road safety. This information is also used in the evaluation of countermeasures and to inform the development of road safety policy [14].

Policy makers need to be aware of changing trends in the incidence of non-fatal road trauma to assist in guiding policy development aimed at reducing road traffic-related injury morbidity. Whether similar temporal trends in non-fatal road trauma are able to be derived using data from

different data collections collecting information on road trauma and commonly applied road-related denominator data for each road user or for different levels of injury severity is yet to be examined in New South Wales (NSW). This research aims to examine the use of police-reported, hospital admission, and linked police-hospital admission records to report on non-fatal road trauma for road users by injury severity to inform policy.

Method

A retrospective analysis of road trauma-related injuries identified in police-reported, hospital admission and linked police-hospital admission records during 1 January 2000 to 31 December 2009 was conducted. Ethics approval was obtained from the NSW Population and Health Services Research Ethics Committee (2010/10/273) and was ratified by the University of NSW Human Research Ethics Committee (HREC 11125).

Data collections

The Admitted Patient Data Collection (APDC) includes information on all inpatient admissions from all public and private hospitals, private hospital day procedures and public psychiatric hospitals in NSW. The APDC contains information on patient demographics, source of referral, diagnoses, external cause(s), hospital separation type (e.g. discharge, death) and clinical procedures. Diagnoses and external cause codes are classified using the International Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM) [15]. Any APDC records with the separation coded as death (i.e. died in hospital) were excluded. Road trauma on public roadways were identified using the ICD-10-AM principal external cause code for each road user category: pedestrian (ICD-10-AM: V01-V06, V09), pedal cyclist (ICD-10-AM: V10-V18, V19), motorcyclist (ICD-10-AM: V20-V28, V29) and motor vehicle occupant (ICD-10-AM: V30-V38, V40-V48, V50-V58, V60-V68, V70-V78, V39, V49, V59, V69, V79, V86) and a ICD-10-AM 4th character identification of 'traffic' for each road user (i.e. occurred on a public roadway). There were 91,952 individuals who sustained an injury during a traffic crash in the hospital admission data collection.

The CrashLink data collection contains information on all police-reported road traffic crashes where a person was unintentionally fatally or non-fatally injured, or at least one motor vehicle was towed away and the incident occurred on a public road in NSW. Information pertaining to the crash and conditions at the incident site; the traffic unit or vehicle; and the vehicle controller and any casualties resulting from the crash; are recorded. Each individual is identified as being non-injured, injured or killed (died within 30 days). No information on injury severity is available. Individuals who were non-injured or killed were excluded. Road users

were identified using the traffic unit group (i.e. pedestrian, pedal cyclist, motorcyclist or motor vehicle occupant). There were 236,538 individuals who sustained an injury during a traffic crash in the police-reported data.

Data linkage

The APDC was linked to the police-reported crashes in CrashLink by the Centre for Health Record Linkage (CHeReL). The CHeReL uses identifying information (e.g. name, address, date of birth, gender) to create a person project number (PPN), for each unique person identified in the linkage process. The record linkage used probabilistic methods and was conducted using *ChoiceMaker* software [16]. A successful link was defined as when the PPN matched in both data collections, and the admission date in the APDC was on the same day or the next day as the crash date in CrashLink. Upper and lower probability cut-offs started at 0.75 and 0.25 for a linkage and were adjusted for each individual linkage to ensure false links are kept to a minimum. Record groups with probabilities in between the cut-offs were subject to clerical review. There were 51,737 individuals who were included in both the police and hospital admission data collections. The overall linkage rate for road trauma recorded by the police to road traffic-related hospital admissions (i.e. the linkage of APDC records to CrashLink) was 56.3%.

Injury severity

Injury severity was calculated directly from the ICD-10-AM injury diagnosis codes, using the probability of survival for each individual code, termed a Survival Risk Ratio (SRR). The SRR for an ICD code is the proportion of survivors among all cases with that ICD-coded injury. The procedure has been compared with the Abbreviated Injury Scale (AIS) and has proved equivalent or superior in assessing mortality risk [12, 17, 18]. In a separate study using the APDC for all land transport trauma, the hospital records for 109,843 individuals were used to generate SRRs for all ICD-10 injury codes during 2001 to 2007 [13]. These data represent a census of all land transport trauma in NSW during the period, and for each ICD injury (ICD_i) the SRR was calculated from Equation 1.

$$SRR_{ICD_i} = \frac{\text{Number of individuals with injury } ICD_i \text{ that survived}}{\text{Total number of individuals with injury } ICD_i} \quad (1)$$

There is no specific measure against which different severity levels in the International Classification of Disease Injury Severity Score (ICISS) may be compared. Dayal et al [19] have suggested ICISS levels to define minor, moderate and serious injury. A similar approach was adopted for this study, with four levels of injury severity identified (i.e. minor, moderate, serious, and severe) (Table 1).

