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Establishing an injury indicator for severe paediatric injury

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ABSTRACT

Background Routinely gathered injury data, such as hospitalisations, may be subject to variation from sources other than injury incidence. There is a need for an indicator that defines severe injury, which may be less vulnerable to fluctuations due to changes in care policies. The purpose of this study was to identify International Classification of Diseases-10 codes associated with severe paediatric injuries and to specify and validate a severe paediatric injury indicator.

Methods Two data sets that included the ISS and the survival risk ratio were used to produce a list of diagnoses to define severe paediatric injury. The list was sent to trauma surgeons who classified each code as severe enough or not severe enough to require care in a trauma centre. The indicator was fully specified, then validated by using a different data set to validate the codes in a real-world situation.

Results Sixty diagnoses were identified as representing severe paediatric injury. Following specification, the indicator was applied to an existing comprehensive data set of paediatric injuries. The decline in hospitalisation of paediatric injuries was significantly steeper for severe than non-severe injuries, suggesting that factors related to the decline in this trauma subset are unlikely to be related to changes in access or other components of trauma care delivery.

Conclusions This indicator can be used for the evaluation of trends in severe paediatric trauma and will help identify populations at risk. This research may inform policies and procedures for referrals of severe childhood injury to appropriate levels of care.

INTRODUCTION

Hospitalisation of children and youth under 20 years of age accounted for 15% of all injury hospitalisations in Canada in 2005–2006 (n=29 244).[1] Between 1994 and 2003, an estimated average 25 500 children age 14 and under were hospitalised annually for serious injuries.[2] Well-designed injury surveillance systems have been identified as one approach to develop and evaluate injury prevention strategies.[3] Injury surveillance is one way to collect data and prompt action to reduce the burden of injury, though some injury prevention advocates question whether surveillance alone is adequate for prevention.[4 5] Further, using routinely collected data on hospitalisations for surveillance has been criticised because changes in hospitalisation counts and trends for injury may be due to changes in health service delivery or thresholds for admission rather than reflecting changes in injury incidence. One way to resolve this problem is by developing an indicator that reflects severe injury that would almost always require hospitalisation rather than one for all injury hospitalisations.

Indicators for severity of injury have included mortality, hospital admission, attendance at the emergency department and time off work or school. Perhaps more objectively, the ISS, the AIS and the International Classification of Diseases (ICD)-derived ISS (ICISS) have all been used for measuring and rating severity.[6] The AIS and ISS are based on individual patient injuries according to six body regions, but vary across diagnoses. The ICISS, initially based on the ICD-9 classification of trauma injuries, has since been developed with both ICD-9 and ICD-10.[7] The ICISS assumes that a patient's probability of survival can be predicted based upon the survival rates of prior patients with similar injuries as classified by the ICD. Those with a lower probability of survival are defined as severe.[8] The use of different scoring systems results in a lack of consistency in defining indicators for injury severity and limits the assessment of trends over time and comparisons between jurisdictions. Instead of routine surveillance, developing reliable indicators has been identified as important for evaluating the progress made in reducing injuries within regions and comparing this progress on an international level.[9]

Many injury severity measures have been derived from and apply primarily to the adult population, and may not be relevant to children. Children have unique anatomic and physiological differences and vary in their injury patterns compared with adults. There are also differences in cardiorespiratory variables, airway anatomy, response to blood loss, thermoregulation and equipment required for their treatment.[10] There is a paucity of information on severe paediatric injuries, hence the need for an indicator of severe paediatric injury that can be universally applied to obtain population-based data for ongoing surveillance. The AIS/ISS is often not applicable in this context as it is typically only calculated and tabulated into regional trauma registries, which may only code injured patients in trauma centres. Because of the wide geographic distribution of paediatric trauma centres, however, many injured children may be cared for in non-trauma centres and thus may not be typically or systematically included into surveillance systems dependent on AIS/ISS scoring.[11]

The purpose of this study was to develop and validate a population-based indicator of severe paediatric injury that can be broadly applied using existing ICD-10[12] coded hospitalisation data.

