Comparison of Victorian road trauma trends using traditional and alternative measures of serious injury derived from linked data

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Abstract

Systematic problems have been identified in Victoria's road safety data system collection, collation and management which have led to problems in the measurement of serious injury. In particular, measurement of the severity of injury sustained in road crashes for the purpose of monitoring the road toll and trends in road trauma relies largely on the classification of injury outcome by police when reporting a crash. As a consequence trends in serious injury, a key outcome measure of performance in the Victorian road safety strategy, may not reflect actual serious injury trends or the effectiveness of the strategy. Previous research has described a range of alternative measures of serious injury that could potentially be calculated consistently over time from Victorian road safety data sources. These include those related to resource use, threat to life and the non-fatal burden of injury. This paper outlines data requirements required to calculate alternative measures of serious injury that could potentially be adopted in the road safety domain and describes the creation of a linked dataset of police reported crash records and Transport Accident Commission (TAC) claims data containing high level injury outcome information able to be used to derive various measures of serious injury. It then presents a comparison of serious injury trends using traditional police reported measures and alternative measures derived from the linked dataset. Such comprehensive information will facilitate a sound evidence base on factors determining serious injury outcomes, allowing good evidence-based policy and practise to be developed to effectively address the problem.

Introduction

Whilst the definition of a fatality resulting from a road crash is clear, the definition of serious injury has been problematic in Victoria as it has been in many other jurisdictions. Over the past years, the definition of serious injury in Victoria derived from police crash reporting has varied as have the operational procedures for collecting the data. Furthermore, the degree to which the accuracy measurement of serious injury has been validated has varied over time. As a consequence of the ongoing changes to the serious injury definition and crash data systems, trends in the serious injury measure over time may not reflect real serious injury trends. Issues surrounding the definition and measurement of serious injury due to road trauma in Victoria have also been highlighted as part of a recent parliamentary inquiry into serious injury [14].

The Monash University Accident Research Centre (MUARC) has previously completed work exploring the feasibility and benefits of establishing a linked road injury database including police reported crash data; data on TAC claims for injury compensation from road crashes; hospital admissions data collected by the health department; and in-depth crash inspection data collected by MUARC. Results of the project showed linkage of police reported crash data with the TAC claims dataset is feasible and results in a combined database more capable of measuring detailed injury outcome consistently over time. The use of TAC claims data linked to police reported crash data was established as a way in which a consistent measure of trends in serious injury in Victoria could be provided for use in road safety performance monitoring and for road safety research.

Subsequently, MUARC collaborated with the TAC to establish a linked TAC claims and police crash dataset for use in road safety research and for monitoring trends in serious injury in Victoria. The project included specifying the content of the database and establishing an ongoing linkage process by the TAC. The project performed a review of available measures of injury severity in order to establish measures that can be calculated consistently over time and identified the most appropriate measures of serious injury that can be calculated from the TAC held or derived injury information in the linked dataset.

This paper outlines data requirements required to calculate alternative measures of serious injury that could potentially be adopted in the road safety domain. It also describes the creation of the linked dataset of police reported crash records and Transport Accident Commission (TAC) claims data containing high level injury outcome information used to derive various measures of serious injury. It then presents a comparison of serious injury trends using traditional police reported measures and selected alternative measures derived from the linked dataset.

Alternative measures of serious injury and their calculation

There is a significant body of research describing a range of alternative measures of serious injury with a number of these already in common use internationally. There are a range of these measures that could potentially be used as a new measure of serious injury from road crashes. D'Elia and Newstead [5] considered alternative measures or measures of serious injury that could potentially be calculated consistently over time for use in road safety performance monitoring and for research. It included a review of available measures of injury severity that could potentially be calculated from Victorian road safety data sources. The following were recommended as potential measures grouped by their underlying philosophical derivation:

Resource Use

- Hospital Admission
- Probability of hospital admission given crash involvement
- Length of hospital stay

Threat to Life

- Abbreviated Injury Scale (AIS) injury severity score and associated scores
    - Maximum AIS (MAIS) across all body regions
    - Injury Severity Score (ISS) and New Injury Severity Score (NISS)
- ICD (International Classification of Diseases) Based Injury Severity Score (ICISS)

Non-Fatal Burden of Injury

- Disability-Adjusted Life Years (DALY)

