Improvements in the validity of ICD-based Injury Severity Scores (ICISS)

Gabrielle Davie  
Assoc. Prof. Colin Cryer  
Prof. John Langley  
Dan Russell

Injury Prevention Research Unit, University of Otago, Dunedin
Why?

- NZIPS & other Govt agencies assess their performance in reducing injury over time
- Need to reduce service-provision and access effects when monitoring trends in non-fatal injury

- Severity threshold
- IPRU’s development of “serious non-fatal injury indicators”
Note: 1999 data are affected by the changeover from ICD-9 to ICD-10.
Source: New Zealand Health Information Service, National Minimum Data Set.
NZIPS Indicator

All Serious Non-Fatal Injury - Frequency (I01)

Note: 1999 data are affected by the changeover from ICD-9 to ICD-10. 2004 data are provisional.
Source: New Zealand Health Information Service, National Minimum Data Set.
Relevance

• Valid measurement of injury severity is:
  - critical to producing valid indicators
  - critical for the production of valid information to inform policy and injury prevention practice
What is ICISS?

• ICISS = threat-to-life based injury severity score calculated from routinely collected ICD codes

• To calculate ICISS….

First, for each ICD diagnostic code, the proportion of people who are admitted and survived their injury to discharge was calculated – this is called the Survival Risk Ratio (SRR)

\[
SRR(A) = \frac{\# \text{ hospitalisations with diag A discharged alive}}{\# \text{ hospitalisations with diag A}}
\]
How ICISS is calculated

• For people who have a **single diagnosis** (A) recorded,
  \[ \text{ICISS} = \text{SRR}(A) \]

• For people who have **multiple diagnoses** (A, B, C etc.) recorded,
  \[ \text{ICISS} = \text{SRR}(A) \times \text{SRR}(B) \times \text{SRR}(C) \times \ldots \times \text{SRR}(N) \]

• **ICISS = estimated survival probability**
Definition of a serious non-fatal injury

If ICISS ≤ 0.941 = Serious non-fatal injury

- Includes cases with an estimated probability of death of 5.9% or greater
- Only includes cases of injury that have a very high likelihood of admission to hospital

Examples:
- Fracture of the neck of femur
- Intracranial injury (excluding concussion only cases)
- Injuries of nerves and spinal cord at neck level
Can we improve the predictive ability of ICISS by….

- Using both NZHIS Hospitalisations & Mortality data in ICISS calculation

ICISS as currently used estimates

Survival to hospital discharge given admission

Adding all deaths would, in theory, better reflect Threat to life
Research Aim - 2

Can we improve the predictive ability of ICISS by....

- Accounting for comorbidity
  Is it possible/useful to include comorbid conditions in ICISS calculation?
Mortality diagnoses

Inclusion of non-hospitalised injury deaths

• Have diagnoses coded Mortality data from 2000 on

• Quality of mortality diagnoses?
  For those that died in hospital, compared diagnoses in Hospitalisation & Mortality datasets:
  - Illustrated that recording and coding of non-hospitalised deaths is different to that for deaths occurring in hospital
  - Used hospital diagnoses for this subset
Comorbidity

Inclusion of comorbidity

- **Harborview Assessment for Risk of Mortality (HARM)**
  - 11 comorbid conditions:
    - COPD, Congenital coagulopathy, Diabetes, Cirrhosis, IHD, Hypertension, Psychoses, Epilepsy, Obesity, Alcohol or drug dependence, Neurological degenerative disease

- **Charlson Comorbidity Index (CCI)**
  - 17 comorbid conditions:
    - Similar to HARM comorbid conditions but includes AIDS, Cancer, Connective tissue disease and doesn’t include Epilepsy or Obesity
Comorbidity SRRs

Comorbid SRRs were calculated at 2 levels:

**Variable** – one SRR for each comorbid condition

\[ \text{SRR (diabetes)} = \frac{\text{# hospitalisations with diabetes discharged alive}}{\text{# hospitalisations with diabetes}} \]

**ICD-10-AM** – one SRR for each ICD code within the comorbid conditions

\[ \text{SRR (E10.4)} = \frac{\text{# hospitalisations with E10.4 discharged alive}}{\text{# hospitalisations with E10.4}} \]
Data