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METHODS

Phase I: development of the indicator from data sets

In order to capture as broad a range of diagnostic codes to define severe paediatric injury as possible, two data sets were used. Paediatric hospitalisations in Canada were obtained from the national Discharge Abstract Database (DAD) (population-based administrative data) and the Comprehensive Data Set of the Ontario Trauma Registry (OTR) (aggregated trauma registry data from trauma centres in Ontario), each of which contain different information. Specifically, the ISS is only available in the Comprehensive Data Set of the OTR, while the DAD includes all patients hospitalised across Canada and typically does not include ISS for all patients. Initially, the diagnoses within each data set were identified as severe based on two scoring methods (the survival rate ratio (SRR) for the DAD and the ISS for the comprehensive data set). Diagnoses within the ICD-10 'S00-T98' chapter including injuries, poisoning and other consequences of external causes were evaluated. Any diagnoses outside of the S00-T98 range or diagnoses with 'T80-T88' coding—which is designated for adverse events, including complications of surgical and medical care, or drug interactions—were excluded from the study. In addition to adverse events, injury-related deaths that occurred prior to arrival at the hospital were not included in either data set. Figure 1 provides an overview of the study process and methods.

Discharge Abstract Database

The DAD, managed by the Canadian Institute for Health Information, is a case-level minimum data set including all patients admitted to a hospital in Canada. Paediatric cases in the data set, aged 0–19 years with a discharge diagnosis of a traumatic injury for the period April 2000–March 2004, were assessed. Data from the province of Quebec were excluded as Quebec was not using ICD-10 coding during the study period. There were 108 780 cases of injury used to calculate an SRR for each diagnostic code. Given that children are less likely to die as a result of injury, diagnoses with an SRR equal to or less than 0.980 (probability of death of ≥2%) were considered as severe compared with the usual adult SRR of 0.960 for ICD-9 and 0.941 for ICD-10.[13 14] This limit was established in the first phase of the study in order to include all diagnoses that were potentially serious and/or fatal.

Ontario Trauma Registry

The comprehensive data set within the OTR was used as a second data source to define severe injury diagnoses. The OTR contains detailed data on injured patients hospitalised in 11 trauma facilities in Ontario as a result of major traumatic injury. Variables include demographics, diagnoses (as per ICD-10 codes), ISSs as well as prehospital and inpatient variables related to care and outcomes. Patients aged 0–19 years for the period April 2002–March 2006 were included in this study.

Analysis

The primary element that was evaluated in the OTR was the ISS. Although most cases of injury involve multiple diagnoses, only the primary diagnosis (most responsible) was used as the designated diagnosis for each injury. The lowest ISS within the data set was 13 and the highest score was 75. Similar to the recommendations used by Stevenson *et al*,[15] cases of injury were sorted into the following three categories: moderate (ISS 13–15), severe (ISS 16–24) and critical (ISS 25–75). The frequency distributions for the ISSs were as follows: moderate (N=318, 11.3%), severe (N=1264, 45.0%) and critical (N=1227, 43.7%). Using separate models for each diagnosis, ordinal regression was then used to analyse the odds of each diagnosis falling into either the severe or critical level of injury severity (the outcome variable) based on the patient's ISS. Initially, for development of the indicator, a diagnosis was considered severe if the OR was >1, with a 95% CI that did not cross 1, falling into the critical or severe level compared with the moderate level, or if a diagnosis had a mean ISS score equal to or greater than 20 across all the patients with that diagnosis. If a diagnosis had an OR that indicated that it was likely to be severe or critical (ie, OR >3) and the p value was not significant, it was considered 'close' and was also included. This conservative approach was taken to ensure that no diagnoses were excluded from the initial list because of small numbers.

Synchronise

All diagnoses captured using the two approaches were compared and combined. A list of all of the potentially severe diagnoses was developed. Diagnoses that were included in both processes were combined, and a final list of all potential severe diagnoses was developed.