Resource use measures

Resource use measures are based around the simple premise of counting the number of people utilising a health resource. In general, measures relating to resource use are popular because they are relatively simple to calculate and they provide a reasonable, albeit somewhat coarse, indication of injury severity. They have some significant weaknesses however, including the potential of being affected by hospital admission policy and changes to funding models and the problem of often being non-specific with a wide variety of injury outcomes often encompassed within a single resource use measure. This means that in some instances trends in serious injury measured from resource use may vary over time with no underlying change in real injury rates whilst at other times the measure might be invariant to real changes in certain important injury types. Resource use information can be obtained directly from the Victorian Admitted Episodes Database (VAED) collected by the Victorian Department of Health. Hospital admissions from road traffic crashes can be identified in the VAED, however without linking VAED data to police reported crash data, no other details of the crash important for research and policy development are known. Hospital admission information is also available from TAC claims data for those cases which make a TAC claim for hospitalisation with the information drawn from the VAED by the TAC through the process of recompensing hospital admission costs.

Threat to life measures

Broadly speaking, threat to life measures of injury severity provide a measure of the probability that a patient will die from the injuries sustained. The Abbreviated Injury Scale (AIS), first published in 1971 by the Association for the Advancement if Automotive Medicine [4], was designed to catalogue anatomic injuries sustained in motor vehicle crashes. Its primary role was to aid in crash investigations by providing detailed anatomical descriptions of occupant injury [11]. The AIS has two components: (1) the injury descriptor which is a unique numerical identifier for each injury description; and (2) the severity score. The severity score ranges from 1 (minor) to 6 (maximum). An AIS 1 injury will generally not require hospital treatment, whereas an AIS 6 injury is almost certainly fatal [17]. The actual scores to be assigned to various types of injury were derived by consensus among a wide variety of medical specialists [15]. As trauma patients commonly have more than one injured body part, the severity score for the most severe injury is often used – this is termed the Maximum AIS ('MAIS'). The AIS severity score has some limitations including that it does not address the effects of multiple injuries within one particular body region and scores are not necessarily comparable across body regions.

The Injury Severity Score (ISS), created in 1974 and based on the AIS, was developed as a means for describing patients with multiple injuries using a single severity score [1]. To calculate an ISS for an injured person, the body is divided into six body regions (head or neck, face, chest, abdomen or pelvic contents, extremities or pelvic girdle, external injuries) and only the highest AIS severity score in each body region is used. The three most severely injured body regions have their score squared and added together to produce the final ISS. A modification of the ISS, the New Injury Severity Score (NISS) was developed in 1997 to address the issue of multiple injuries in the same body region [12]. It is very similar to the ISS except it scores the three most severe AIS scores regardless of their body region location, therefore, multiple injuries within a body region can be accounted for.

AIS codes can be assigned directly to road crash injury data by experienced coders who have the clinical details of each injury sustained - a highly time consuming and specialist process. Historically, AIS coding of road crash information has only been used in in-depth crash investigations and although it does occur for major trauma patients, it is almost never seen on mass data records on hospital admission which is important if we wish to capture the complete picture of road trauma. None of the road crash data sources currently available in Victoria include AIS injury coding. AIS and derivative scores (ISS and NISS) can be derived from ICD codes through complex mapping processes and computer programming to convert the codes for the injury diagnoses into an injury severity score.

Rather than being consensus-derived the International Classification of Disease Injury Severity Score (ICISS) is data-derived and, in contrast to the classifications mentioned previously, is based on the actual average fatality rate for a specified injury calculated using a large trauma database. Originally defined in 1996 the ICISS is a score between 0 and 1 and is a "threat-to-life" method that involves estimating probability of death for each ICD injury diagnosis code [13]. Determining an ICISS score involves calculating a survival risk ratio (SRR) for each individual injury diagnosis, using a large sample of injured people from the trauma database. An SRR is the proportion of cases with a certain injury diagnosis in which the patient does not die, or in other words, a given SRR represents the likelihood that a patient will survive a particular injury. Each patient's final ICISS score (survival probability) is calculated by multiplying the probabilities of surviving each of their injuries individually. This may be a single SRR, as in the case of a patient with a single injury, or it may be multiple SRRs, as in the case of a patient with multiple injuries [13]. A severity threshold can then be used to classify hospital admissions as either "serious" or "non-serious".

Benefits of using ICISS include that it accounts for multiple injuries; it is not dependent on a specific version of the International Classification of Diseases (ICD) codes; scores can be calculated directly from the injury codes contained in a given dataset and, it can be applied retrospectively. Limitations include that SRRs generated in one country may not be applicable to another due to different health care systems (may not be externally valid), and SRRs within countries, or even within areas in countries, may become less reliable due to changes in case outcomes over time. However, the recent availability of SRRs calculated specifically for Victoria [2] goes some way in addressing the limitations of using ICISS for calculating trends in serious injury.

