

Alternative Measures of Serious Injury for National Road Safety Strategy Target Setting

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Abstract

The road safety strategies of jurisdictions across Australia have been developed in accordance with Safe System principles and set targets for reducing deaths and serious injuries on our roads. Victoria's road safety strategy, *arrive alive 2008-2017*, aims to reduce deaths and serious injuries by 30% over its 10 year life. Whilst the definition of a fatality is clear, the definition of serious injury has been problematic in Victoria as it has been in many other jurisdictions. In general, the definition of serious injury is derived from Police crash reporting. As a consequence of definitional and operational changes, trends in serious injury over time may not reflect real serious injury trends or strategy effectiveness. This paper presents alternative measures of injury severity that could be used for road safety strategy target setting. It outlines work undertaken to date in Victoria, Western Australia and New South Wales that could lead to a nationally consistent measure of serious injury. It then identifies the ICD Injury Severity Score (ICISS) as a common, robust and universally calculable measure that would enable trends in serious injury to be accurately measured and compared across jurisdictions and could be utilised for road safety target setting across Australia with ultimate inclusion in a future National Road Safety Strategy.

Keywords

Serious injury, Strategy target setting, ICISS

Background

The road safety strategies of jurisdictions across Australia have been developed in accordance with Safe System principles and set targets for reducing deaths and serious injuries on our roads. Victoria's road safety strategy, *arrive alive 2008-2017*, aims to reduce deaths and serious injuries by 30% over its 10 year life. Whilst the definition of a fatality is clear, the definition of serious injury has been problematic in Victoria as it has been in many other jurisdictions. In general, the definition of serious injury is derived from Police crash reporting. In Victoria, it has varied between being admitted to hospital to being taken to hospital as have the operational procedures for collecting the data. In particular,

changes to the Victoria Police crash reporting system in December 2005 have had a major impact on the classification and validation of the serious injury measure casting doubt on the accuracy of the measure of serious injury and leading to major discontinuities in the injury data reported (Figure 1). Most notable is a discontinuity in the serious injury data reported after December 2005. Since that time the coding of serious injury was changed to being derived from a combination of taken and admitted to hospital with attempts to validate the hospital admission status through follow-up and other data sources. As a consequence of the ongoing changes to the serious injury definition and crash data systems and operational reporting biases, trends in serious injury over time, a key outcome measure of jurisdictional road safety strategies, may not reflect real serious injury trends or strategy effectiveness.