Phase II: expert opinion

In order to establish 'face' validity, the list of diagnoses identified in the first phase was reviewed by two independent paediatric surgeons, both with expertise in trauma and trauma systems. They rated the severity of each diagnosis as 'yes', 'no' or

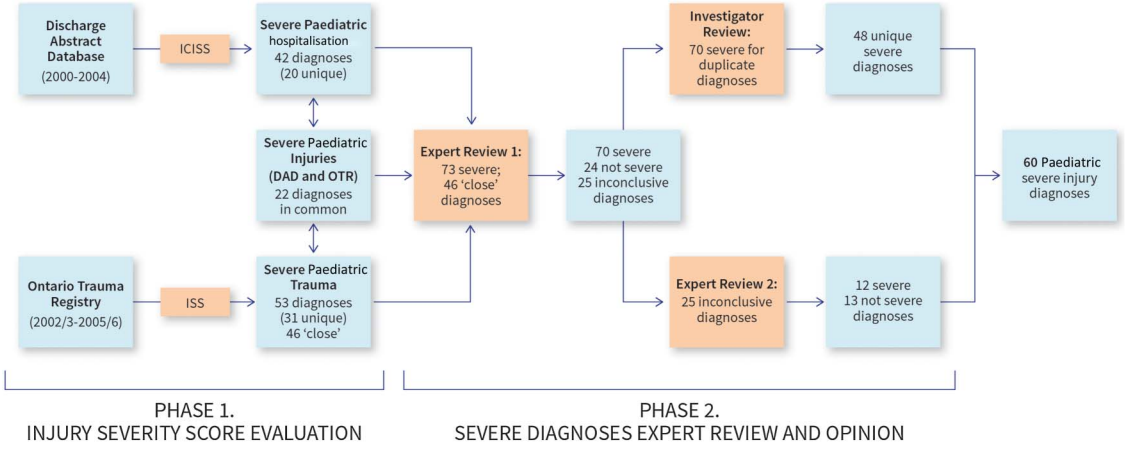

Figure 1 Process model for the development of severe paediatric injury indicator. DAD, Discharge Abstract Database; ICISS, International Classification of Diseases-derived ISS; OTR, Ontario Trauma Registry.

Table 1 ICD-10 codes constituting severe injury-related hospitalisations among children and youth 0–19 years of age

Number	ICD-10	Diagnosis	Source Data set	
1	S01.9	Open wound of head, part unspecified	DAD	
2	S02.1	Fracture of base of skull		OTR
3	S02.7	Multiple fractures involving skull and facial bone	DAD	
4	S02.9	Fracture of other facial bones		OTR
5	S04	Injury of cranial nerves		OTR
6	S05.7	Avulsion of eye		OTR
7	S06.1	Traumatic cerebral oedema	DAD	OTR
8	S06.2	Diffuse brain injury	DAD	OTR
9	S06.3	Focal brain injury	DAD	OTR
10	S06.4	Epidural haemorrhage		OTR
11	S06.5	Traumatic subdural haemorrhage	DAD	OTR
12	S06.6	Traumatic subarachnoid haemorrhage	DAD	OTR
13	S06.8	Other intracranial injuries	DAD	OTR
14	S06.9	Intracranial injury, unspecified	DAD	
15	S07.0	Crushing injury of face	DAD	OTR
16	S11	Open wound of neck		OTR
17	S12	Fracture of neck		OTR
18	S13	Dislocation, sprain and strain of joints and ligaments at neck level		OTR
19	S14.1	Complete lesion of cervical spinal cord	DAD	OTR
20	S14.6	Other and unspecified injuries of neck		OTR
21	S15	Injury of blood vessels at neck level		OTR
22	S21	Open wound of thorax		OTR
23	S22	Fracture of rib(s), sternum and thoracic spine		OTR
24	S24	Injury of nerves and spinal cord at thorax level		OTR
25	S25.0	Injury of thoracic aorta	DAD	OTR
26	S25.3	Injury of innominate or subclavian vein	DAD	OTR
27	S25.4	Injury of pulmonary blood vessels	DAD	OTR
28	S26.0	Injury of heart with haemopericardium	DAD	
29	S26.8	Other injuries of heart (contusion, laceration, puncture)	DAD	
30	S27	Injury of other and unspecified intrathoracic organs	DAD	
31	S28	Crushing injury of thorax and traumatic amputation of part of thorax		OTR
32	S31	Open wound of abdomen, lower back and pelvis		OTR
33	S32	Fracture of lumbar spine and pelvis		OTR
34	S35.0	Injury of abdominal aorta	DAD	OTR
35	S35.1	Injury of inferior vena cava	DAD	OTR
36	S36	Injury of intra-abdominal organs	DAD*	OTR*
37	S37	Injury of urinary and pelvic organs		OTR
38	S38.1	Crushing injury of other and unspecified parts of abdomen, lower back and pelvis		OTR
39	S42.0	Fracture of clavicle		OTR
40	S42.1	Fracture of scapula		OTR
41	S72.0	Fracture of neck of femur		OTR
42	S75.0	Injury of femoral artery	DAD	
43	S77	Crushing injury of hip and thigh		OTR
44	S78	Traumatic amputation of hip and thigh		OTR
45	S86	Injury of muscle and tendon at lower leg level		OTR
46	S88.0	Traumatic amputation at knee level	DAD	
47	T01.9	Multiple open wounds, unspecified	DAD	
48	T06.8	Other specified injuries involving multiple body regions	DAD	
49	T20.3	Burn of third degree of head and neck	DAD	OTR
50	T21	Burn and corrosion of trunk		OTR
51	T22.3	Burn of third degree of shoulder and upper limb, except wrist and hand		OTR
52	T24	Burn and corrosion of hip and lower limb, except ankle and foot		OTR
53	T27	Burn and corrosion of respiratory tract		OTR
54	T29.3	Burns of multiple regions, at least one burn of third degree mentioned	DAD	OTR
55	T30.3	Burn of third degree, body region unspecified	DAD	
56	T58	Toxic effects of carbon monoxide	DAD	OTR
57	T68	Hypothermia	DAD	OTR
58	T71	Asphyxiation	DAD	OTR
59	T75.1	Drowning and non-fatal submersion	DAD	OTR
60	T79.4	Traumatic shock (immediate/delayed following injury)	DAD	

