Low-value injury admissions in an integrated Canadian trauma system: a multicenter cohort study

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Abstract

Background: Injury represents 260,000 hospitalisations and $27 billion in healthcare costs each year in Canada. Evidence suggests that there is significant variation in the prevalence of hospital admissions among ED presentations between countries and providers but we lack data specific to injury admissions. We aimed to estimate the prevalence of potentially low-value injury admissions following injury in a Canadian provincial trauma system, identify diagnostic groups contributing most to low-value admissions and assess inter-hospital variation. Methods: We conducted a retrospective multicenter cohort study based on all injury admissions in the Québec trauma system (2013-2018). Using literature and expert consultation, we developed criteria to identify potentially low-value injury admissions. We used a multilevel logistic regression model to evaluate inter-hospital variation in the prevalence of low-value injury admissions with intraclass correlation coefficients (ICC). We stratified our analyses by age (1-15; 16-64; 65-74; 75+ years). Results: The prevalence of low-value injury admissions was 16% (n=19,163) among all patients, 26% (2136) in children, 11% (4695) in young adults and 19% (12,345) in older adults. Diagnostic groups contributing most to low-value admissions were mild traumatic brain injury in children (48% of low-value pediatric injury admissions; n=922), superficial injuries (14%, n=660) or minor spinal injuries (14%, n=634) in adults aged 16-64, and superficial injuries in adults aged 65+ (22%, n=2771). We observed strong inter-hospital variation in the prevalence of low-value injury admissions (ICC=37%). Conclusion: One out of six hospital admissions following injury may be of low-value. Children with mild traumatic brain injury and adults with superficial injuries could be good targets for future research efforts seeking to reduce health care services overuse. Inter-hospital variation indicates there may be an opportunity to reduce low-value injury admissions with appropriate interventions targeting modifications in care processes.

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Results: The prevalence of low-value injury admissions was 16% (n=19,163) among all patients, 26% (2136) in children, 11% (4695) in young adults and 19% (12,345) in older adults. Diagnostic groups contributing most to low-value admissions were mild traumatic brain injury in children (48% of low-value pediatric injury admissions; n=922), superficial injuries (14%, n=660) or minor spinal injuries (14%, n=634) in adults aged 16-64, and superficial injuries in adults aged 65+ (22%, n=2771). We observed strong inter-hospital variation in the prevalence of low-value injury admissions (ICC=37%).

Conclusion: One out of six hospital admissions following injury may be of low-value. Children with mild traumatic brain injury and adults with superficial injuries could be good targets for future research efforts seeking to reduce health care services overuse. Inter-hospital variation indicates there may be an opportunity to reduce low-value injury admissions with appropriate interventions targeting modifications in care processes.

What is known

Low-value care leads to inefficient use of resources and less favorable patient outcomes.

The literature suggests that unnecessary hospitalisations may be prevalent but we lack data on this problem for injury admissions.

What this study adds

We found high variability in the prevalence of potentially low-value injury admissions between hospitals in a trauma system, suggesting the presence of low-value care.

Results suggest that children with mild traumatic brain injury and adults with superficial injuries or minor spine injuries may constitute targets for future research aiming to assess benefits & harms and identify solutions to reduce unnecessary injury admissions.

Introduction

Injury represents 3.5 million visits to emergency rooms and 260,000 hospitalisations per year in Canada[1]. Furthermore, injury care costs Canadians $27 billion per year, more than heart and stroke disease combined[1]. Evidence suggests that low-value care, defined as *the provision of medical services for which the potential for harm exceeds the potential for benefit* , consumes around 30% of healthcare resources[2, 3]. Research has shown that there is considerable variation in the prevalence of hospital admissions among ED presentations between countries and providers[4-6], suggesting the presence of low-value hospital admissions[2]. These admissions contribute to hospital overcrowding, increased costs, medical errors, mortality, morbidity and functional decline[7-9]. A recent scoping review and expert consultation survey identified hospital admission in specific injury populations as a potentially low-value practice[10]. However, we lack knowledge on the frequency of low-value injury admissions and on inter-provider variations.

The objectives of this study were to estimate the prevalence of potentially low-value injury admissions following injury, identify diagnostic groups that most contributed to low-value admissions, and assess inter-hospital variation.

