

An evaluation of ICISS methodology for determining the severity of road crash injuries using linked data

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Abstract

The ability to measure injury severity is important for meaningful comparison of outcomes of road crash casualties. In Western Australia (WA), publicly reported measures of injury severity following a road crash are based on information sourced from Police crash reports. These severity ratings are determined by the attending Police Officer and categorised as: [1] fatal; [2] hospitalised; [3] minor injury; or [4] non-medical. A more robust measure is required in WA to measure the severity of road crash casualties.

Other sources for measuring the seriousness of an injury following a road crash have been used in WA. These include the ICD-based ICISS methodology, which has been applied to diagnosis data contained in WA hospital admission records. This approach has shown that serious injuries contribute to approximately 26% of WA hospital admissions by road crash casualties and are growing at a faster rate than non-serious injuries.

Additionally, the Royal Perth Hospital (RPH) Trauma Registry in WA records the Abbreviated Injury Scale (AIS) scores for all patients admitted overnight or with an AIS score of three and above. All AIS scores stored in the RPH Trauma Registry are determined by clinicians following consultation with patient. The Insurance Commission of WA (ICWA), which is the compulsory third party motor vehicle insurance provider in WA, also records AIS scores. Differently to RPH, ICWA AIS scores are determined by in-house coders working on clinical notes provided by doctors and hospitals.

Using linked hospital admissions, death registrations and road crash data in WA from 1995 to 2007, this paper will compare ICISS methodology against three other injury severity scaling methodologies: 1) police crash reports; 2) AIS recorded in the RPH Trauma Registry and; 3) AIS recorded by ICWA.

Keywords

Serious Injuries, Road Crash Analysis, Injury Severity, Record Linkage, ICISS

Introduction

In most developed countries, the 'road toll' means the number of fatalities occurring within 30 days of a road crash. This is monitored closely by road authorities, policy makers and the press, yet does not truly reflect the full impact of road crashes.

It has been acknowledged for some time that short and long term consequences from critical, severe or serious injury impose a significant burden on individuals, families and society.

Accurate, repeatable and meaningful measures for killed and seriously injured (KSI) road crash casualties are needed. These include those who die within 30 days of the crash, those who die later than 30 days and those who survive but are likely to have long term effects such as temporary or permanent impairment or reduced quality of life

Another criterion is that, ideally, the information used to measure 'serious injury' in the KSI figure needs to be available for reporting soon after the crash (ie within one to three months).

Attempts have been made to draw on early data available through standard crash reports; however there has been concern for some time that the current (default) measure for KSI (derived from either the police 1-18 form or alternatively the main roads killed or hospitalised categorisation) is too reliant on police crash protocols, reporting practices and data capture and recording methods. In these, the severity categorisation is made by attending police officers, or the person making the report to authorities.

Information derived from actual hospitalisations is reported annually for comparison purposes, but has not been available within an acceptable timeframe for regular reporting. Further, linked (or combined) police and hospital information has shown significant differences in the number and nature of casualties deemed to be "hospitalised". To investigate this issue and propose a solution, the Road Safety Council approved RTTF funding for the Road Safety Data Linkage and Analysis Project in 2007 to be undertaken within the Data Linkage Branch, Department of Health WA.

In the initial three year period, the project has brought together all available routinely collected road crash and injury information from MRWA, ICWA and DoHWA dating from 1985 onwards. Records for more than 68,500 hospital admissions and 1 million crash reports have been linked together and a range of potential measures of 'serious injury' have been defined measured or estimated. The aim is to produce agreed, robust, timely measures to assess the impact of safety improvements for the Towards Zero Strategy initiative.

Data Sources

The analysis in this report could not have been achieved without access to a number of road safety related data sources. The WA Data Linkage System (WADLS) developed by the Data Linkage Branch at the Department of Health WA has had ethics approval to link road safety data to the core Health data set since January 2007. Prior to this, road safety linkage was performed by the Injury Research Centre (IRC) at the University of WA since 1989.