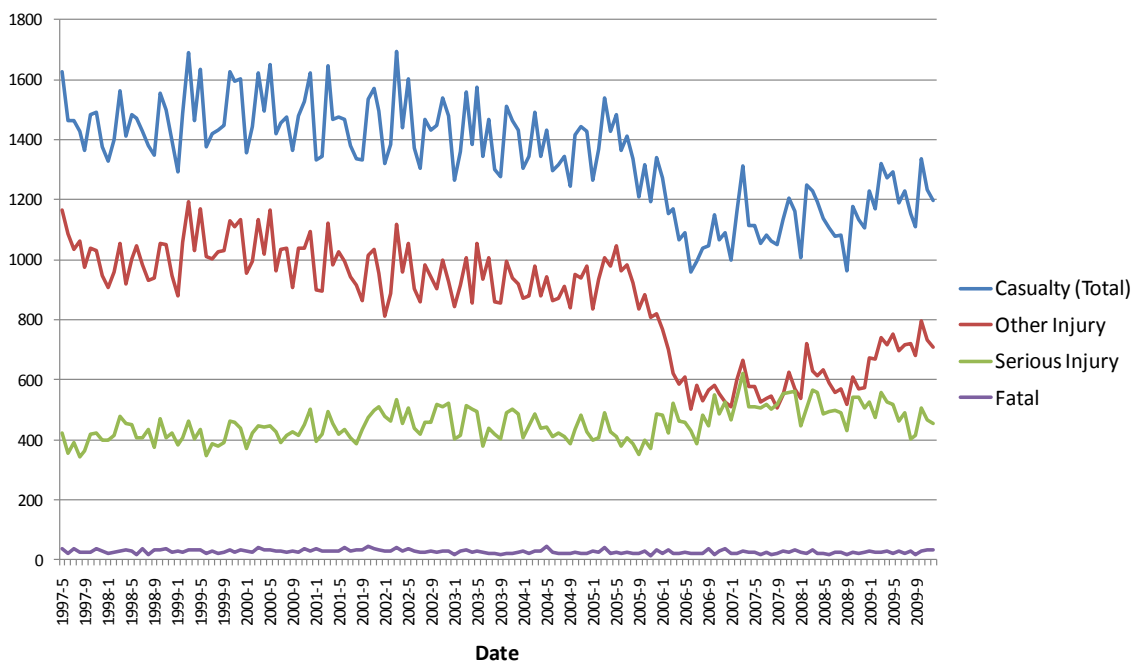


Figure 1: Police reported casualty crashes in Victoria

Other jurisdictions have also had problems with the measurement of serious injury derived from Police crash reports. In Western Australia there has been concern for some time that the measure of serious injury is too reliant on Police crash protocols, reporting practices and data capture and recording methods [1]. In New South Wales inaccuracies in reporting injury severity in Police collected crash data were identified in 1998 that could not be rectified. Subsequently severity has only been coded to give three levels, namely fatality; injury; and not injured. Prior to 1998, the current 'injury' category was represented by two discrete injury severity levels being hospital admission and other injury [2]. Overall, it is clear that Police reported crash data on its own cannot be relied upon to provide an appropriate measure of serious injury for the monitoring of road safety performance and its use is possibly questionable in other analytical frameworks such as evaluation studies.

This paper presents alternative measures of injury severity derived from linked data that could be used for road safety strategy target setting. It outlines work undertaken to date in Victoria, Western Australia and New South Wales that could lead to a nationally consistent measure of serious injury. It then identifies the ICD Injury Severity Score (ICISS) as a common, robust and universally calculable measure that would enable trends in serious injury to be accurately measured and compared across jurisdictions and could be utilised for road safety target setting across Australia with ultimate inclusion in a future National Road Safety Strategy.

Alternative Measures of Serious Injury and their Derivation

Data Linkage

The problems surrounding the recording of injury severity in Police reported crash data only serve to emphasise the importance of linking such data to other injury datasets with higher consistency and higher resolution injury outcome data, such as ICD injury codes sourced from hospital separations data. Hospital separations data alone could be used to examine trends in serious injury due to road crashes with relevant cases identified using hospital coded external cause codes to identify land transport accidents. This would not require any data linkage to be undertaken, however does rely on the completeness and accuracy of the external cause code. McKenzie et al. [3] found that the level of coder agreement for external causes of injury for hospitalisations in Australian public hospitals was such that researchers need to be aware of the reliability of their specific data of interest when they wish to undertake trend analyses or case selection for specific causes of interest, with missing external cause information and missing documentation having the greatest impact on the quality of external cause coding [4].

In addition to deriving alternative measures of serious injury for national road safety target setting, the enhancement of Police reported crash data with higher resolution injury outcome data provides researchers with the opportunity to conduct a broad range of research examining the association between injury outcomes and many factors not included in hospital data alone, such as crash circumstances or vehicle details, information which is present in or may be derived from Police crash reports. In Victoria, D'Elia and Newstead [5] completed a project that explored the feasibility and benefits of establishing a linked road injury database including Police reported crash data, Transport Accident Commission (TAC) claims data (which covers all claims made to the TAC for third party injury compensation for injuries arising from transport accidents) and hospital admissions data. Each dataset was provided without identifying information such as name, address and date of birth, necessitating the use of a de-identified linkage approach. The linkage of de-identified hospital admissions data was not found to be feasible without identifying information. However the linkage of Police reported crash data with TAC claims data was feasible and resulted in a combined database more capable of measuring

detailed injury outcome consistently over time with the claims data including International Classification of Diseases (ICD) codes for injuries assessed from the claim.

In Western Australia, concern that linked Police and hospital information showed significant differences in the number and nature of casualties deemed to be “hospitalised” led to the investigation of this issue in further detail through the 2007 project “Road Safety Data Linkage and Analysis” undertaken within the Data Linkage Branch, Department of Health [3]. In New South Wales, Boufous et al. [6] identified the benefits that data linkage of relevant databases has in overcoming the limitations of individual data sources, such as the Police reported crash data collected in their state. Their 2008 report describes the process of linking hospital separations and road crash datasets in order to provide a more comprehensive picture on traffic injuries in NSW.

Alternative Measures of Serious Injury

The linkage of Police reported crash data to other injury datasets with higher consistency and higher resolution injury outcome data, such as ICD injury codes, allows for the derivation of alternative measures of serious injury to the traditional Police determined measures of taken or admitted to hospital. In Victoria, the use of TAC claims data linked to Police reported crash data was identified as a way in which consistent measures of trends in serious injury could be provided for use in road safety performance monitoring and for road safety research with an earlier investigation by Hoareau et al. [7] having derived several measures of injury severity from TAC claims.