Table 1: Injury severity levels used for the International Classification of Disease Injury Severity Score (ICISS)

Injury severity	ICISS range	% of records in APDC ¹	Examples of common injuries in range
Minor	1.0 – 0.993	20.4	External abrasions, contusions, lacerations
Moderate	0.992 – 0.966	45.5	Fracture of minor bones, dislocations, minor organ contusions
Serious	0.965 – 0.855	27.3	Fracture of major bones/ribs, organ lacerations, spine fractures
Severe	0.854 – 0.0	6.9	Major organ/vessel damage, major brain/spinal cord damage

¹Admitted Patient Data Collection.

Data management and analysis

All analyses were performed using SAS version 9.2 [20]. The three non-fatal injury data collections (i.e. hospital, linked police-hospital and police) were disaggregated by injury severity, road user type and year of crash to analyse temporal trends in road traffic crashes. Three commonly used denominators were used to calculate incidence rates by per 100,000 population per year; by per 10,000 vehicle registrations per year; and by per 10,000 licence holders per year. The total population, number of registered vehicles and number of driver licences are provided in Table 2.

Annual population numbers for NSW were derived from the Australian Bureau of Statistics (ABS) annual Australian demographic statistics [21]. Direct standardisation was used to age-standardise population rates, using the Australian population in 2001 as the standard population [22]. Ninety-five percent confidence intervals (95%CI) were calculated assuming a Poisson distribution [23]. The number of registered vehicles and licence holders were derived from the Transport for NSW annual statistical reports [24]. Trends in incidence rates were indexed to the year 2001 by dividing the rate in each year by the 2001 rate, in order to generate plots of trends over time. Because of over-dispersion, negative binomial regression was used to examine the statistical significance of changes in the trend over time of the annual rates of road crash casualties, road crash casualties by injury severity, and road crash casualties by type of road user [25].

Table 2: Number of records in the police and hospital linked data and number of vehicle registrations, licences and population in NSW by year, 2001-2009

	Hospital data	Linked police and hospital data	Police reported data	Vehicle registrations		Licences		Population
				Motor vehicles	Motor cycles	Motor vehicles	Motor cycles	
Year	n	n	n	n	n	n	n	n
2001	9,068	5,352	29,913	3,647,300	90,000	3,761,324	395,493	6,605,719
2002	9,144	5,302	28,447	3,734,300	94,400	3,837,582	404,924	6,651,745
2003	9,208	5,478	27,208	3,838,900	99,300	3,917,080	400,370	6,689,526
2004	9,269	5,379	26,323	3,949,256	105,289	3,939,409	405,661	6,730,149
2005	9,557	5,696	25,209	4,012,351	111,253	3,983,326	413,667	6,783,912
2006	10,293	5,944	25,439	4,097,516	120,827	4,048,742	425,441	6,856,782
2007	9,726	5,456	25,845	4,177,115	133,512	4,137,742	438,846	6,958,448
2008	9,451	5,236	24,048	4,273,025	146,583	4,181,259	460,997	7,059,690
2009	9,540	5,155	24,106	4,354,278	162,076	4,240,536	480,503	7,126,947

Sources for denominator data: Australian Bureau of Statistics, 2009. Australian demographic statistics, Sept 2009. Catalogue no 3101.0. ABS, Canberra and NSW Centre for Road Safety, 2010. Road traffic crashes in New South Wales: Statistical statement for the year ended 31 December 2009. Roads and Traffic Authority, Sydney.

Results

Overall, the largest declining rate trend for road crash casualties during 2001 to 2009 was shown per 10,000 vehicle registrations using the police-reported data, with the trend estimated to decrease significantly by 4.7% per year ($p < 0.0001$; 95%CI for the decrease 4.1% to 5.4%). This compares to a decrease of 4.0% per year ($p < 0.0001$; 95%CI for the decrease 3.4% to 4.5%) using per 10,000 licences as the denominator and a decline of 3.4% per year ($p < 0.0001$; 95%CI for the decrease 2.9% to 3.9%) using per 100,000 population denominator. Hospital admissions data did not show the same rate of decline for road casualties per 100,000 population as shown in police-reported data, with an estimated 0.1% decrease in admissions ($p = 0.7$; 95%CI for the decrease -0.4% to 0.6%). The linked police-hospital data also showed a declining trend, but the decrease was not as high as police-reported data, with an estimated decrease of 0.9% per year ($p < 0.0001$; 95%CI for the decrease 0.5% to 1.3%) (Figure 1).