The linked data sources utilised throughout this report are as follows:

- Main Roads WA – crash reports reported to WA Police;
- WA hospital admissions;
- WA death registrations;
- Insurance Commission of WA – third party claims;
- Royal Perth Hospital (RPH) Trauma Registry.

A summary of potential measures for KSI by each of the data sources available is provided in Table 1, and shows the trade off between timeliness and data quality and completeness.

Table 1: Summary of scope and availability of potential measures for KSI

System	Measure	Data Collection		Timeliness		Access	
		Fatalities	Serious Injuries	Fatalities	Serious Injuries	Fatalities	Serious Injuries
WAPOL	1-18 Fatal & "Serious" ("Critical")	Entered into 1-18 at scene of crash once attended by WAPOL		Reported next working day in morning on 1-18		Entered into "Casualty" database as a statistic normally 24hrs following report of 1-18	
MRWA	P72 Fatal & Hospital	Collected by WAPOL once entered by member of public. Consolidation of crash is performed by WAPOL then forwarded to MRWA for database entry to IRIS		MRWA receive consolidated P72 crash reports from WAPOL normally 6-8 weeks after P72 reported, irrespective of the severity of crash		P72 information entered into IRIS database ; additional information regarding RUM codes, geometry and more added later; available for research 5 months after end of calendar year.	
ICWA	AIS	Coding is performed by ICWA at initial stage of injury claim. Additional coding may be entered upon receipt of medical reports or following further medical evidence.		Changes are in place to review coding 6 months following initial claim, then updated once again at settlement. Any psychological injuries cannot be coded in AIS.		Claims data normally available 6 months following end of calendar year; completeness may depend on the stage of claim for AIS coding.	
HMDS – Hospital Morbidity	≥ 1 overnight stay ICISS	Following discharge from hospital, the patient's clinical notes are reviewed and coded into discharge summary		At a state level, discharge summaries are normally coded and entered into the HMDS database with 95% completeness 7 months following date of discharge.		Hospital morbidity data available with 100% completeness 1 year following end of financial year.	
RPH Trauma	AIS / ISS	Patients admitted to RPH for overnight stay or result in a fatality following admission to hospital whereby the trauma events occurred within 7 days of arrival at RPH		Fatalities are entered into the Trauma database immediately but are not finalised until autopsy report reviewed.	Trauma score recorded for all patients as close to admission as possible regardless of minor or major trauma.	Major trauma added to database within days of initial collection and finalised after discharge. Minor injuries entered into Trauma database a month following discharge. RPH Trauma Registry data normally available 6 months following end of calendar year.	

Injury Severity Measures

Linked hospital and death information – ICISS

Linked hospital admission records were extracted from the WA Hospital Morbidity Data System (HMDS) for the period 1 January 1995 to 31 December 2007. Deaths registered in WA between 1 January 1995 and 31 December 2007 were also linked to HMDS and used to determine the survivability of a patient post discharge from hospital.

ICISS methodology was utilised in this study to calculate the severity of an injury and was derived for all ICD injury diagnosis codes. Hospital admissions are selected with a principal diagnosis in range 800 to 999 for ICD-9-CM or in range S00 to T89 for ICD-10-AM. Survival Risk Ratios (SRR) are calculated for each diagnosis code as a ratio of the number of cases with a given diagnosis code who survived. Each case is then assigned an ICISS, which is the product of SRR for all injury diagnoses (Langley et al. ²). All injury

diagnoses are included in the calculation of a patient's SRR if they fall within the specified ranges listed above. For example, if a patient has five valid diagnosis codes in addition to a principal diagnosis, then all six diagnoses will contribute to the calculation of SRR, not just the principal diagnosis is used. A given SRR represents the likelihood that a patient will survive those injuries. Each patient's ICISS score is the product of the probabilities of surviving each of their injuries (Stephenson et al. ⁴). ICISS may be calculated using a single SRR (as in the case of a single injury) or it may be calculated using multiple SRR (as in the case of multiple injuries) (Osler, Rutledge et al. ¹).