Measures able to be derived from TAC claims data include admitted to hospital, measures relating to *resource use* such as length of hospital stay, and *threat to life* measures such as the Abbreviated Injury Scale (AIS) (published by the Association for the Advancement of Automotive Medicine) and its derivatives such as the Injury Severity Score (ISS), able to be derived via the mapping of ICD injury codes assigned to TAC claimant injuries. They also include measures such as ICISS (ICD Based Injury Severity Score) that can be calculated from the ICD codes directly. These “threat to life” measures are described in more detail as follows:

- AIS and ISS: The AIS is a specialised trauma classification of injuries based mainly on anatomical descriptors of the tissue damage caused by the injury. It has two components, namely the injury descriptor and the severity score (1-6) assigned to each injury descriptor. The AIS is a severity measure for a single injury. Many derivative severity scales have been developed to combine multiple injuries to create a single composite score for each patient such as the ISS.
- ICISS: Due to the proprietary nature of the AIS, researchers developed empirically derived measures of severity based on ICD diagnoses and short term outcomes such as hospital mortality coded with the ICD

system. One family of empirically derived measures of injury severity is ICISS. This approach to injury severity assessment is based on the calculation of Survival Risk Ratios (SRRs) for each ICD code. The SRRs are derived by dividing the number of patients that survive a given ICD injury diagnosis code by the number of patients with that diagnosis code. ICISS is then the product of the SRRs corresponding to a patient's set of injuries.

In addition to the threat to life measures, measures of functional outcomes and disability or the *non-fatal burden of injury* such the Disability-Adjusted Life-Year (DALY), which is a measure of the overall burden of disease, could also be derived.

A recent project saw the Monash University Accident Research Centre collaborate with the TAC in order to establish a long-term and ongoing linked TAC claims and Police reported 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 dataset and establishing an ongoing linkage process by the TAC. It also included an examination of the manner in which multiple injury codes may be mapped into a consistent injury outcome system from which measures of serious injury may be derived. 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 derived from the TAC held or derived injury information in the linked dataset. The review of measures of injury severity led to the following measures being recommended for calculation from the TAC linked dataset either presently or in the short to medium term:

Resource Use

- Number of hospitalised claims
- Proportion of claims admitted to hospital
- Length of hospital stay

Threat to Life

- Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS)
- ICD Based Injury Severity Score (ICISS)

Non-Fatal Burden of Injury

- Disability-Adjusted Life Year (DALY)

In general, measures relating to resource use provide a reasonable indication of injury severity, although they may be affected by hospital admission policy and changes to funding models meaning that trends in serious injury may vary over time. Also, whilst measuring the non-fatal burden of injury would be of significant interest, measures such as the DALY still require appropriate validation, especially prior to use within the road safety context. The next

section shall examine how the linkage of Police reported crash data to hospital admission information in Victoria, Western Australia and New South Wales may lead to a nationally consistent measure of serious injury that could be used for road safety strategy target setting based on threat to life.

Threat to Life Measures in Victoria, Western Australia and New South Wales

The review of available measures of injury severity identified the AIS, its derivative ISS and ICISS as providing reasonable estimates of threat to life or probability of death. In Victoria, both sets of measures may be derived from the linked Police reported crash data and TAC claims data. The TAC receives injuries coded using the ICD-10-AM (10th Revision, Australian Modification) format for hospital coded injuries of hospital admitted patients via the Victorian Department of Health. In terms of measures of serious injury, ICISS is able to be calculated directly from the ICD injury codes held, however the derivation of AIS would need to occur via a process that firstly back-maps ICD-10-AM to ICD-9-CM (9th Revision, Clinical Modification) then sees ICD-9-CM mapped to AIS using the proprietary ICDMAP-90 software program [8] designed for large administrative datasets.

In their 2008 paper, Chapman and Rosman [9] describe the use of ICISS methodology in Western Australia to determine the severity of road crash injuries using SRRs calculated from linked hospital admission records and death registrations. The retrospective nature of ICISS and its ability to be derived from large datasets were highlighted. Chapman and Rosman [9] state that ICDMAP-90 had previously been used to convert ICD-9-CM codes to AIS codes to determine injury severity, however that this method had become obsolete with the introduction of ICD-10-AM in Western Australia during 1999. ICISS is one way of evaluating injury severity derived directly from hospital admission data that is not dependent upon the underlying coding system for injury diagnosis, i.e. the algorithm to derive ICISS is not specific to a particular version of ICD.