Methods

Study Design & Population

Our multicenter, retrospective cohort study was based on the 59 designated trauma centers of the Québec trauma care continuum, an integrated trauma system covering a population of 8.5 million in a geographic area of approximately 1.7 million km^2 that provides care for approximately 20,000 injured patients each year[11]. The system comprises 3 level I adults trauma centers and 2 pediatric trauma centers providing highly specialized care in metropolitan areas (Montréal and Québec city), 5 level II centers offering similar services in smaller urban areas (i.e. lower volume), 22 level III and 27 level IV centers generally in rural areas that stabilize major trauma cases then transfer them to high level care. We included all patients admitted with a primary diagnosis of injury from April 1, 2013 to March 31, 2018 to any trauma center in the system. Patients were followed from hospital admission to discharge.

Study Data

We extracted data from the Québec trauma registry, based on mandatory data collection for all hospital admissions for which injury was the primary motivation in all provincial trauma centers. Data is collected prospectively from patient charts in each center by trained medical coders. The registry is centralized and managed by the Québec Ministry of Health and Social Services. Data quality mechanisms include standardized training for medical coders, periodic validation of the data to correct incoherence and continuous facilitated information exchange between data coders, trauma coordinators and clinical experts[12]. Random re-abstraction of patient chart data suggests the trauma registry has 98% accuracy on patient demographics, vital status, injury codes, interventions and discharge destinations (data not published).

Selection of Criteria to Identify Low-Value Injury Admissions

We used recommendations for the design and content validation of health instruments to develop a tool to identify potentially low-value injury admissions from the Québec trauma registry[13]. First, a trauma registry specialist, a trauma researcher and a trauma clinical expert used published literature[14-22] and their knowledge on trauma systems to select and define criteria consistent with patients not requiring hospitalisation (Supplemental Digital Content 1). For example, minor injury defined as a maximum Abbreviated Injury Scale (AIS) score [?] 2 and the absence of interventions requiring hospitalisation, such as a surgery. Second, 8 experts (2 emergency physicians, 2 critical care physicians, a trauma surgeon, a general practitioner, a trauma care coordinator, and a trauma system manager) were individually consulted to validate the relevance and the definition of each criteria and were asked if any other criteria should be added. Based on these consultations, the list of interventions that did not require hospitalization was modified. Third, criteria were applied to trauma registry data and an age-stratified random sample of patient records were extracted and revised by the same experts to refine criteria. This last step was repeated three times until no further modifications were suggested. Criteria which were suggested but not retained in the final version were considered in sensitivity analyses (see section below). The final tool included 6 criteria (supplemental digital content 1).

Statistical Analysis

To identify diagnostic groups most contributing to low-value injury admissions, our steering committee grouped ICD primary diagnosis codes (supplemental digital content 2) and we stratified them by age group (1-15, 16-64, 65-74, 75+). We then described the following aspects of resource use among low-value admissions: i) therapeutic interventions in the ED and following admission (grouped as medication, reduction/immobilization, skin repair, other; supplemental digital content 1), ii) diagnostic imaging in the ED and following admission (none, X-ray, computed tomography by body region, magnetic resonance imaging, angiography/arteriography), iii) length of hospital stay (days from admission to discharge).

To evaluate inter-hospital variation in the prevalence of low-value injury admissions, we used a multilevel logistic regression model to generate intraclass correlation coefficients (ICC). Inter-hospital variation was considered to be weak, moderate and strong for ICC under 5%, between 5% and 20%, and over 20%, respectively[23]. We adjusted for patient case mix using age (1-4, 5-12, 13-15, 16-54, 55-64, 65-74, 75-84, 85+), sex, anatomic injury severity (New Injury Severity Score; 1-3, 4, 5-6, 8-11, [?]12)[24], the Glasgow Coma Scale (GCS) score on arrival in the ED ([?]13, 14, 15), injury mechanism (motor vehicle collision, fall from height, fall from own height, knife/firearm, other), number of injuries (1, 2, 3+), primary injury diagnosis and number of comorbidities (0, 1, 2, 3+). Analyses were conducted for the whole sample and according to age (1-15, 16-64, 65-74, 75+). We handled missing data on the GCS, often not evaluated in patients with minor, extracranial injury, using multiple imputation according to recent recommendations[25].

Sensitivity analyses

We conducted sensitivity analyses for criteria that were mentioned by members of the steering committee during the development of criteria to identify low-value injury admissions but did not gain consensus. Thus, we successively removing patients in whom hospital admission may have been justified from the numerator: i) patients with a GCS of 13 or 14 on arrival, ii) patients who developed complications during their stay, iii) patients discharged home with services or to long-term care/nursing home, and iv) patients transferred-in from another hospital. For each sensitivity analysis, we compared the prevalence of low-value admissions and inter-hospital variation (ICC) to values from the main analysis.