For road trauma-related hospital admissions in the APDC, rates of moderate and serious injury per 100,000 population increased from 2001 to a peak in 2006, after which they declined, resulting in an estimated 0.9% increase per year for serious injury ($p = 0.007$; 95%CI for the increase 0.2% to 1.5%) and an estimated annual decrease of 0.3% for moderate injury ($p = 2.61$). Compared to 2001 levels, the serious injury rates in the linked police-hospital data were similar to those in the hospitalisation data (estimated 0.7% increase per year, $p = 0.041$; 95%CI for the increase 0.03% to 1.3%). However, the rates for severe injury were slightly higher in the linked police-hospital data than in the hospitalisation data alone, for moderate injury slightly lower, and for minor injury substantially lower (Figure 2).

The trends in road crash casualty rates for each road user type varied per 100,000 population. Motorcycle and pedal cycle casualty rates calculated using the hospitalisation data increased by 6.3% per year ($p < 0.0001$; 95%CI for the increase 5.5% to 7.0%) and 5.5% per year ($p < 0.0001$; 95%CI for the increase 4.3% to 6.7%), respectively. Motor vehicle and pedestrian rates decreased by 1.7% per year ($p < 0.0001$; 95%CI for the decrease 1.3% to 2.1%) and 2.2% per year ($p < 0.0001$; 95%CI for the decrease 1.6% to 2.8%), respectively. The trends were similar for road casualty rates using the linked police-hospital data for all road user classes except pedal cyclists. The rate trends were different for casualties using police-reported data, which indicated decreases in pedal cycle (estimated decrease of 1.5% per year, $p = 0.014$; 95%CI for the decrease 0.3% to 2.6%), motor vehicle (estimated decrease of 3.8% per year, $p < 0.0001$; 95%CI for the decrease 3.3% to 4.4%) and pedestrian casualty rates (estimated decrease of 5.2% per year, $p < 0.0001$; 95%CI for the decrease 4.6% to 5.9%) and an overall increase of 1.8% per year ($p = 0.005$; 95%CI for the increase 0.6% to 3.1%) in motorcycle casualty rates (Figure 3).

Discussion

Despite advances, road trauma accounts for an estimated 1.3 million deaths annually worldwide and is projected to become the third leading cause of the burden of disease by 2030 [26]. In Australia, although the road toll has been decreasing, the burden of road trauma remains significant at around 1,400 deaths and 32,500 serious injuries each year [27]. In Australia, the economic cost of road trauma has been estimated at AUD\$27 billion [28]. In order to identify where gains can be made to reduce this cost by reducing the rate of road casualties, information on road casualty trends over time are required. Overall, a declining trend in road casualties was found in NSW, with the strength of the decline varying, depending on which data collection was used to estimate the incidence rate. While three different denominator data were used to examine casualty trends over time, there were no substantial differences in overall road trauma trends using each of these denominators. These similar trends provide impetus that the denominators selected are able to provide a consistent reflection of road casualty trends in NSW to inform policy decision making.

This study identified that incidence rates calculated using police-reported data showed a substantially greater declining trend compared to rates calculated using the hospitalisation data and the linked police-hospital data. Based on an examination of the non-linked records between the police and hospitalisation data, it appears that 75% of police-reported data consisted of individuals with only minor injuries (i.e. individuals identified as being injured by police who were not admitted to hospital). It appears that the larger declining trend in police-reported casualty rates over the study period compared to the hospitalisation data might result from either a real decline in the number of casualties with minor injuries, and/or a reduction in reporting to police and/or police attendance at crash scenes, and/or a reduction in the identification of 'injured' individuals by police. Unfortunately, the relative contribution of these effects could not be ascertained. However, it is clear that 'minor injury', represented by the majority of the police-reported records, appears to be influenced by temporal changes unrelated to experience of road trauma. Similarly, in New Zealand [4] temporal trends (1988–2001) in police-reported traffic crashes, where 80% of casualties were estimated to have minor injuries, indicated substantially greater declines than found when hospitalisation data was examined. Implications for policy makers are that minor injury following road trauma appears to be influenced by artefact and temporal trends of minor road trauma and may not reflect actual incidence of minor injury.