*S36.0—OTR; S36.1—DAD/OTR; S36.2—OTR; S36.3—OTR; S36.4—OTR; S36.5—DAD/OTR.
DAD, Discharge Abstract Database; ICD, International Classification of Diseases; OTR, Ontario Trauma Registry.

'maybe' with respect to their recommendation of requirement of care of that specific injury in a paediatric trauma centre. Injuries were rated as severe if the experts believed that they would be optimally treated in a paediatric trauma centre. Inconclusive diagnoses, where the reviewers either did not agree or both rated as 'maybe' were then sent to two different trauma surgeons. These surgeons were asked to rate the 25 inconclusive diagnoses as either 'yes' or 'no', and a diagnosis was deemed severe if either surgeon said 'yes'.

During this process, the investigators examined all of the diagnoses initially identified as severe. Several diagnoses were duplicated because of the number of fifth and sixth digits used in ICD-10 coding. For example, S36 and S36.01, S36.02, and so on, were treated as different diagnoses initially for precision, but ultimately grouped under a single code, S36. This grouping was only applied in situations where all of the diagnoses were considered severe (such as in the case of S36—injury of intra-abdominal organs).

Phase III: specification

Once the list of severe diagnoses was complete, the indicator was fully specified, including descriptions of the numerator, the denominator, the data source and the purpose of the indicator.

Phase IV: application in another data set

The proposed indicator was then applied to a third database; the provincial injury-related hospital DAD from British Columbia (BC), Canada, for all hospitalised children and youth, 0–19 years of age, for the period April 2002–March 2011. The

investigators examined trends in paediatric injury hospitalisations generally and then compared the trends in severe versus non-severe injury hospital separations and length of stay (days in hospital). The proportionate decreases in severe versus non-severe injuries over the 9-year time period were compared using a Generalized Linear Model (SPSS V.22).

RESULTS

Phase I: development of the indicator from data sets

Figure 1 details the results of the indicator development process. There were 42 diagnoses in the discharge abstract data set with SRR scores ≤0.980. The diagnoses with the lowest SRR scores were injury of pulmonary blood vessels, injury of subclavian vein, burn of third degree (body region unspecified) and poisoning of other primary systemic and haematological agents. Despite having low frequencies, these diagnoses all had a high estimated probability of death (100%).