In subsequent work, Chapman and Rosman [3] compared ICISS against Police reported crash reports, AIS recorded in the Royal Perth Hospital (RPH) trauma registry and AIS recorded by the Insurance Commission of Western Australia (ICWA). The RPH trauma registry records AIS scores for all patients admitted overnight or with an AIS score of three or above. All AIS scores stored in the RPH trauma registry are determined by clinicians following consultations with the patient. ICWA, which is the compulsory third party motor vehicle insurance provider in Western Australia, also records AIS scores however these are determined by in-house coders working on clinical notes provided by doctors and hospitals. It was noted that not all road crashes reported to Police are included in the ICWA dataset. Rosman and Chapman [3] concluded that ICISS provides good estimates of serious injury when compared to AIS.

Following from the 2008 data linkage project by Boufous et al. [6] the Injury Risk Management Research Centre in New South Wales have undertaken a new

project to link Police reported crash data with hospital admission data from the NSW Department of Health. The linked dataset will enable measures of serious injury to be derived using ICD-10-AM injury codes from the hospital data. Specifically, ICISS will be calculated as a measure of road trauma injury severity. The potential also exists to obtain AIS scoring through the further linkage of data from the Motor Accidents Authority, which regulates the compulsory third party personal injury insurance scheme for motor vehicles registered in NSW.

ICISS: A Common, Robust and Universally Calculable Measure of Serious Injury

The previous section highlighted how Police reported crash data linked to hospital injury information can lead to measures of serious injury that are potentially more reliable than traditional measures derived from Police crash reports. Of the alternative measures of serious injury described, the threat to life measures AIS and ICISS would provide nationally consistent measures of injury severity that could be used for road safety strategy target setting. The state of data linkage and the calculation of these threat to life measures were examined in three jurisdictions and have been summarised as follows:

- *Victoria:* Police reported crash data has been linked to TAC claims data which includes hospital injuries coded using ICD-10-AM. ICISS is able to be calculated directly from the injury codes held however the derivation of AIS would need to occur through a mapping process.
- *Western Australia:* Police reported crashes have been linked to hospital admission records also allowing ICISS to be calculated directly. AIS determined by clinicians is available from the RPH trauma registry for the more serious cases and ICWA can provide AIS determined by in-house coders for most, but not all, road crashes.
- *New South Wales:* A project to link Police reported crash data to hospital admission data has been undertaken and will endeavour to calculate ICISS directly from the linked dataset with the potential to obtain AIS scoring in future.

If we wish to obtain a sense of actual trends in injury severity due to road trauma, it would be desirable to examine as many measures of serious injury as possible, noting that each has its own strengths and weaknesses. These would include AIS, ICISS and DALY (once sufficiently validated). Certainly at a local level one should consider all of these measures in addition to those relating to resource use. In terms of having a *national* alternative measure of serious injury the following points are relevant:

- In Australia and New Zealand, injuries in hospital separations data have been coded using the ICD-10-AM coding system since 1999.

- There is currently no map for converting ICD-10-AM to AIS for large administrative datasets.
- Back-mapping hospital coded injuries from ICD-10-AM to ICD-9-CM leads to a loss of some injury information.
- AIS can be mapped from ICD-9-CM using ICDMAP-90 however the ICD-9-CM injury coding system is out-dated.
- ICDMAP-90 has not been updated for some time thus maps to a superseded version of AIS.
- AIS and ICDMAP-90 are proprietary.
- AIS coded for each case individually should provide better estimates of injury severity than AIS mapped from ICD-9-CM or than ICISS, however is not available in every jurisdiction, nor is it available for every linked Police crash report.
- ICISS may be calculated directly and avoids the need for back-mapping injury codes.
- Stephenson et al. [10] found that ICISS is a viable alternative to ICDMAP-based measures for coding injury severity on large datasets.
- ICISS is not dependent on the underlying injury coding system utilised, e.g. ICD-10-AM, although does need the SRRs calculated for the particular system being used.
- Future versions of the ICD injury coding system, such as the 11th Revision of ICD currently underway, pose no barrier to the use of ICISS in future as it is empirically derived.
- ICISS is easily able to be applied retrospectively.
- Stephenson et al. [11] have published SRRs derived using Australian and New Zealand hospital data coded to ICD-10-AM so that ICISS may be calculated in any jurisdiction where ICD-10-AM injury coding is used and SRRs are not calculated locally.
- Stephenson et al. [11] concluded that ICISS appears to be a reasonable way to estimate severity for databases using ICD-10-AM and suggest development of a further version of ICDMAP for use with ICD-10 data is unnecessary, as it is unlikely to result in significantly improved severity estimates.