If no SRR exists for a particular diagnosis code, then the SRR for that diagnosis code is assumed to be equal to one.

Only one hospital admission was included for an individual injury event per patient. All re-admissions for the same (or similar) injury event were excluded. Re-admissions were identified as occurring within 90 days of discharge and had similar external cause of injury. This methodology reduced over counting of road crash hospital admissions.

Records where a hospital stay ended in death were included in the analysis regardless of the length of stay. A hospital admission was classified as "Dead" if one of the following events occurred:
HMDS mode of separation field is coded as "Deceased";
Death occurs within 60 days of hospital discharge whereby the patient died from the original injury (as recorded in HMDS and linked Death record).

Pre-defined severity of injury thresholds have been utilised in this study to identify serious and non-serious injuries. The severity of injury thresholds evaluated by Langley et al. ² and Cryer et al. ⁵ ensure that only those injuries representing a significant threat to life are included (i.e., serious injuries). The severity of injury thresholds were estimated by comparing injuries that normally require hospital admission against those typically categorised as minor. Analysis by Langley et al. ² reported that low thresholds of severity are heavily weighted towards trends in minor injury. This is due to vast numbers of minor injuries requiring hospital admission. The severity thresholds used throughout this study have been chosen to capture injuries with a very high probability of admission, thus minimising bias in ascertainment (Cryer et al. ³). High severity of injury thresholds allow for a high probability of hospitalisation per injury incidence which is minimally influenced by changes in service delivery, treatment methods and the like (Cryer et al. ⁵).

Serious injuries were identified by Langley et al. ² as those hospital admissions (for ICD-9-CM) with ICISS values less than 0.96. A severity of injury threshold of ICISS < 0.96 was used to identify serious injuries for ICD-9-CM and represents approximately 14% of hospital admissions for the period January 1988 to June 1999.

Serious non-fatal injuries requiring hospital admission (for ICD-10-AM) were defined by Cryer et al. ⁵ using a severity of injury threshold less than or equal to 0.941. Those cases with an ICISS score greater than 0.941 are considered to be non-serious. An ICISS score of less than or equal to 0.941 is equivalent to selecting patients whose injuries give a survival probability of 94.1% or a probability of death of at least 5.9%. A severity of injury threshold of ICISS ≤ 0.941 (for ICD-10-AM) represents 10% of hospital admissions over the period July 1999 to December 2006.

AIS (Abbreviated Injury Scale) and ISS (Injury Severity Score)

AIS was developed to provide researchers with a simple numerical method for ranking and comparing injuries by severity and to standardise the terminology used to describe injuries. The AIS is universally accepted as the foundation of injury severity scaling systems. The AIS was initially developed in 1971 by the Association for the Advancement of Automotive Medicine (AAAM) and have been providing periodic updates and support since that time.

The AIS provides more than 2,000 injury descriptors into nine body regions (head, face, neck, thorax, abdomen, spine, upper extremities, lower extremities and external). Each injury is assigned an AIS score on an ordinal scale ranging from 1 (minor injury) to 6 (maximum injury, possibly lethal) as follows:

1. Minor;
2. Moderate;
3. Serious;
4. Severe;
5. Critical;
6. Maximal (normally fatal).

An AIS score of 3 or above is universally identified as a serious injury.

ISS is also an anatomically based ordinal scale, with a range from 1 to 75. To calculate the ISS the nine AIS body regions are grouped into six body regions. The six body regions used to calculate ISS are:

1. Head;
2. Face;
3. Chest;
4. Abdomen;
5. Extremities; and
6. External.

The ISS is then calculated as the sum of the squares of the highest AIS scores for the three most severely injured body regions. An exception to this calculation exists when any of the single body regions has an AIS of 6 (i.e. fatal), then an ISS of 75 is assigned. Additionally, if the severity of an injury cannot be determined, then an AIS of 9 is assigned. An ISS cannot then be calculated and a score of 99 is given.

