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## Access to a Canadian provincial integrated trauma system: A population-based cohort study



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### ABSTRACT

**Background:** Access to specialised trauma care is an important measure of trauma system efficiency. However, few data are available on access to integrated trauma systems. We aimed to describe access to trauma centres (TCs) in an integrated Canadian trauma system and identify its determinants.

**Methods:** We conducted a population-based cohort study including all injured adults admitted to acute care hospitals in the province of Québec between 2006 and 2011. Proportions of injured patients transported directly or transferred to TCs were assessed. Determinants of access were identified through a modified Poisson regression model and a relative importance analysis was used to determine the contribution of each independent variable to predicting access.

**Results:** Of the 135,653 injury admissions selected, 75% were treated within the trauma system. Among 25,522 patients with major injuries [International Classification of diseases Injury Severity Score (ICISS < 0.85)], 90% had access to TCs. Access was higher for patients aged under 65, men and among patients living in more remote areas ( $p$ -value < 0.001). The region of residence followed by injury mechanism, number of trauma diagnoses, injury severity and age were the most important determinants of access to trauma care.

**Conclusions:** In an integrated, mature trauma system, we observed high access to TCs. However, problems in access were observed for the elderly, women and in urban areas where there are many non-designated hospitals. Access to trauma care should be monitored as part of quality of care improvement activities and pre-hospital guidelines for trauma patients should be applied uniformly throughout the province.

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### Introduction

Injuries represent one of the most important public health problems in the world [1]. In Canada, injuries are the leading cause of death during the first four decades of life [2]. Half of the deaths due to injuries occur at the site of the incident and it is estimated that the remaining 50% could be avoided if they had access to

appropriate medical care [3]. Major injuries should be treated in a designated trauma centre (TC), certified by competent health authorities [3]. These TCs are acute care facilities which have a trauma team immediately available to assess patients and dispose of all the resources needed to provide appropriate and definitive care to these patients [2]. An integrated trauma system consists of a network of TCs that cover the whole health service territory and include service corridors with pre-hospital transport and inter-hospital transfer agreements [4].

The benefits of access to specialised trauma care on mortality and functional outcome following injury have been fairly well demonstrated [5,6]. Several studies have evaluated access to level I or II TCs in health care systems with no formal trauma system or an

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exclusive system [7–10]. However, data on access to TCs in an integrated, mature trauma system are lacking.

The aim of this study was to determine the proportion of access to TCs and identify its determinants in an integrated and mature trauma system, globally and among major trauma.

## Methods

### Setting and study design

The study was based on the integrated trauma system of the province of Québec. Québec has about 8 million inhabitants, making it the second most populous province in Canada [11]. The province has 110 acute care centres including 59 TCs [12]. The Québec trauma system was instated in 1992 and involves regionalised care from urban level I TCs to rural community hospitals including: 6 level I, 4 level II, 21 level III and 28 level IV TCs [13]. Designation levels are based on American College of Surgeons criteria [14]. Standardised pre-hospital protocols ensure that major trauma cases are taken to TCs and standing agreements regulate interhospital transfers within the system [15]. We conducted a population-based retrospective cohort study of all adult (aged  $\geq 16$ ) acute-care admissions between 1st April 2006 and March 31, 2011 with a primary diagnosis of injury.

### Study population and data sources

Data were extracted from a medico-administrative hospital discharge database (MED-ECHO) which includes information on all provincial hospital admissions [16]. Patients with multiple admissions for the same traumatic event due to transfer or readmission were included according to their index admission, defined as the admission to the TC with the highest designation level or for patients with no admission to TC, the admission with the longest length of stay.

We included all adult admissions with a primary diagnosis of injury (ICD-10-CA codes between S00 and T14 excluding foreign bodies, burns, frostbite and suicide). We excluded patients older than 64 admitted for an isolated hip fracture [ICD-10-CA codes S72.0, S72.1 and S72.2 with no serious secondary injuries] and non Québec residents who represented only 1.7% of all admissions.