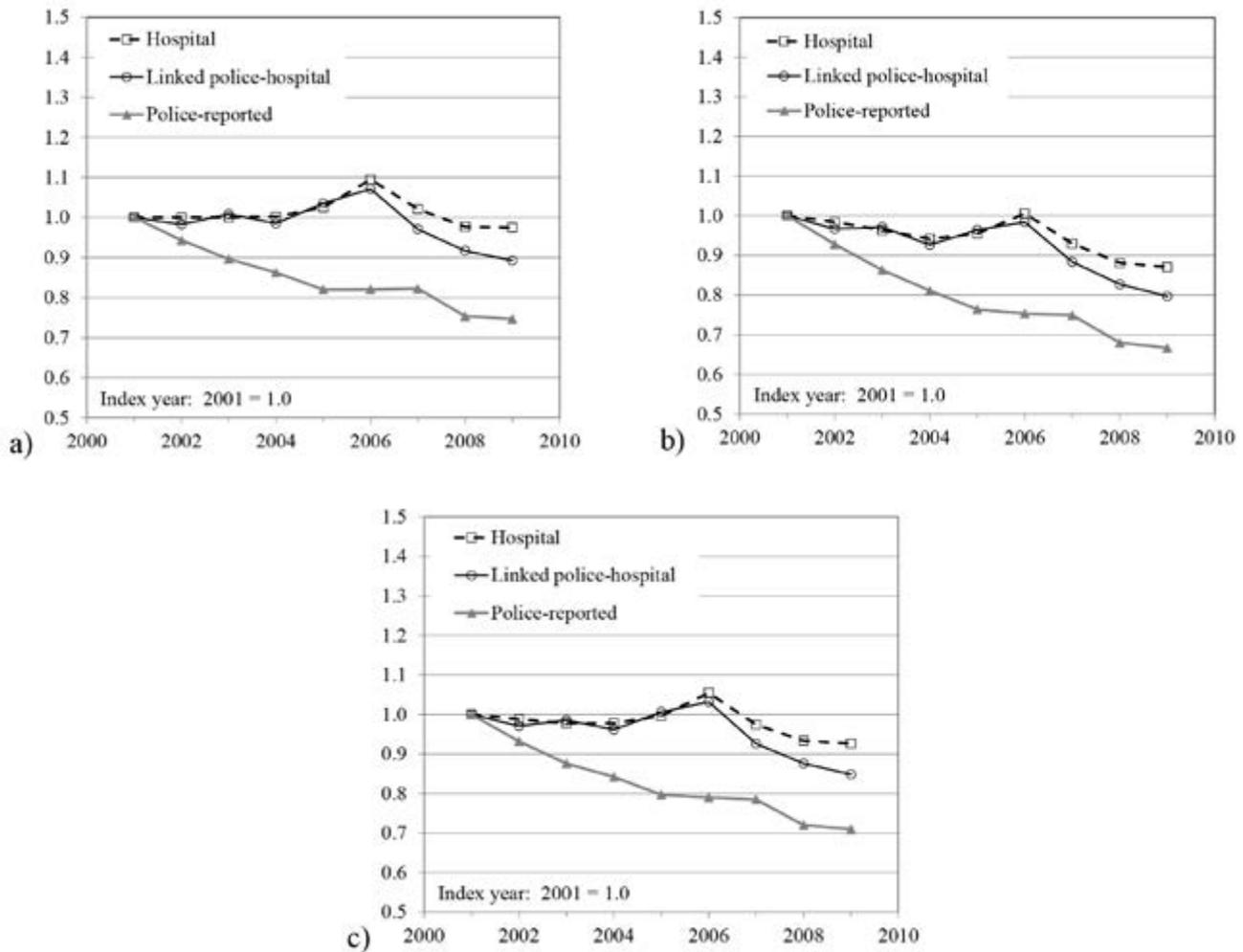


Figure 1: Trends in rates of road crash casualties in the hospitalisation, police-reported and linked police-hospital data collections; a) per age-adjusted 100,000 population, b) per 10,000 registrations, c) per 10,000 licences