- Hospitalisations with S00-T89 PD discharged dead at any admission within 90 days of injury date where injury date was 1/1/2000-31/8/2003 excluding those readmissions where the 1st admission didn’t have S00-T89 PD

plus
- 1st admission hospitalisations with an S00-T89 PD & injury date between 1/1/2000 & 31/8/2003 that either stayed at least one night in hospital or died within 90 days

plus
- Fatalities located in the Mortality Collection with date of death between 1/1/2000 & 31/8/2003 who had an S00-T89 diagnosis in any field

- 186,835 cases of which 9,968 (5.3%) were deaths
(Excluding data from Mortality collection, there were 182,673 cases of which 1,969 (1.1%) were deaths)
Method - 1

- Calculated the following ICISSs:

<table>
<thead>
<tr>
<th>ICISS</th>
<th>Mortality Collection</th>
<th>Comorbidity Approach</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICISS1</td>
<td>(traditional)*</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>ICISS2</td>
<td>No</td>
<td>HARM</td>
<td>ICD-10-AM code</td>
</tr>
<tr>
<td>ICISS3</td>
<td>No</td>
<td>HARM</td>
<td>Variable</td>
</tr>
<tr>
<td>ICISS4</td>
<td>No</td>
<td>Charlson</td>
<td>ICD-10-AM code</td>
</tr>
<tr>
<td>ICISS5</td>
<td>No</td>
<td>Charlson</td>
<td>Variable</td>
</tr>
<tr>
<td>ICISS6</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ICISS7</td>
<td>Yes</td>
<td>HARM</td>
<td>ICD-10-AM code</td>
</tr>
<tr>
<td>ICISS8</td>
<td>Yes</td>
<td>HARM</td>
<td>Variable</td>
</tr>
<tr>
<td>ICISS9</td>
<td>Yes</td>
<td>Charlson</td>
<td>ICD-10-AM code</td>
</tr>
<tr>
<td>ICISS10</td>
<td>Yes</td>
<td>Charlson</td>
<td>Variable</td>
</tr>
</tbody>
</table>
Method - 2

- Because average # of diagnoses per person in Hospitalisations data was 3x that from Mortality Collection, used ‘worst injury’ methodology

\[ \text{ICISS} = \text{smallest}[ \text{SRR}(A), \text{SRR}(B), \ldots , \text{SRR}(N) ] \]

- For the ICISS scores that included comorbidity, comorbid SRRs (cSRRs) contributed as follows:

\[ \text{ICISS} = \text{smallest}[ \text{SRR}(A), \text{SRR}(B), \ldots , \text{SRR}(N) ] \times \text{smallest}[ \text{cSRR}(1), \text{cSRR}(2), \ldots , \text{cSRR}(M) ] \]

where A, B, \ldots N = injury diagnoses and 1, 2, \ldots M = comorbid variable/ICD code
Method - 3

- Compared the **discrimination** and **calibration** of ICISS2-ICISS10 with ICISS1

**Discrimination** – assessed by concordance; ability of ICISS to predict survivors from non-survivors on scale from 0-1

**Calibration** – assessed by Calibration curves & H-L statistic; indicates accuracy of estimates of probability of death
<table>
<thead>
<tr>
<th>ICISS</th>
<th>Concordance</th>
<th>95% CI*</th>
<th>H-L</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICISS1</td>
<td>0.777</td>
<td>(0.772 , 0.783)</td>
<td>2757</td>
<td>0.123</td>
</tr>
<tr>
<td>ICISS2</td>
<td>0.800</td>
<td>(0.795 , 0.806)</td>
<td>1352</td>
<td>0.163</td>
</tr>
<tr>
<td>ICISS3</td>
<td>0.794</td>
<td>(0.790 , 0.798)</td>
<td>1361</td>
<td>0.150</td>
</tr>
<tr>
<td>ICISS4</td>
<td>0.818</td>
<td>(0.813 , 0.823)</td>
<td>1673</td>
<td>0.184</td>
</tr>
<tr>
<td>ICISS5</td>
<td>0.816</td>
<td>(0.811 , 0.821)</td>
<td>1710</td>
<td>0.175</td>
</tr>
<tr>
<td>ICISS6</td>
<td>0.851</td>
<td>(0.848 , 0.855)</td>
<td>2222</td>
<td>0.227</td>
</tr>
<tr>
<td>ICISS7</td>
<td>0.874</td>
<td>(0.870 , 0.877)</td>
<td>1233</td>
<td>0.282</td>
</tr>
<tr>
<td>ICISS8</td>
<td>0.866</td>
<td>(0.863 , 0.870)</td>
<td>1256</td>
<td>0.262</td>
</tr>
<tr>
<td>ICISS9</td>
<td><strong>0.891</strong></td>
<td><em>(0.888 , 0.894)</em></td>
<td><strong>926</strong></td>
<td><strong>0.328</strong></td>
</tr>
<tr>
<td>ICISS10</td>
<td>0.885</td>
<td>(0.882 , 0.888)</td>
<td><strong>910</strong></td>
<td>0.301</td>
</tr>
</tbody>
</table>