There were 53 diagnoses from the OTR that were identified as being associated with severe paediatric injury. The majority of severe cases were injuries to the head (n=1720), injuries to the thorax (n=317) and injuries to the abdomen, lower back and spine (n=186). Across all diagnoses, ISS scores ranged from 13 to 75 and injuries related to 'crushing injury to the head', 'crushing injury of the thorax' and 'traumatic amputation of part of thorax' were among the most severe injuries, with mean ISS values of 75. Diffuse brain injury (mean ISS=36.1) and traumatic cerebral oedema (mean ISS=33) also had high ISSs.

Phase II: expert opinion

Using both data sets, a total of 73 diagnoses were captured. Twenty-two were common to both data sets; 20 diagnoses were in the DAD only; and 31 in the OTR only (figure 1). Once reviewed, there was initial agreement that 70 diagnoses were defined as severe, 24 were defined as not severe and there was no agreement on 25 diagnoses. Secondary review of these 25 inconclusive diagnoses resulted in agreement on severe classification for 11 of the 25 diagnoses, with one other ultimately included based on at least one of the reviewers classifying it as a 'yes'. It is worth noting that many of the diagnoses upon which there was no agreement fell in the 'other injuries' or 'not specified' categories. The grouping of diagnoses that were very similar resulted in the elimination of 22 diagnoses that fell within the same ICD-10 code but had a different number of digits. Ultimately, 60 diagnoses were identified and considered to define severe paediatric injury (table 1) and formed the basis of our indicator. Of these, 20 were common to both DAD and OTR, 12 were unique to the DAD and 28 were unique to OTR.

Phase III: specification

The full specification for the severe injury indicator is detailed in table 2. Elements include descriptions of the numerator, the denominator, the method of calculation and the limitations of the indicator.

Phase IV: application in a BC database

Subsequent to the establishment of face validity and the specification, the investigators applied the paediatric severe injury indicator to the BC injury-related hospital DAD for all BC children and youth, 0–19 years of age, for the period April 2002–March 2011 (total nine fiscal years). The resulting analysis is presented in table 3 and figures 2 and 3. Table 3 illustrates the average

Table 2 Indicator specification

Indicator	Age-standardised rate of severe injury-related hospitalisations per 100 000 population, 0–19 years of age
Definition	The number of child and youth hospital separations per 100 000 population for a particular year, for severe injuries, stratified by sex, age group, geographic health region when available (excluding patient safety/complications/medical misadventures and deaths that occurred outside of hospital).
Why is it important?	Severe injury-related hospitalisation rate is a key measure of injury and the use of health services. The indicator provides an understanding of the burden of severe injury among children and youth and the impact on health services. The indicator is less susceptible to changes in health service delivery or thresholds for admission than using all injury hospitalisations.
How should it be used?	The *severe injury-related hospital separations rate* indicates the number of children and youth (0–19 years) who are discharged from hospital following treatment for a severe injury each year. Increases in hospital separations for specific severe injuries would indicate the need for more effective injury prevention in that specific area. Decreases in severe injury hospital separations would indicate that existing injury prevention strategies are effective and should be sustained.
Key terms	*Hospital separation* is defined as the number of inpatients (having spent at least one night following admission to a hospital) who leave hospital through discharge.
How is it calculated?	*Numerator:* Total number of child and youth (0–19 years) severe injury-related hospital separations assigned to the included relevant ICD-10 codes for a particular year. *Denominator:* Mid-year total for children and youth (0–19 years) population for the same year as the numerator. *Method of calculation:* Number of severe child and youth injury-related hospital separations ×100 000 mid-year total for child and youth (0–19 years) population.
What data are needed?	▶ Number of *severe injury-related hospital separations* for children and youth aged 0–19 years (stratified by sex, age group (<1, 1–4, 5–9, 10–14, 15–19) and geographic health region when available). ▶ *Population of children and youth* 0–19 years of age (stratified by sex, age group (<1, 1–4, 5–9, 10–14, 15–19) and geographic health region when available). ▶ *Severe injury hospital separations data* defined by the ICD-10 codes in table 1.
Where can it be found?	Separation data are included in the Discharge Abstract Database provided by Canadian provinces to the *Canadian Institute for Health Information*.
Limitations	It should be noted that an individual can be admitted to hospital more than once for treatment of the same injury and that injury separation data are simply the numbers of discharges following admission for treatment of injury. They do not represent either the *number of injuries* that led to the separations nor the *number of injured people* who were discharged from hospital. Despite the effort to include ICD-10 codes indicating severe injuries, hospital admission policies may differ among hospitals and over time. Consequently, injuries that might be admitted in one hospital may not be in another and may differ over time depending on such things as changing medical treatment practices, available beds, institutional policies and other resources. There are children who suffer considerable consequences from their injury, although it is not considered severe using this definition. Thus, the current indicator is an underestimate of the total burden of child and youth injury, and should be treated as such.