Results

All road crash casualties reported to WA Police are recorded in the MRWA IRIS database. Those persons deemed to be seriously injured by MRWA are identified simply as those “requiring hospitalisation”, although hospital admission and emergency presentations are not distinguished, leading to an overestimation in the number of recorded hospitalisations.

Actual hospital discharge summaries provided to the state-wide Hospital Morbidity Data System (HMDS) provide a more accurate measure of the number of crash casualties admitted to hospital. The length of stay in hospital can be used as a proxy for severity.

With the introduction of the Online Crash Reporting Facility (OCRF) in 2009, a review of serious injury scoring and reporting is appropriate. Rather than include all hospitalised casualties, as a first step towards determining serious injuries, ICWA have suggested identifying serious injuries as those with at least an overnight stay in a WA hospital.

Figure 1 displays the numbers of KSI road crash casualties in WA over the period 1995 to 2007 according to the different injury severity measures currently used by WA road safety stakeholders. Two new measures - ICISS and a state-wide estimate from RPH trauma records - are included for comparison. In all cases double counting is avoided by linking to death records.

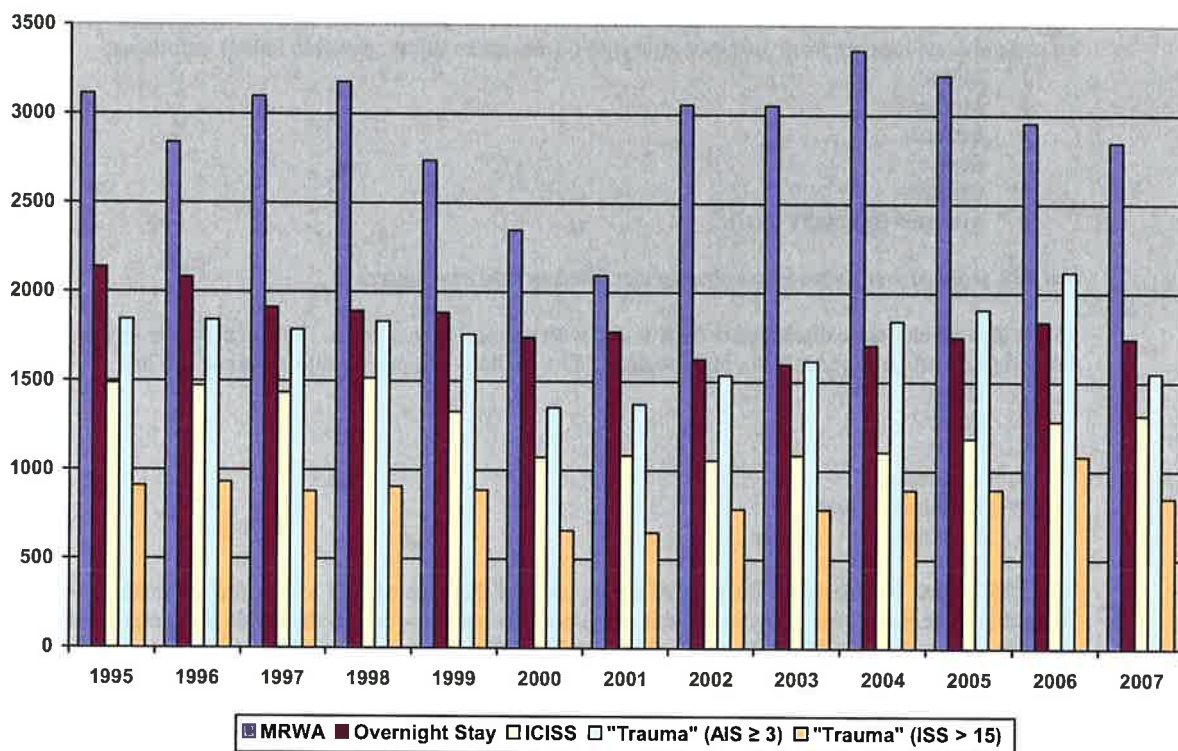


Figure 1: Killed and Seriously Injured (KSI) road crash casualties reported by WAPOL (i.e. MRWA), hospital morbidity, ICISS & “Trauma”

As expected, KSI figures reported using MRWA crash reports alone are higher than all other road measures (see Figure 1). The reason for such high estimations for KSI by crash reports to MRWA is likely to be related to the difference in interpretation of the term “hospitalisation” by those reporting the crash (i.e. WA Police, drivers, casualties, etc). Hospitalisation refers to admission and emergency presentations that do not lead to admission to a hospital ward should not be included.