Non-fatal burden of injury measures

A comprehensive review of non-fatal burden of injury measures was undertaken in a recent MUARC PhD thesis [18]. It identifies only three measures that have been used to estimate the burden of injury employing routinely generated epidemiological data. These are disability adjusted life-years (DALYs) and quality adjusted life-years (QALYs), which can both be estimated directly from ICD injury codes, and the Functional Capacity Index (FCI) based on AIS. Given the international recognition of the methodology and the availability of data to support its calculation, D'Elia and Newstead recommended the DALY as a potential alternative measure of serious injury from road crashes [5]. As described by Murray and Lopez [10], one DALY can be thought of as one lost year of "healthy" life. Watson [18] noted that DALYs were developed solely for use at the population level by the WHO in characterising the global burden of disease and injury. This raises some questions about the appropriateness of using DALYs assigned to an individual as a measure of injury severity as would be necessary in the road safety context. However, it was also noted that DALYs provide an inexpensive, efficient but "broad-brush" approach to estimating disease burden and the impact of interventions. D'Elia and Newstead [5] note that measuring the non-fatal burden of injury in road safety would be of significant interest but measures such as the DALY still require appropriate validation prior to use within the road safety context. Calculation of the DALY measure requires a number of items of data including the normal life expectancy of a person based on their age at time of injury, disability weights associated with each injury type and the average duration of the injury until recovery or death. The Australian Bureau of Statistics (ABS) regularly produces life expectancy tables that can be used for calculating DALYs. Access to the other two measures is more problematic. Like AIS or ICISS measures, calculation of DALYs also requires ICD coded injury data that can be obtained directly from the VAED or TAC claims data. An intrinsic property of the DALY that is important to consider in its implication for road safety policy is that it weights death and disability more highly for younger people than for older people. Use of the DALY as a measure of road safety performance could have the impact of giving less weight to countermeasures which target older road users than those targeting younger road users. The impact of this consequence would need to be carefully considered.

The Linked TAC-RCIS system

Motivated by problems with the current road safety data systems with respect to measuring injury outcomes D'Elia and Newstead [7] explored the feasibility of establishing a linked road injury dataset including police reported crash data, TAC claims data, hospital admissions data from the VAED and in-depth crash inspection data. Due to the enormity of the task of gaining approvals to link each of these data sets using personal identifiers, the project used de-identified linkage methods. Results showed linkage of police reported crash data from VicRoads' Road Crash Information System (RCIS) with the TAC claims dataset was feasible and resulted in a combined dataset more capable of measuring detailed injury outcome consistently over time.

An important finding of this project was that the de-identified linkage of hospital admissions data was not found to be feasible; concluding that successful linkage would require identifying information. Although hospital admissions from traffic accidents can be generally identified in the VAED through use of the ICD External Causes codes and the TAC claim status recorded, there was found to be not enough other information to enable a reliable match without using personal identifiers. This was not considered a fundamental flaw as the critical VAED injury code information is already passed to the TAC and included in their claims data. The limitation it creates is not being able to identify VAED road crash cases that did not lodge a TAC claim. We note that adding VAED data to the linked TAC-RCIS data would offer some value, however the incremental benefit of linking the VAED to the TAC-RCIS system would need to be assessed in order to judge the merit of including the VAED. Depending on the final definition of serious injury, it could be the case that a very large proportion of serious injuries are already captured in the linked TAC-RCIS crash dataset, and the extra coverage that linking the VAED would provide might not be worth the investment required to overcome the technical and other issues associated with that linkage.

A subsequent study conducted by D'Elia and Newstead [5] saw MUARC collaborate with the TAC to establish a long-term on-going linked TAC-RCIS database. The capability for measuring detailed injury outcomes comes primarily from the ICD-10-AM injury codes in the TAC hospitalised claims data which are obtained from the Department of Health via the process of the TAC recompensing the Department of Health for hospital costs. For non-hospital admission claimants, the TAC codes injuries in-house using the Systematized Nomenclature of Medicine - Clinical Terms (SNOMED CT). Each set of injury coding systems are mapped internally by the TAC to ICD-9-CM and the current version of the TAC-RCIS dataset contains the full set of injury information in the ICD-9-CM format. D'Elia and Newstead [5] also aimed to establish the use of TAC claims data linked to police reported crash data as a way of providing a consistent measure of trends in serious injury in Victoria. In particular, the broad objectives of the project were to establish:

1. an on-going linked dataset of police reported crash records and TAC claims data for use in a broad range of research requiring injury outcome information; and
2. a measure or measures of serious injury derived from the linked dataset that can be calculated consistently over time for use in road safety performance monitoring and as for base research.