ICD, International Classification of Diseases.

Table 3 Average length of stay (days)

	Non-severe paediatric injury	Severe paediatric injury
2002/2003	4.09	7.82
2003/2004	4.22	6.74
2004/2005	4.15	7.82
2005/2006	4.46	7.96
2006/2007	4.16	6.35
2007/2008	4.54	9.51
2008/2009	4.64	7.71
2009/2010	4.55	8.30
2010/2011	4.78	6.88
Mean	4.40	7.67 (p<0.01)

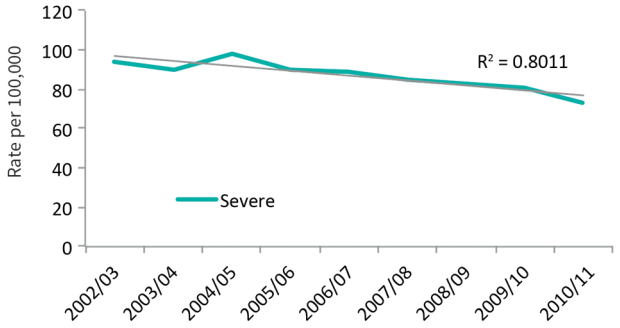

Figure 2 Age-standardised rate of child and youth severe injury in British Columbia (BC), 2002/2003–2010/2011. The age-standardised rate of severe injury-related hospitalisations among BC children and youth declined significantly (p=0.001) in the period 2002/2003–2010/2011, decreasing by 22% from a high of 94.55 per 100 000 in 2003/2004 to a low of 73.21 per 100 000 in 2010/2011. The proportionate decline in severe injury-related hospitalisations during the 9-year period 2002/2003–2010/2011 was significantly greater (p<0.001) than the proportionate decline observed in non-severe injury-related hospitalisations (22% vs 18%).

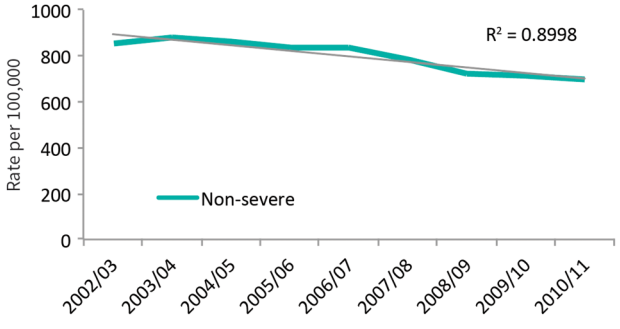

Figure 3 Age-standardised rate of child and youth non-severe injury in British Columbia (BC), 2002/2003–2010/2011. The age-standardised rate of non-severe injury-related hospitalisations among BC children and youth declined significantly (p=0.001) in the period 2002/2003–2010/2011, decreasing by 18% from a high of 854.91 per 100 000 in 2003/2004 to a low of 697.12 per 100 000 in 2010/2011.

length of stay following severe injury, which is significantly higher, compared with non-severe injury (7.67 vs 4.40; p<0.01). Figures 2 and 3 illustrate the trends in severe and non-severe paediatric injury. The proportionate decline in paediatric injury was significantly steeper for severe injuries compared with non-severe injuries (22% vs 18%; p<0.001), suggesting that changes in health service delivery or other changes were not responsible for the decline in this population.