Serious injuries are also likely to be over estimated by including all hospital admissions with at least an overnight stay in a ward. It is likely that older road crash casualties as well as the very young could skew this estimation for serious injury as these age groups are more likely to be admitted overnight for observation regardless of the severity of the injury. Hence overnight stays may not be a good representation of serious injuries.

The RPH Trauma Registry has been utilised here to estimate KSI figures for all of the trauma registries in WA. Two thresholds for serious injury have been charted for “Trauma” in WA (i.e. AIS ≥ 3 and ISS > 15). Three of the five trauma registries include casualties with minor or major trauma, whereas the remaining two registries only include casualties with major trauma (ISS > 15). It is likely that the best KSI estimate for all of the five trauma registries in WA will fall between AIS ≥ 3 and ISS > 15, as displayed in Figure 1. ICISS does fall between the two Trauma estimates and represents an average of 40% of MRWA KSI figures (i.e. MRWA estimates for KSI exceed ICISS by as much as 60%).

A fall in KSI road crash figures occurred between 1999 and 2001 for most indicators of KSI displayed in Figure 1. As discussed previously, a change in the coding of hospital admissions did take place in mid 1999

(i.e. ICD-10-AM). Prior to this change, ICD-9-CM was utilised for the coding of injuries. This change in coding is likely to explain the reduction in KSI estimates for ICISS, overnight stay and the two “Trauma” estimates charted in Figure 1. On the other hand, the fall in KSI road crash casualties for MRWA over the same period of 1999 to 2001 cannot be fully explained. One possible reason for the drop could be linked to a small change in the P72 crash report form in 2001, or crash reporting requirements. In an attempt to explain the drop in KSI road crash casualties, MRWA performed an audit of the crash report files held by WA Police against those entered in to the MRWA/IRIS database. No significant differences were identified in the audit. Hence, no real explanation for the drop in KSI road crash casualties can be identified by MRWA for the period 1999 to 2001.

Figures 2 and 3 compare KSI measures across road user groups.

The road user group for ICISS is sourced in either the hospital morbidity record or death record. In the case of the hospital morbidity record, road user group is stored in the external cause of injury code whereas death records have the road user group stored in the cause of death code. In either case, using ICISS methodology, motor vehicle occupants accounted for just over 50% of KSI casualties over the 13 year period (see Figure 2). On the other hand, WA Police recorded close to 75% of KSI casualties to be motor vehicle occupants over the same period. Some of the differences in the two methodologies are likely to be associated with differing definitions for motor vehicles as “Other Vehicles” for ICISS is made up of tractors, trucks, prime movers, road trains and buses, whereas these vehicle types are likely to be included in the motor vehicle category by WA Police (see Figure 3).

There are more cyclists, bicyclists and pedestrians in Figure 2 compared to that recorded by WA Police (see Figure 3). It is expected these three road user groups are less likely to report the crash to WA Police. This may be due to misunderstandings as to when a road crash should be reported to WA Police as well as confusion as to whether crashes on footpaths and cycle ways should be reported to WA Police or not. For both of these scenarios, however, hospital morbidity data will record the casualty as a traffic crash, and will be subsequently included in the ICISS calculation.