As mentioned earlier, the first aim was achieved through MUARC collaborating with the TAC in order to develop a linked TAC-RCIS dataset. This included specifying the content of the dataset and establishing an on-going linkage process by the TAC noting that the TAC have linked claims data with police crash records over many years. To achieve the second aim, the injury coding practices of the TAC were reviewed and issues such as the use of multiple coding systems and their potential translation into a single system were examined. The TAC linked dataset included information from the following sources:

- TAC Claims Dataset;
- Victoria Police Traffic Incident System (TIS, known as VPARS – Victoria Police Accident Records System – at the TAC); and
- VicRoads Road Crash Information System (RCIS).

TIS was used to add crash details to TAC claims that did not link to RCIS. In order to allow for the broadest possible research uses, the linked dataset included as many relevant variables from each data source as possible after taking into account privacy considerations.

The findings of the MUARC research projects have been significant as they demonstrate that the underlying data to support the measurement of a range of alternative measures of serious injury has already been developed. This data system not only supports the calculation of these new measures but also contains all the other required information to facilitate the range of monitoring, policy and research uses that will need to be carried out using whichever new measure or measures of serious injury is adopted.

Calculation of demonstration time series for selected measures of serious injury

This section presents demonstration monthly time series of a number of the alternative measures of serious injury identified above for the period 2001-2010 inclusive. These measures have been calculated using the linked TAC-RCIS dataset and are presented along with the traditional measure derived from police reported crash data (currently hospital admission). The following measures were selected for comparison and are presented in Figure 1:

Traditional

- Serious Injury - Police

Resource Use

- TAC Claims - Admissions (Hospital Admission)

Threat to Life

- MAIS ≥3 and MAIS ≥2
- Average ISS and Average NISS
- ICISS (Worst Injury) <0.96

A more detailed description of each measure follows:

Serious Injury - Police

This measure is derived from police reported crash data and has been extracted from the official state road crash statistics held in the VicRoads administered Road Crash Information System (RCIS) being the number of persons seriously injured each month.

TAC Claims - Admissions (Hospital Admission)

TAC claims data from the TAC-RCIS linked dataset was used to identify hospital admission based on the TAC variable that records the number of bed days for the life of the claim. The series shows the number of persons seriously injured each month as defined by this hospital admission.

The following threat to life measures are derived from TAC claimant injury information available in the TAC-RCIS linked dataset. As explained earlier, the TAC obtains injuries coded to ICD-10-AM from the Department of Health for hospital admitted cases and codes injuries in-house using SNOMED CT for non-hospital admission claimants. Each set of injury coding systems are mapped internally by the TAC to ICD-9-CM and the current version of the TAC-RCIS dataset contains the full set of injury information in the ICD-9-CM format. For the purpose of calculating demonstration time series, the ICD-9-CM coding system was used meaning that all injuries sustained by all claimants have been included, although it is expected that claimants that have been seriously injured would have been admitted to hospital.

MAIS ≥3 and MAIS ≥2

The Stata module ICDPIC (ICD Programs for Injury Categorization) [16, 3] was used to classify injuries into a severity and body region. This allowed the ICD-9-CM diagnosis codes to be mapped into the Abbreviated Injury Scale (AIS) by body region. Maximum AIS (MAIS) across all body regions was then determined. Claimants with MAIS greater than or equal to 3 (serious injury) and with MAIS greater than or equal to 2 (moderate injury) were identified. Each series shows the monthly number of persons with MAIS ≥ 3 or MAIS ≥ 2 respectively.