DISCUSSION

An indicator of severe paediatric injury was developed and validated using a robust methodology including creation in two different data sets, validation by experts and ongoing application in a third, unique database.

The main findings of this study suggest that using either ISS or SRR alone to capture severe injuries in the paediatric population may underestimate the number of severe diagnoses. The DAD used the SRR method and captured 32 diagnoses. Using the OTR and the ISS in this study, 48 diagnoses were captured (20 diagnoses were common to both). The ISS defines the injury severity, but fails to indicate the intensity, urgency and complexity of treatments required by patients to survive and achieve an optimal recovery.[16] Our findings that not all diagnoses that were considered severe were identified by either data set suggest that either one may be inadequate 'gold standard' for the paediatric population. In general, previous studies have acknowledged that the SRR consistently performs better than ISS in predicting mortality,[17–21] but neither was found to be sufficient alone as a predictor of severe paediatric injuries in the current study.

Combining both methods helped to define an initial list of diagnoses that can define severe paediatric injury that could be used at a population level. The subsequent validation suggests that this combined approach produced a robust list of diagnoses that can be used together as an indicator of severe paediatric injury. This indicator may have two primary purposes. First, research in adults has demonstrated that while injury hospitalisations in general are decreasing severe injuries are not. This suggests that changes in clinical practice may be driving the downward trend rather than a real reduction in injuries.[10] Development and specification of an indicator of severe paediatric injury allowed for a similar comparison for children. This can be used for population-based injury surveillance to examine trends over time.

The second use of this indicator may be to define which patients should receive care at a paediatric trauma centre. Wang *et al*,[22] in California, highlighted the importance of capturing information on all children that should reach paediatric trauma care. The results of that study reported that "23% of children with severe injuries, and 18.1% of paediatric deaths more than two days after injury, were cared for in non-trauma-designated facilities". Using the severe paediatric injury indicator may help to assess the effectiveness of appropriate regional trauma systems for children and can be used to inform triage guidelines in the future.

STRENGTHS AND LIMITATIONS

This is the first Canadian study to develop an indicator to define severe paediatric injury. The data sets used in the analysis were obtained from routinely collected health administrative data and were population based. The large number of cases analysed initially in two data sets may increase the generalisability of the results across Canada. However, the results are all based on Canadian data and may not be generalisable to other populations, particularly those with different healthcare systems. The different time periods for the data sets used is also a limitation, but was based on the availability of the data. Finally, although we used a conservative approach to capturing diagnoses, it is possible that a severe but rare diagnosis was missed using this approach.

CONCLUSION

An indicator of severe paediatric injury, based on a robust methodology, can be used to analyse changes in severe paediatric injury over time and to assess the performance of paediatric trauma systems.

What is already known on the subject?

- Indicators of severe injury can be a better measure of trends because they are less subject to the influences of changes in healthcare practice and policy.
- Most injury indicators have been developed for the adult population.

What this study adds?

- A specified and validated indicator of severe paediatric injury.
- This indicator can be used at a population level by jurisdictions using International Classification of Diseases-10 coding.

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Contributors IP helped design, analyse and write the final version of the manuscript. MK designed the study, conducted the analysis and wrote a first draft of the manuscript. NLY provided input into study design and critically appraised all versions of the manuscript. HT and ABN helped with study design and critically appraised all versions of the manuscript. AKM supervised and contributed to study design, analysis and writing of the manuscript. As senior author she has agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Competing interests None declared.

Ethics approval As this study employed a secondary data analysis of anonymous data, there were no study participants, and York University's Human Participants' Review Committee granted this study an exemption for ethical approval.