All analyses were performed using Statistical Analysis Software (SAS Institute, Cary, NC, version 9.4). The study was approved by the research ethics committee of the CHU de Quebec – Universite Laval.

Results

Our study sample included 118,032 injury admissions, of which 19,163 (16%) were considered to be potentially low-value (Figure 1, Supplemental Digital Content 1). This proportion was 26%, 11%, 14% and 20% in children, young adults, adults 65 to 74 years of age and adults over 74 years of age, respectively. Overall, 64% of patients were aged 65 years or older, 39% were male, 75% were injured in a fall and 53% had isolated injuries (Supplemental Digital Content 3). Children had less severe injuries (59% with maximum AIS=1 compared to 40% in adults), more head injuries (60% compared to 20% in adults) and were more often transferred-in from another hospital (16% compared to 6% in adults).

The diagnostic groups contributing most to low-value injury admissions were mild traumatic brain injury in children (n=922; 48% of low-value pediatric injury admissions; Figure 2), superficial injuries (660; 14%) or minor spine injuries (634; 14%) in adults aged 16-64, and superficial injuries in adults aged 65+ (2771; 22%).

Out of the 19,163 patients with a potentially low-value injury admission, 5582 (29%) had a therapeutic intervention considered not to require hospital admission (Supplemental Digital Content 1; Figure 3) in the emergency department and 3471 (18%) patients had such an intervention after admission. Administration of medication was the most common intervention in every patient group, except patients with an extremity fracture, in whom reductions and immobilizations were more frequent. In addition, physiotherapy and social services consultations were used in 51% and 29% of patients, respectively. These numbers went up to 70% and 41% in patients aged 75 +.

Overall, 18,265 (95%) patients had at least one diagnostic imaging procedure (Table 2), of which over 90% were conducted in the ED. X-ray was used in over 90% of patients in every age group except children. Head CT was the predominant advanced imaging modality in every age group (38% of patients). Median length of stay varied from 1 day in children to 13 days in adults aged 75+ and varied across diagnostic groups (Table 1). Our population of potentially low-value injury admissions in the Quebec trauma system accrued on average 36,642 hospital days per year. Among the 19,163 potentially low-value injury admissions, there

were over 2,500 complications including 520 cases of delirium, 598 urinary tract infections, 50 stage II-IV decubitus ulcers and 98 hospital-acquired pneumonias.

We observed strong inter-hospital variations in the prevalence of potentially low-value injury admissions, with an ICC of 37% (Figure 4). When we stratified by age, inter-hospital variations remained strong for patients aged 74 + and were moderate for every other age group (Supplemental Digital Content 4). Even within designation levels, variation remained high with prevalences varying between 10% and 23% for level I and II trauma centers. However, highly specialized (level I/II) centers had lower average prevalences than smaller referral (level III/IV) centers.

Sensitivity analyses

When patients with a GCS of 13 or 14 or patients who developed an in-hospital complication were removed, prevalence and ICCs all changed by less than 10% (Supplemental Digital Content 5). The removal of patients transferred-in had an impact on prevalence in children (22% compared to 26%) as did the removal of patients who were discharged home with services or to long-term care or a nursing home (6% compared to 16%). However, all ICC remained over the threshold for strong inter-hospital variation.

Discussion

In this multicenter retrospective cohort study, 16% of all injury admissions in a Canadian trauma system were potentially low-value. Predominant diagnostic groups included mild traumatic brain injury in children, superficial injuries or minor spine injuries in adults aged 16-64, and superficial injuries in adults aged 75+. Prevalences varied from 0% to 34% between hospitals.

The important contribution of children with mild traumatic brain injury to potentially low-value injury admissions is consistent with other studies on children admitted for observation with minor head injury despite extremely low rates of missed injuries[16-18, 26-31]. Contributory factors documented in the literature include the lack of ability of children to communicate symptoms, perceived seriousness of the consequences of missed injuries, physician discomfort with prognostication in non-pediatric centers, pressure from parents, concerns about non-accidental injury, and observation to avoid exposure to ionizing radiation from CT[32-36]. However, 368 (40%) of children admitted for mild traumatic brain injury had a CT in the ED. Children represented only 2% (737 days) of hospital days per year accrued for potentially low-value injury admissions in our study population.