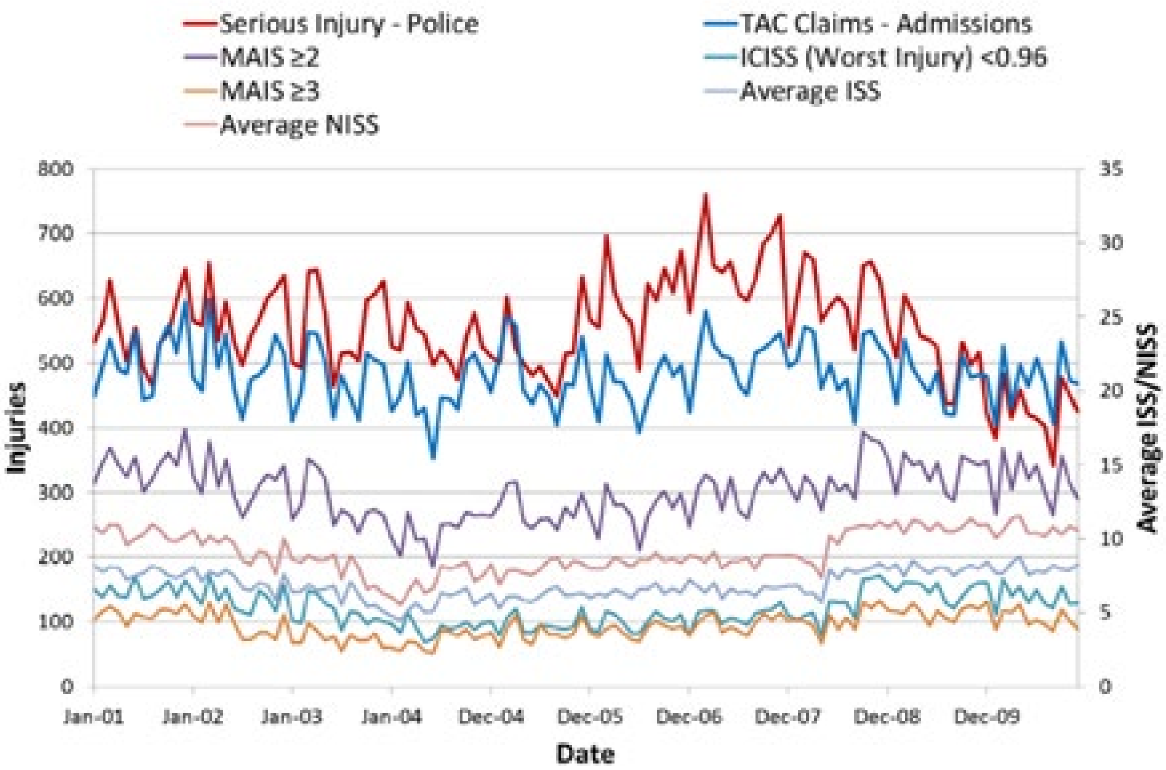

Figure 1. Monthly time series of selected measures of serious injury for Victoria for the period 2001-2010 inclusive

Average ISS and Average NISS

The ICDPIC module also produced the AIS derivative scores Injury Severity Score (ISS) and New Injury Severity Score (NISS). In order to produce monthly trends of injury, Average ISS and Average NISS were calculated and are shown.

ICISS (Worst Injury) <0.96

In order to calculate ICISS (International Classification of Diseases Injury Severity Score) from the TAC-RCIS linked dataset, it was necessary to source Survival Risk Ratios (SRRs) calculated from ICD-9-CM coded data. For the purpose of producing demonstration time series, SRRs calculated from Western Australia data were used and were provided by the Data Linkage Branch at the Department of Health WA. For ICISS based on ICD-9-CM, a severity threshold of less than 0.96 was used to define serious non-fatal injury. The monthly series shows the number of persons with an ICISS score of less than 0.96 based on the single worst injury diagnosis.

Comparison of serious injury trends

Calculation of demonstration time series for the selected measures of serious injury (Figure 1) enables a broad comparison of trends to be made between the traditional measure of serious injury derived from police crash reports (currently hospital admission); hospital admission as identified from TAC claims data; and the threat to life measures (note that Average ISS/NISS uses the scale on the right). TAC hospital admissions and police reported serious injuries seem to track more closely at the beginning and end of the series with variation occurring through the middle. On the other hand, hospital admissions as derived from TAC claims data track relatively closely with the threat to life measures. These comparisons suggest that hospital admission derived from TAC claims data provides a more consistent measure of serious injury road trauma over time than that derived from police reported crash data.

Conclusion

Recommending a single measure of serious injury from road crashes to replace the traditional measure of serious injury derived from police crash reports, currently hospital admission, is a difficult task. Each of the alternate measures which are accessible based on the availability of required data have strengths and weaknesses. Having a comprehensive road safety data system incorporating the combined recommended measures of serious injury is vital to ensure the new measures accurately and consistently measure serious injury trends in Victoria whilst facilitating the range of policy and research uses the data needs to serve. The linked TAC-RCIS data system forms a sound basis from which to build. The availability of such comprehensive information will facilitate a sound evidence base on factors determining serious injury outcomes, allowing good evidence-based policy and practise to be developed to effectively address the problem.

Acknowledgements

This project was funded through the Monash University Accident Research Centre's Baseline research program for which grants have been received from the following Victorian government agencies: the Department of Justice, the Roads Corporation (VicRoads) and the Transport Accident Commission (TAC).

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