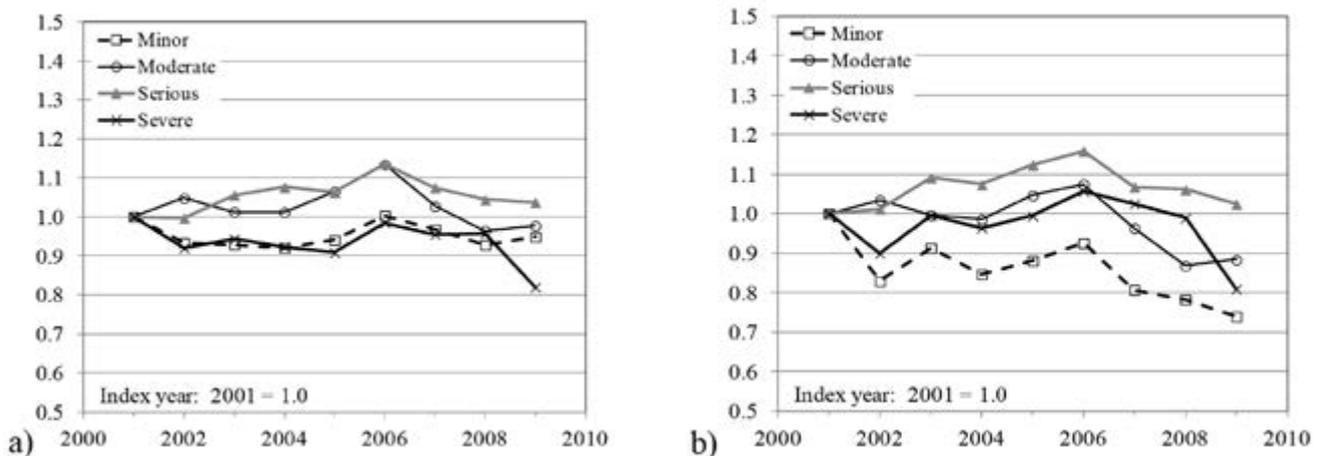


Figure 2: Trends in rates of road crash casualties per age-adjusted 100,000 population by injury severity, in the data collections; a) hospitalisation, b) linked police-hospital data