Considering these points, it is apparent that a measure of injury severity that is common across jurisdictions needs to be determined using a large-scale mapping process from linked data seeing that individually coded AIS is not available in every jurisdiction. Given that mapping to AIS is not ideal, it is ICISS

which provides a common, robust and universally calculable measure that would enable trends in serious injury to be compared across jurisdictions and hence be able to be utilised in a national road safety target setting sense. It is also useful that ICISS may be empirically derived, is not proprietary and can be updated easily and retrospectively when changes to the underlying injury coding system occur. We note that ICISS is expected to be available in the three jurisdictions examined by this paper by the end of 2011 after which it is hoped other jurisdictions may follow suit.

Limitations of SRRs and ICISS

In identifying ICISS as a national alternative measure of serious injury, it is worth noting some of its limitations. One limitation identified by Henley and Harrison [12] is that, in calculating SRRs, the inability to identify individuals who have undergone more than one hospital separation within the period considered can result in an overestimation of cases in relation to the number of deaths. Another limitation identified in their paper relates to their objective of demonstrating the effect on the accuracy of estimation of mortality by adjusting for the effect of including non-injury diagnoses (comorbidity).

A major limitation often quoted in applying ICISS is the dependence of the data on the system from which SRRs are derived, with SRRs calculated in this way not being independent. Specifically, it is thought that outcomes from other injuries in multiple trauma cases may influence the SRR for a particular diagnosis code. A further limitation relates to the observation that although ICISS is internally valid (i.e. valid within the injury population from which the SRRs have been calculated) it potentially lacks external validity (i.e. validity in use of the SRRs in other injury populations). One study compared national level data from New Zealand and Australia and showed both good external and internal validity [13]. In the short-term both Victoria and New South Wales plan on using SRRs derived using Australian and New Zealand hospital separations data as calculated by Stephenson et al. [11], although it is recommended that jurisdictions calculate their own SRRs where possible, such as in Western Australia.

In addition to resolving the issue of external validity, we also recommend that jurisdictions calculate their own regularly updated SRRs to optimise their applicability as versions of the ICD codes change. Unlike the use of SRRs derived by Stephenson et al. [11], the use of continually updated jurisdictional SRRs applied to the period of interest would help overcome the issue of validity over time which it could be argued is as important as external validity considering that the ICD coding system is constantly revised. We believe that the direct calculation of SRRs by each jurisdiction would be the best approach for comparability of estimates for the purposes of national road safety strategy target setting, consistent with recent work on the comparison of serious injury trends internationally mentioned below.

Another potential issue that should be noted is that poorly coded ICD codes would have a negative impact on the SRRs derived and hence the quality of ICISS estimates. A paper by Bergström et al. [14] examining the Swedish National Patient Registry found that errors in ICD-10 coded injuries in hospital discharge data were common, but that the consequences for injury categorisation were moderate and the consequences for injury severity estimates were in most cases minor. Finally it is possible that SRRs may become a less reliable guide to the probability of death over time due to changes in case outcomes [12]. In their paper, Henley and Harrison [12] flag their intention to consider generating a new set of SRRs based on Australian and New Zealand data. It might be expected that any updates may also use updated calculation methods that address some of the limitations presented leading to improved estimates of injury severity from ICISS.

With respect to the comparability of trends in serious injury, work has recently been progressed on serious injury indicators for international comparisons. A report by Cryer et al. [15] identified the need to develop reliable methods for the comparison of serious injury trends between developed countries. It discusses ICISS as an objective severity measure for the New Zealand Injury Prevention Strategy and highlights that international comparisons of non-fatal injury are often based on hospital inpatient data contaminated by differential health service effects between countries, before describing how the International Collaborative Effort for Injury Statistics (www.cdc.gov/nchs/injury/advice.htm) is pursuing an agenda to develop injury morbidity indicators for international comparisons which were considered at its meeting in September 2010 (www.cdc.gov/nchs/injury/ice/swansea2010/swansea2010_agenda.htm). At the meeting, discussion on non-fatal injury indicators occurred including biases in international comparisons and the removal of health services effects through creation of a draft specification of a serious non-fatal injury indicator for use in such comparisons. Final outcomes from this work would inform future work on the comparison of trends in serious injury across jurisdictions in Australia.

Conclusion

This paper presented alternative measures of serious injury derived from linked data that could be used for road safety strategy target setting. It outlines work undertaken to date in Victoria, Western Australia and New South Wales that could lead to a nationally consistent measure of injury severity. It then identified the ICD Injury Severity Score (ICISS) as a common, robust and universally calculable measure that would enable trends in serious injury to be accurately measured and compared across jurisdictions and could be utilised for road safety target setting across Australia with ultimate inclusion in a future National Road Safety Strategy.

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