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REFERENCES

1 Canadian Institute of Health Information. Injury Hospitalizations Highlights Report (In Focus: Pediatric Injury Hospitalizations in Canada, 2005–2006). 2007. https://secure.cihi.ca/free_products/ntr_highlights_2007_en.pdf (accessed Oct 2015).
2 Safe Kids Canada. Child and Youth Unintentional Injury: 10 years in review 1994–2003. 2006. http://www.mhp.gov.on.ca/en/prevention/injury-prevention/skc_injuries.pdf (accessed May 2012).
3 Stone DH, Morrison A, Ohn TT. Developing injury surveillance in accident and emergency departments. *Arch Dis Child* 1998;78:108–10.
4 Johnston BD. Surveillance: to what end? *Inj Prev* 2009;15:73–4.
5 Johnston BD, Ebel BE. Child injury control: trends, themes, and controversies. *Acad Pediatr* 2013;13:499–507.
6 Kim YJ. Injury severity scoring systems: a review of application to practice. *Nurs Crit Care* 2012;17:138–50.
7 Osler T, Rutledge R, Deis J, *et al*. ICISS: An international classification of disease-9 based injury severity score. *J Trauma* 1996;41:380–6; discussion 386–8.
8 Davie G, Cryer C, Langley J. Improving the predictive ability of the ICD-based Injury Severity Score. *Inj Prev* 2008;14:250–5.
9 MacKay JM., Vincenten JA. Leadership, infrastructure and capacity to support child injury prevention: can these concepts help explain differences in injury mortality rankings between 18 countries in Europe? *Eur J Public Health* 2012;22:66–71.
10 Kenefake ME, Swarm M, Walthall J. Nuances in pediatric trauma. *Emerg Med Clin N Am* 2013;31:627–52.
11 Mooney DP, Gutierrez IM, Chen Q, *et al*. Impact of trauma system development on pediatric injury care. *Pediatr Surg Int* 2013;29:263–8.
12 Canadian Institute for Health Information. *International Statistical Classification of Canadian Institute for Health Information Diseases and Related Health Problems: Tenth Revision Volume One-Tabular List*. Ottawa, Canada, 2012.
13 Cryer C. Injury outcome indicators—validation matters. *Int J Inj Contr Saf Promot* 2005;12:219–24; discussion 225.
14 Stephenson SC, Langley JD, Civil ID. Comparing measures of injury severity for use with large databases. *J Trauma* 2002;53:326–32.
15 Stevenson M, Segui-Gomez M, Lescohier I, *et al*. An overview of the injury severity score and the new injury severity score. *Inj Prev* 2001;7:10–13.
16 Newgard CD, Hedges JR, Diggs B, *et al*. Establishing the need for trauma center care: anatomic injury or resource use? *Prehosp Emerg Care* 2008;12:451–8.
17 Rutledge R. Injury severity and probability of survival assessment in trauma patients using a predictive hierarchical network model derived from ICD-9 codes. *J Trauma* 1995;38:590–7; discussion 597–601.
18 Rutledge R, Hoyt DB, Eastman AB, *et al*. Comparison of the Injury Severity Score and ICD-9 diagnosis codes as predictors of outcome in injury: analysis of 44,032 patients. *J Trauma* 1997;42:477–87; discussion 487–9.
19 Rutledge R, Osler T, Emery S, *et al*. The end of the Injury Severity Score (ISS) and the Trauma and Injury Severity Score (TRISS): ICISS, an International Classification of diseases, ninth revision-based prediction tool, outperforms both ISS and TRISS as predictors of trauma patient survival, hospital charges, and hospital length of stay. *J Trauma* 1998;44:41–9.
20 Rutledge R, Osler T, Kromhout-Schiro S. Illness severity adjustment for outcomes analysis: validation of the ICISS methodology in all 821,455 patients hospitalized in North America in 1996. *Surgery* 1998;124:187–96.
21 Wong SS, Leung GK. Injury Severity Score (ISS) vs. ICD-derived Injury Severity Score (ICISS) in a patient population treated in a designated Hong Kong trauma centre. *Mcgill J Med* 2008;11:9–13.
22 Wang NE, Saynina O, Kuntz-Duriseti K, *et al*. Variability in Pediatric Utilization of Trauma Facilities in California: 1999 to 2005. *Ann Emerg Med* 2008;52:607–15.

Medical students depressed

The *Journal of the American Medical Association* published a systematic review revealing a 27.2% prevalence of depressive symptoms and 11.1% of suicidal ideation among medical students.