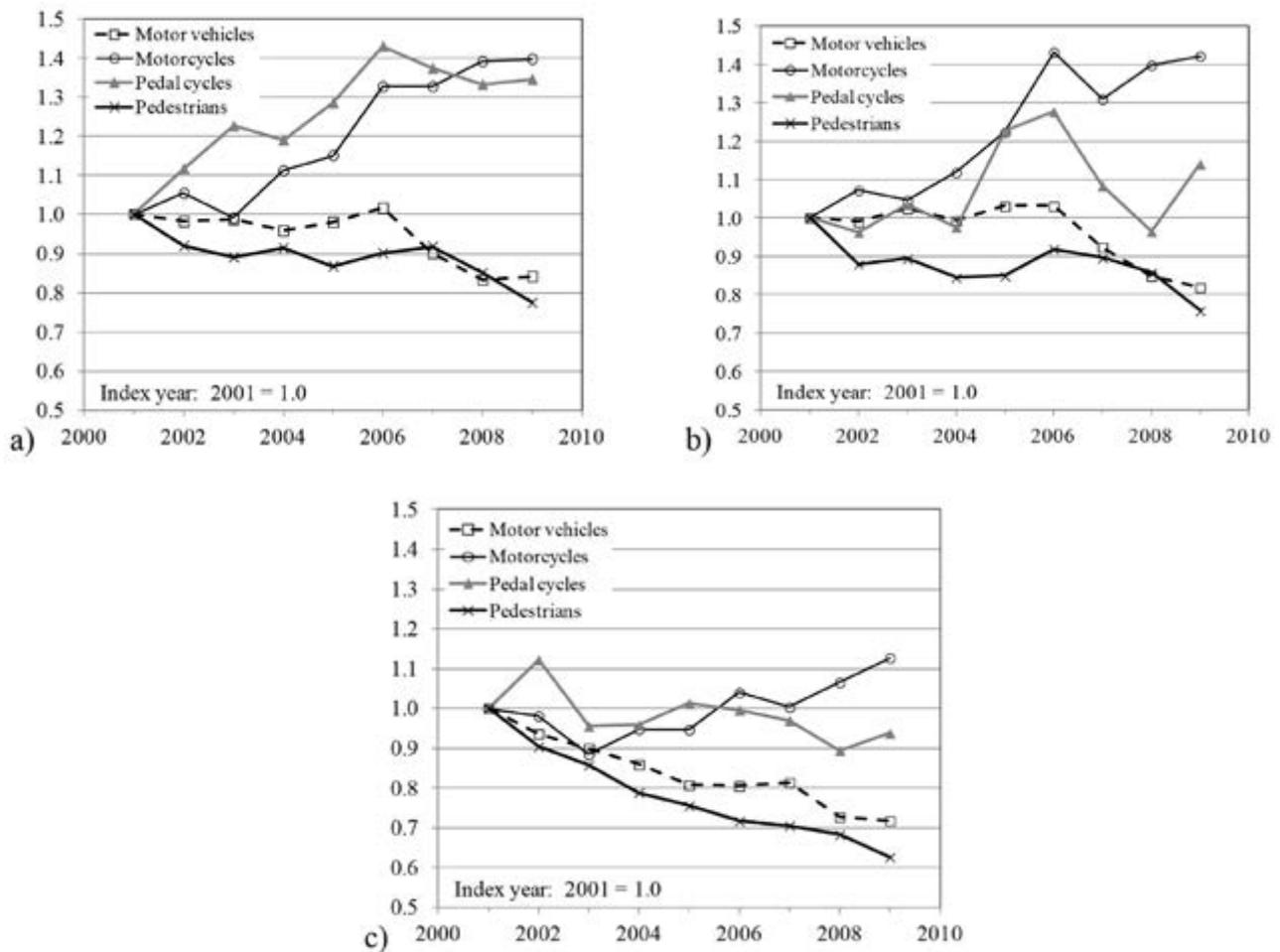


Figure 3: Trends in rates of road crash casualties per age-adjusted 100,000 population by road user class, in the data collections; a) hospitalisation, b) linked police-hospital data, c) police-reported data

It is difficult to explain with certainty the reason for the increase in the road casualty trend in 2006 and what this implies for the evaluation of the impact of road safety policy. This increase could be due to a real increase in road trauma and/or to changes in hospital admission policy or service delivery. It is likely that if there were changes in hospital admission policy there would be a decrease in minor injury admissions, with serious injuries remaining constant as these injuries would be likely to be admitted to hospital regardless of admission policies. However, this was not evident, as there was an increase in road casualties for every severity level and road user type. In addition, the 2006 peak for road casualties was also evident in other Australian states [27]. Therefore, the peak does not appear to be an artefact of the current analysis, but a real increase in casualties in that year.

The examination of trends over time by injury severity using the hospitalisation data and linked police-hospital data were similar, except for minor and, to some extent, moderate injury trends. As 66% of the hospitalisation data

consisted of individuals with minor or moderate injury, it is likely that the divergence between the hospitalisation data and the linked police-hospital data trends result from the difference in the incidence of these injuries in each data collection. The decrease in minor injury in the linked police-hospitalisation data could be due to a decreasing tendency of reporting to police and/or police attendance at minor injury crashes, or an increasing tendency of hospitals to admit casualties with minor injuries. The relative contribution of these effects could not be ascertained with certainty. However, the impact of each of these conditions would have a different impact on policy making, for example if there was a decline in individuals reporting crashes or in police attending crashes, this would have implications for police-community liaison and police resourcing, respectively.

The examination of road casualties by type of road user found increasing casualty trends for pedal cyclists and motorcyclists and decreasing trends for motor vehicle occupants and pedestrians in the hospitalisation data.

Casualty trends in the linked police-hospital data were fairly similar to those identified using the hospitalisation data, except for pedal cyclists. However, using only police-reported data found decreasing casualty trends for pedal cyclists, motor vehicle occupants and pedestrians and an increasing trend for motor cyclists. Casualty trends for pedal cyclists appear to be the principal difference for road user types for all three numerator data collections. Pedal cyclists are known to be under-enumerated in police-reported crash data [9, 29, 30] and this appears to account for the diverging trends.

That only 56.3% of hospitalised road trauma on public roadways linked to police-reported crashes is of concern. Other research involving linkage between police-reported and hospitalised road trauma has found similar linkage rates [31-33]. In NSW, it appears that 43.7% of road trauma that involved individuals hospitalised was not reported to and/or recorded by police as a crash that involved an individual being injured. Reasons for non-identification by police of some road trauma involving hospitalisation are not clear, but could involve individuals not reporting a crash to police, or police not identifying individuals involved in a crash as injured, or police not attending crash scenes. It is also possible that some police records were not able to be successfully linked to hospitalisation records, due to absent or inaccurate information used for data linkage.