Adults aged 16-64 had the lowest prevalence of low-value admissions. They also had the most varied primary diagnoses, with none representing more than 14% of admissions. They had the highest frequency of motor vehicle collisions, which is widely used as a triage criteria because of its potential for serious injuries, but often leads to overtriage[37]. Intoxication could also explain potentially low-value admissions in these patients, since substance abuse is most prevalent in this group and intoxicated patients pose a challenge in terms of diagnostic evaluation, notably for traumatic brain injuries and spinal injuries[38, 39]. This group represented 11.4% (4,181 days) of hospital days per year accrued for potentially low-value injury admissions in our study population.

Patients aged 65 years and over comprised 64% of the low-value admissions in our sample. Factors contributing to admission in this population may be frailty, low mobility, lack of social support, cognitive conditions or comorbidities[40-42]. They may be admitted while social service evaluations are conducted and/or alternative care is secured. Research has shown that these patients are particularly complex to care for since many have important comorbidities, difficulties with mobility or communication, or develop delirium, all of which contribute to longer lengths of stay[43]. They are also more susceptible to hospital-related adverse events such as functional decline or nosocomial infections, which often lead to additional hospital days[44, 45]. Delayed discharge due to problems accessing post-acute care is also a problem in older adults[46, 47]. This age group represented 86.6% (31,724 days) of hospital days per year accrued for potentially low-value injury admissions in our study population.

We observed strong inter-hospital variation in the prevalence of potentially low-value injury admissions, but more specialized trauma centers, in general, had a lower prevalence than level III and IV centers. A potential explanation is that physicians working in centers with a higher volume of injury presentations have a better understanding of whether or not patients require hospital admission. This may also be due to bed availability, which could be less of an issue in rural hospitals due to low patient volume[48].

Most patients did not receive any therapeutic intervention while others received interventions that can be administered in the ED (e.g. closed reductions, immobilisations or administrations of analgesics or antithrombotics). However, the majority of patients received a radiographic evaluation and/or a CT scan, over 90% of which were done before admission. This is consistent with estimates of overuse of imaging, notably for minor head injury[34, 49].

Strengths and limitations

We had access to high-quality, current clinical data which, contrary to hospital discharge data, has detailed information on physiological parameters and anatomical injury severity. Furthermore, unlike many trauma registries that condition inclusion on injury severity, the Quebec trauma registry includes all hospital admissions for injury in any designated trauma center. However, our study did not include patients admitted to non-designated hospitals, which are estimated to represent 25% of all injury admissions. Thus, we may have underestimated the prevalence of low-value injury admissions because non-designated hospitals could be less comfortable with discharging patients from the ED, even for minor injuries. Due to the lack of a validated definition for low-value injury admissions, we used broad filters based on literature and expert consultations and conducted extensive sensitivity analyses. Therefore, despite efforts to develop a clinically meaningful definition (including revision of a random stratified sample of patients included and excluded after each iteration of the algorithm), cases can only be interpreted as *potentially*low-value. We did not exclude patients based on comorbidities as we had no information on their severity and most patients over 65 had at least one comorbidity, which may be well controlled and unrelated to admission. Considering the retrospective nature of our data, our study is subject to potential measurement error and missing data (50% for the GCS). There may be measurement error among variables used to adjust inter-hospital comparisons (e.g. under-reporting of comorbidities). We may also have omitted potential confounders such as patient mobility, pain, socio-economic status and social support, because they were not available in the registry. This could lead to an overestimation of inter-hospital variation. In addition, the registry does not contain information on patients who were returned home from the ED so we could not compare patients admitted to those who were not. Finally, there is also a possibility that hospitals with a low prevalence of low-value injury admissions are undertriaging patients in which hospital admission was required. However, we consider this unlikely as highly specialized, high-volume centers in which undertriage is less likely, tended to have a lower prevalence than lower-level centers in our sample.

Impact and future research

This study sets the foundation for further research targeting improved value in injury care. This research should aim to determine whether low-value injury admissions could be reduced by interventions optimizing care in the ED or in the community and should consider healthcare professionals, patient and family perspectives. First, we will need to assess whether low-value admissions are potentially avoidable using case revision methodology. We would then need to identify modifiable contributing factors, for example discomfort with clinical examination and management of children with traumatic brain injury in non-pediatric centers and difficulty obtaining physiotherapy evaluation and social services consultations in the ED to determine if older adults can be safely discharged with available community services. Thereafter, interventions such as Audit & Feedback with a positive deviance approach and consensus recommendations could be used to modify care processes (e.g. inter-hospital transfer, virtual consultations, screening tools, community services). Older adults are of particular interest. On one hand, their complexity and frailty makes it harder to adequately modify practices to reduce care. On the other hand, they are a group in which such modifications could

yield considerable gains both in terms of resources saved and improved outcomes since they have a high risk of functional decline and other hospital-related adverse events[44, 45].