*Bootstrap adjusted CI
Results – Concordance

- **Best** = ICISS9 (mortality data and CCI at ICD-10-AM level)
  
- **Worst** = ICISS1 (traditional)

- ICISS6-10 (hospitalisation and mortality data) all had better concordance than ICISS1-5 (hospitalisation data only)

- Scores using comorbidity data had higher concordance than corresponding score that didn’t include comorbidity

- Scores using CCI had better concordance than those using HARM

- Scores using comorbidity SRRs at ICD-10-AM level had higher concordance than respective scores using SRRs at variable level
Results – Calibration 1

- Since the vast majority of cases have ICISS close to 1, only cases with estimated mortality ≤ 30% are presented. (Corresponds to 90-99% of the data depending on which ICISS)
- Differences in performance is difficult to assess through calibration curves
- Calibration was generally better at lower levels of estimated mortality
Results – Calibration 2

- Scores that used hospital data only to calculate SRRs (ICISS1-5) underestimated mortality whereas those that used hospital + mortality data (ICISS6-10) overestimated mortality
- H-L statistic was better for scores that included comorbidity
- Scores that included mortality data & CCI (ICISS9&10) had the best H-L statistics
In summary

Can we improve the predictive ability of ICISS by….

• Using both NZHIS Hospitalisations & Mortality data in ICISS calculation - YES

• Accounting for comorbidity – YES
Issues – mortality data

- Recording & coding of deaths that occur outside hospital is very different to that for in-hospital deaths

- Injury diagnostic codes used in the Mortality Collection appear to be less specific than those in the NMDS – may explain the overestimation of mortality by models include deaths from the Mortality Collection (ICISS6-10).

IPRU is currently negotiating funding to explore the reliability of the diagnoses in the Mortality Collection
Issues – Comorbidity

• Data availability?

• Only the worst comorbid SRR was included. In comparison, the HARM approach had separate terms in model for each comorbid condition.

• Age is correlated with comorbidity.
  
  Is including comorbidity usefully better than the simpler term, age?  
  Is there justification for including both?

• Since vast majority of comorbidity occurs in older people:
  
  Should SRRs be population group dependent? E.g. SRRs be calculated separately for 0-74 yr olds & 75+ yr olds.  
  Should there be separate serious non-fatal indicators for children/adults and for older people for all priority areas?
**Policy implications**

Suggests the methodology used to obtain severity scores from which injuries are classified could be improved

**Impact on current NZIPS serious non-fatal injury indicators?**

- Using ICISS1<=0.941 essentially selects a "basket" of diagnoses that have high probability of admission (face validity)
- Diagnoses captured are essentially the operational definition of serious non-fatal injury used for the NZIPS
- Using e.g. ICISS9, would require a different threshold to be chosen
  Hypothesis = ICISS9 threshold chosen that results in an operational definition of "serious injury" based on a similar list of diagnoses

**Unlikely current NZIPS indicators are misleading**
Conclusions

• Evidence to suggest the predictive ability of ICISS can be improved by using Mortality data and accounting for comorbidity

• Current NZIPS serious non-fatal injury indicators calculated without either **BUT** expect this work doesn’t compromise their validity

Rather than modify the methodology used to define ‘serious non-fatal injuries’ on an ad-hoc basis, it was agreed by the Interagency Injury Indicators Group to update every 5 yrs (2010).