Policy makers need to be aware of the limitations of different data sources used to examine and report on road safety trends, particularly police-reported data sources and their under-enumeration of pedal cycle crashes. For policy makers, it is likely that hospitalisation data would be most useful to identify and examine serious injury trends (however no detailed information is available regarding the crash circumstances in these records), whereas police-reported crashes could be used as an overall estimate of the extent of road trauma (but no information is available on the injuries or treatment received). However, when estimating road trauma trends over time using police-reported crashes, it appears that a multiplying factor of at least 40% should be added to existing road trauma estimates to allow for under-enumeration of road trauma by police, particularly of the crashes that involve hospitalisation.

There are several limitations of the current study. The ICISS relies on the correct diagnosis and classification of injuries in the hospitalisation data, and validation of diagnosis coding was not conducted as part of this study. However, other research has identified that audits of diagnosis coding in hospitalisation data is of good to excellent quality [34]. The three denominator data commonly used in NSW, and used in this study may underestimate risk of a vehicle crash as they do not take into account the number of hours spent driving, the number of kilometres travelled, nor the number of individuals travelling in a vehicle. In fact not having 'true' exposure data for each type of road user, either the

person-time risk (e.g. time spent cycling) or population at-risk (e.g. number of cyclists), is likely to underestimate the risk of injury over time. The lack of appropriate and reliable denominator data is a problem for calculating 'true' injury temporal trends. This is also an issue if trends between road users' injuries are to be examined as the amount of time exposed on a roadway between road users will also differ. When using record linkage there is likely to be some degree of error in the data linkage process. In the current study, the CHEReL estimates the false positive rate for this linkage to be 0.4% (i.e. the proportion of false matches) and estimates the rate of false negatives at 0.5% (i.e. failure to identify matches).

Conclusions

It appears that the trends in road trauma casualty rates are influenced by a range of factors other than the incidence of injury, particularly minor and moderate injuries. Interpretation of non-fatal road casualty trends is likely to be influenced by the numerator data selected for review. Policy makers should endeavour to review road casualty trends from a range of data collections to inform policy development regarding road safety. This will ensure that any artefacts that might be present in one data collection, or if there are divergent trends for different types of road users between collections, will be able to be taken into account.

Acknowledgements

The authors wish to thank the NSW Ministry of Health for providing access to information in the APDC, the Australian Bureau of Statistics for providing access to the morbidity data file and the Centre for Health Record Linkage for conducting the record linkage, particularly Katie Irvine and Michael Smith. We would also like to thank Transport for NSW for providing access to CrashLink, particularly Margaret Prendergast, Stewart Hay, Andrew Graham, Bill Pink and Phil Sparkes.

References

1. Amoros, E., Martin, J., Chiron, M., and Laumon, B., Road crash casualties: characteristics of police injury severity misclassification. *The Journal of Trauma*, 2007. 62(2): p. 482-490.
2. Lyons, R.A., Ward, H., Brunt, H., Macey, S., Thoreau, R., Bodger, O., and Woodford, M., Using multiple datasets to understand trends in serious road traffic casualties. *Accident Analysis & Prevention*, 2008. 40(4): p. 1406-1410.
3. Department of Infrastructure and Transport, Road deaths Australia May 2012. 2012, Commonwealth of Australia: Canberra.
4. Langley, J., Stephenson, S., and Cryer, C., Measuring road traffic safety performance: monitoring trends in nonfatal injury. *Traffic Injury Prevention*, 2003. 4: p. 291-296.
5. Transport for NSW, NSW Road Safety Strategy 2012-2021. 2012, Transport for NSW: Sydney.