Conclusion

In the inclusive trauma system of the province of Quebec, we estimated that one out of six hospital admissions following injury may be low-value. This represented on average 36,642 hospital days per year in the 59 designated trauma centers in the province of Quebec alone. These resources may be better invested in ambulatory care. Children with mild traumatic brain injury, young adults with superficial injuries or minor spine injuries, and older adults with superficial injuries may be good targets for future research efforts seeking to reduce overuse. Strong variations between providers suggests that appropriate interventions have the potential to reduce low-value injury admissions following injury in Canada and thus improve patient outcomes and free up resources. We expect our results to be generalizable to other Canadian provinces. Future research should aim to identify modifiable determinants of low-value injury admissions and to develop potential solutions, which consider healthcare professional, patient and family perspectives.

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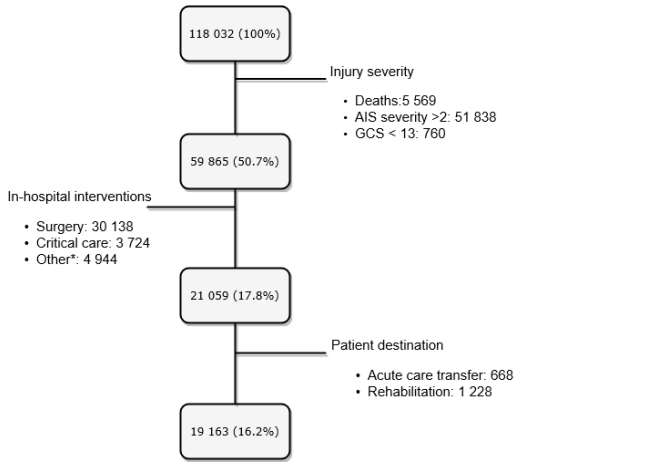
Figure 1. Identification of low-value injury admissions



*Other interventions exclude those considered not to require hospital admission (Supplemental digital content 1)

Figure 2. Absolute (curves) and relative (bars) frequency of low-value injury admissions by primary diagnoses and age group

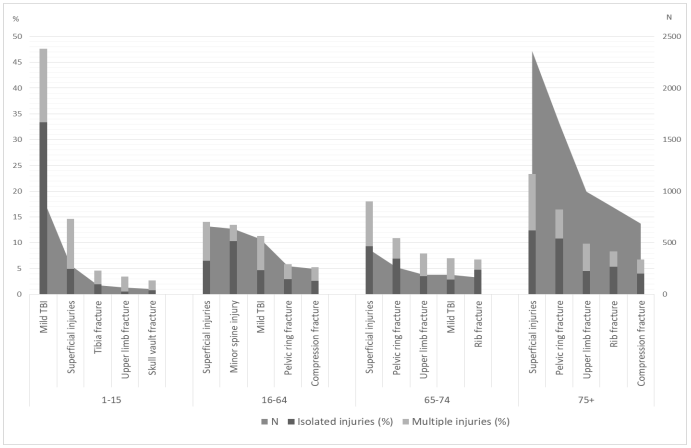


Figure 3. Therapeutic interventions by age group and diagnosis among low-value injury admissions (n)

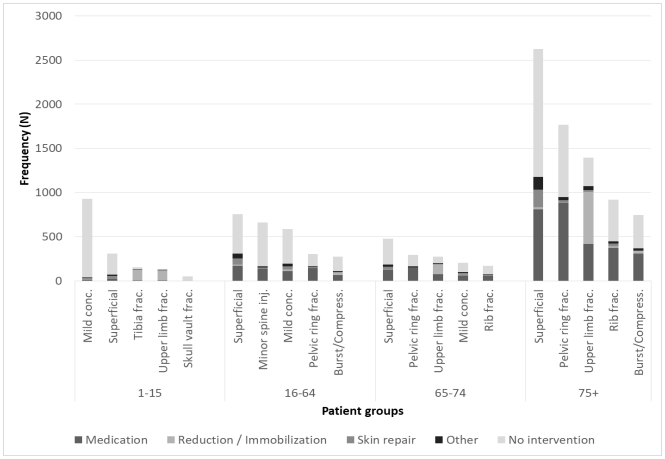


Figure 4. Adjusted prevalence of potentially low-value injury admissions by hospital and trauma center designation level