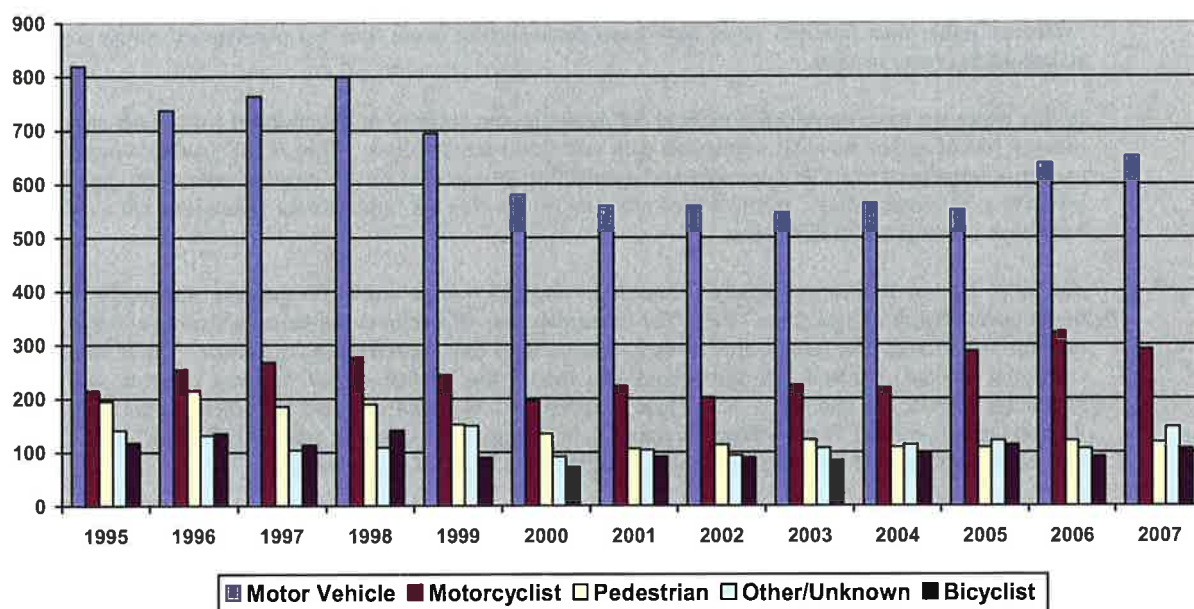


Figure 2: Killed and Seriously Injured (KSI) road crash casualties by road user group utilising ICISS methodology

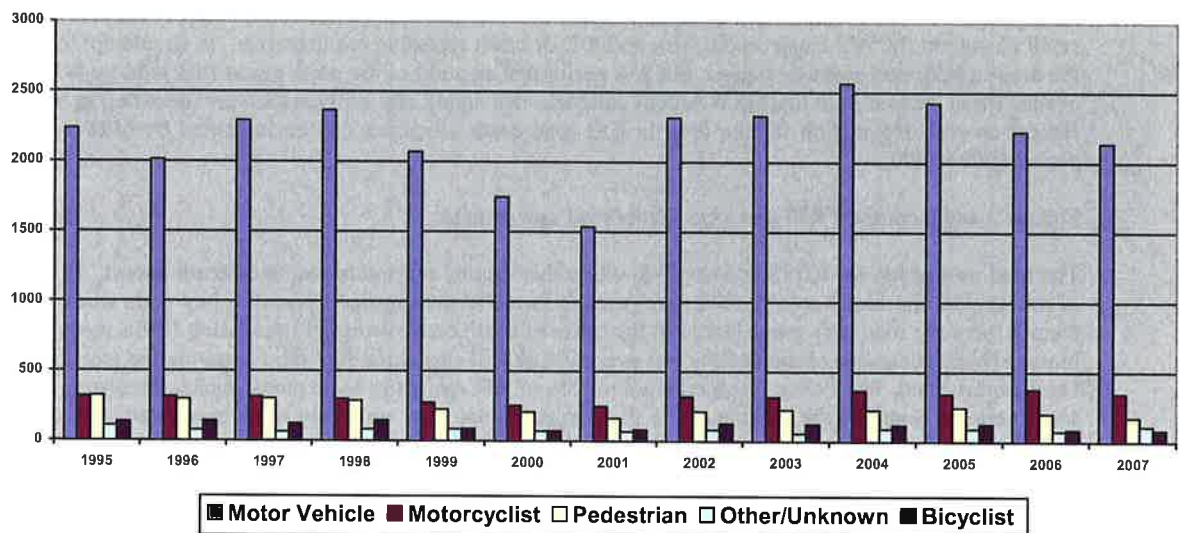


Figure 3: Killed and Seriously Injured (KSI) road crash casualties by road user group as reported to WA Police (i.e. MRWA)