6. Wilson, S., Begg, D., and Samaranayaka, A., Validity of using linked hospital and police traffic crash records to analyse motorcycle injury crash characteristics. *Accident Analysis & Prevention*, 2012. 49: p. 30-35.
7. Cryer, C., Westrup, S., Cook, A., Ashwell, V., Bridger, P., and Clarke, C., Investigation of bias after data linkage of hospital admissions data to police road traffic crash reports. *Injury Prevention*, 2001. 7: p. 234-241.
8. Moudon, A., Lin, L., Jiao, J., Hurvitz, P., and Reeves, P., The risk of pedestrian injury and fatality in collisions with motor vehicles, a social ecological study of state routes and city streets in King County, Washington. *Accident Analysis & Prevention*, 2011. 43: p. 11-24.
9. Langley, J., Dow, N., Stephenson, S., and Kypri, K., Missing cyclists. *Injury Prevention*, 2003. 9(4): p. 376-379.
10. UK Department for Transport, Linking police and hospital data on road accidents in England: 1999 to 2009 results. 2011, UK Department for Transport, London.
11. Mitchell, R., Williamson, A., and Curtis, K., What is the potential of trauma registry data to be used for road traffic injury surveillance and informing road safety policy? *Journal of Safety Research*, 2011. 42: p. 345-350.
12. Stephenson, S., Henley, G., Harrison, J., and Langley, J., Diagnosis based injury severity scaling: investigation of a method using Australian and New Zealand hospitalisations. *Injury Prevention*, 2004. 10: p. 379-383.
13. Bambach, M., Mitchell, R., Grzebieta, R., Williamson, A., and Watson, W., Injury severity indicators and their impact on data linkage. 2012, Transport and Road Safety (TARS) Research, University of New South Wales: Kensington.
14. Horan, J.M. and Mallonee, S., Injury surveillance. *Epidemiologic Reviews*, 2003. 25: p. 24-42.
15. National Centre for Classification in Health, ICD-10-AM. Fifth ed. 2006, Sydney: National Centre for Classification in Health.
16. Choicemaker Technologies. Open Source Choicemaker Technology. 2011 [cited 2011 10/7/2011]; Available from: <http://oscm.sourceforge.net/>.
17. Davie, G., Cryer, C., and Langley, J., Improving the predictive ability of the ICD-based injury severity score. *Injury Prevention*, 2008. 14: p. 250-255.
18. Willis, C., Gabbe, B., Jolley, D., Harrison, J., and Cameron, P., Predicting trauma patient mortality: ICD [or ICD 10 AM] versus AIS based approaches. *ANZ Journal of Surgery*, 2010. 80(11): p. 802.
19. Dayal, S., Wren, J., and Wright, C., Mapping injury severity scores against hospitalisation day stays for injury priority areas (excluding workplace injury). 2008, Public Health Intelligence, Health and Disability Systems Strategy Directorate, Ministry of Health: Wellington.
20. SAS Institute, SAS: statistical software, version 9.3. 2012, SAS Institute: Cary, North Carolina.
21. Australian Bureau of Statistics, Australian Demographic Statistics, Sept 2009. Catalogue no 3101.0. 2009, ABS: Canberra.
22. Australian Bureau of Statistics, 2001 Census Basic Community Profile and Snapshot. 2004, ABS: Canberra.
23. Dobson, A., Kuulasmaa, K., Eberle, E., and Schere, J., Confidence intervals for weighted sums of Poisson parameters. *Statistics in Medicine*, 1991. 10: p. 457-762.
24. NSW Centre for Road Safety, Road Traffic Crashes in New South Wales: Statistical Statement for the year ended 31 December 2009 2010, Roads and Traffic Authority: Sydney.
25. Armitage, P., Berry, G., and Matthews, J., *Statistical Methods in Medical Research*. Fourth Edition ed. 2002, Cornwell: Blackwell Science.
26. World Health Organization, The Global Burden of Disease 2004 update. 2008, World Health Organization: Geneva.
27. Henley, G. and Harrison, J., Trends in serious injury due to land transport accidents, Australia 2000-01 to 2007-08, in *Injury Research and Statistics Series*. 2011, Australian Institute of Health and Welfare: Canberra.
28. Australian Transport Council, The National Road Safety Strategy, 2011-2020. 2011, Australian Transport Council: Canberra.
29. Roads and Traffic Authority NSW, Traffic Accident Database System Data Manual. 2003, Roads and Traffic Authority, NSW: Sydney.
30. Amoros, E., Martin, J., and Laumon, B., Under-reporting of road crash casualties in France. *Accident Analysis and Prevention*, 2006. 38: p. 627-635.
31. Rosman, D. and Knuiman, M., A comparison of hospital and police road injury data. *Accident Analysis & Prevention*, 1994. 26(2): p. 215-222.
32. Alsop, J. and Langley, J., Under-reporting of motor vehicle traffic crash victims in New Zealand. *Accident Analysis & Prevention*, 2001. 33: p. 353-359.
33. Loo, B. and Tsui, K., Factors affecting the likelihood of reporting road crashes resulting in medical treatment to the police. *Injury Prevention*, 2007. 13: p. 186-189.
34. Henderson, T., Shephard, J., and Sundararajan, V., Quality of diagnosis and procedure coding in ICD-10 administrative data. *Medical Care*, 2006. 44(11): p. 1011-1019.