### Variables and measurement

The principal outcome, access to the trauma system, was defined either as transportation to a TC from the scene of the accident (direct access) or transfer to a TC from a non-designated hospital (indirect access). A list of potential determinants of access to the trauma system was identified through the literature [5,9,17–19], and consultation with the project steering committee comprising physician consultants responsible for the provincial trauma accreditation process, emergency department physicians, critical care physicians and trauma surgeons. These included gender, age, injury severity, comorbidities, injury mechanism (motor vehicle collision, falls, penetrant and others which includes aggressions, accidental impact, unclassifiable, undetermined and missing. The latter constitutes only 1.2% of all admissions), the day of admission (weekend versus week day), number of trauma diagnoses, body region of the most severe injury, geographical remoteness, and year of admission. Injury severity was measured by the International Classification of Diseases Injury Severity Score (ICISS), which is the product of survival probabilities assigned to each injury [20,21]. Comorbidities were described using the classification suggested by Charlson [22].

### Statistical analysis

Percent access was calculated globally and for patients presenting with major trauma, defined as an ICISS score  $<0.85$  [7,23]. The categorisation of continuous variables was supported by literature and methodological considerations [13,15,24,25]. We used a Robust Poisson method to generate risk ratios (RR) of access to TCs and 95% Confidence Intervals (95% CI) for each potential determinant adjusted for all other potential determinants [26,27]. We then conducted a relative importance analysis [28] to determine the percentage of variance in access to TCs explained by each determinant.

### Sensitivity analyses

We evaluated access to level I and II TCs and its determinants for major trauma and critically injured patients (ICISS  $< 0.75$ , cut-off chosen by the study steering committee). For these analyses, patients treated in level III or IV TCs were excluded. To evaluate the robustness of all our results to the injury severity measure used, we repeated analyses using the Injury Severity Score (ISS) derived through an ICD-10-to-Abbreviated Injury Scale algorithm codes [29].

All Analyses were performed using SAS (version 9.3) software. The study was approved by the research ethics board of Laval University (CERUL).

## Results

The study population comprised 135,653 injury admissions. Over half of admissions were men, 40% were 65 years of age or older, almost one third had pre-existing conditions and almost one fifth were admitted for major trauma (Table 1). Globally, 75% of injury admissions were treated in a TC and access rose to 90% for patients with major trauma ( $n = 25,522$ ). Access increased with increasing injury severity but decreased with age and was lower for patients with comorbidities (Table 1). Access was higher for men, injuries due to motor vehicle collisions, and for patients with head and neck, spine and upper back injuries. Access varied by area of residence both in the whole population and in patients with major trauma. Urban regions (Montréal, Québec city, Laval) and Nunavik (which is the most remote region of the province territory with no trauma centre), had the lowest access to TCs (Fig. 1).

In multivariate analyses for major trauma patients, all potential determinants were statistically significant predictors ( $p < 0.001$ ) of access to trauma care except day of admission, and selected comorbidities (myocardial infarction, cerebrovascular disease, peptic ulcer disease, moderate or severe liver disease, and metastatic carcinoma). Access to TCs for patients residing in towns with 10,000 to 100,000 inhabitants and small towns ( $<10,000$ ) was, respectively 5 and 3 times higher than for patients residing in metropolitan regions. Those aged 85 years or older had almost 40% lower access to trauma care than patients aged  $<55$  years, and men had a 30% increase in access compared to women. Paraplegia/hemiplegia, mild liver disease, cancer and diabetes with complications were the comorbidities related to the most important decrease in access (Table 2).

The most important determinants of access to TCs for major trauma patients were the region of residence followed by injury mechanism, injury severity, number of trauma diagnoses and age (Fig. 2).

### Sensitivity analyses

Access to level I and II TCs was 62% and 70%, respectively for major and critically injured patients. We identified similar

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