Conclusion

A robust measure of serious injury is required by road safety strategists and policy analysts in order to understand the impact of interventions on WA roads. Reporting of killed and seriously injured (KSI) measures, rather than fatalities alone have been discussed for some time but consistency across road safety stakeholders is also needed.

In this paper we have described a method for assessing the severity of hospitalised road crash casualties by making use of linked hospital admission data and death registrations. This ICISS methodology described earlier is retrospective in its approach and availability (or access) to the hospital admission data currently involves a 12 month delay. A number of other injury severity (or 'seriousness') measures are available and have been investigated in this paper.

The RPH Trauma Registry routinely collects AIS and ISS trauma scores for patients admitted to RPH with minor and/or major trauma since 1994. The remaining four WA trauma registries have not yet been linked to the WADLS though discussions are currently underway to link the remaining registries. The ICISS has been compared against AIS and ISS throughout this report, and shown to fall midway between the standard thresholds of $AIS \geq 3$ and $ISS > 15$. There is currently a 6 month time lag for access to the RPH Trauma Registry data (i.e. RPH Trauma Registry data can be accessed for calendar year 2009 from 1st July 2010), but the coded discharge records required for calculation of the ICISS is much longer.

An overnight stay in hospital is another measure that could be used to identify serious injuries by road crash casualties in WA, though a number of factors unrelated to the severity or seriousness of injuries are likely to skew estimates for KSI. Older casualties as well as the very young, are often admitted to hospital for an overnight stay simply for observation subsequently skewing the number of overnight stays by road crash casualties. By including all overnight stays in hospital as serious injuries, we are likely to see overestimates for KSI.

Currently, KSI figures are quoted from road crash reports collected by MRWA and WA Police. This study clearly indicates this methodology far exceeds estimates provided by three other data sources, including ICISS. MRWA estimates for KSI exceed estimates for overnight stay by an average of 60% over the 1995 to 2007 time period, whereas this is increased to 130% above ICISS estimates over the same time period. It is likely that emergency presentations are included in the KSI estimate by MRWA, rather than only those admitted to hospital plus fatalities.

ICWA also routinely collect AIS trauma scores for all third party claims lodged with the commission, though ICWA has only been scoring and collecting AIS since 2005. Additional years of data collection are required in order to make a reasonable evaluation of ICISS against data sourced by ICWA. It is therefore recommended that the Data Linkage Branch continue to link ICWA third party claims data to WADLS for future analysis.

The ICISS provides a good estimate for serious injuries when compared to the accepted internationally accepted AIS and ISS that are routinely collected by the RPH Trauma Registry. This method requires access to the hospital admission data that is routinely collected by HMDC, but does not rely on the version of the underlying coding system for diagnoses of injury. However the coded injury and linked death information needed to calculate the ICISS is not usually available until 12 months after discharge from hospital (i.e. FY08/09 will be available on 1st July 2010) which may not suit the needs of road safety stakeholders.

A summary of potential measures for KSI is provided in Table 1, and shows the trade off between timeliness and data quality and completeness.

As well as the need for timely coded information to assess acute severity of injuries, a better estimate of the social and economic burden of injuries and their consequences is needed. Long term outcomes, including quality of life and future functional capacity for those seriously injured on WA roads need to be taken into account.

Analyses described in this report and any further work to be undertaken on the burden of injury rely on individually linked health, trauma, insurance and crash data, that is now available in WA from 1985 onwards.

Acknowledgements

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