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Evaluating potential spatial access to trauma center care by severely injured patients

Fiona L. Lawson [a], Nadine Schuurman [a,*], Lisa Oliver [b], Avery B. Nathens [c]

[a] Department of Geography, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia, Canada V5A 1S6
[b] Health Analysis Division, Statistics Canada, 100 Tunney's Pasture Driveway Ottawa, Ontario, Canada K1A 0T6
[c] Keenan Research Centre, Li Ka Shing Knowledge Institute, St. Michael's Hospital, 30 Bond Street, Toronto, Ontario, Canada M5B 1W8

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ABSTRACT

Injuries are a major public health problem around the world. Previous research has suggested that providing prompt access to specialized trauma center care may greatly improve the health outcomes of trauma patients. In this paper, a geographic information system (GIS) method is used to examine potential spatial access to trauma centers by individuals who were either hospitalized or died as a result of a major trauma. Overall, it was determined that 68.5% of individuals who suffered from a major trauma lived within one hour travel time of a Level I or II trauma center. In addition, major traumas resulting in death were found to have poorer potential spatial access to trauma center care than those that were admitted to hospital.

1. Introduction

Injury is a significant source of premature mortality, hospitalizations, and health care expenditure around the world. Globally, 5.8 million people die every year as a result of an injury and millions more are hospitalized (World Health Organization, 2010). Although the overall death rate from injury has declined in Canada over the past decade, it remains alarmingly high at 42.06 per 100,000 and each year the total direct and indirect costs of injuries amount to an estimated $19.8 billion (SMARTRISK, 2009). Although injury prevention strategies play an important role in reducing the rate of injuries, the care patients receive after an injury has occurred can dramatically affect their chances of survival (Liberman et al., 2005; MacKenzie et al., 2006). Unfortunately, poor spatial access to trauma center care may be leading to potentially preventable injury-related mortality and morbidity in Canada.

While previous research has focused on measuring spatial access to trauma center care by the general population (Branas et al., 2005; Hameed et al., 2010), the work presented in this paper is unique in that it evaluates spatial access to trauma center care by individuals who have sustained a major trauma. In other words, this approach acknowledges that the spatial distribution of injury may not parallel the spatial distribution of the general population, which is a reasonable assumption given that not all population groups have the same risk of severe injury (Charyk-Stewart et al., 2010; Cubbin and Smith, 2002; Laupland et al., 2005; Pickett et al., 1997).

In this paper we begin by outlining the rationale for trauma center care and then provide a brief description of trauma services in Canada. Next, we use hospitalization and mortality data to identify major traumas and then use geographic information systems (GIS) to measure their potential spatial accessibility to trauma center care. More specifically, we determine what proportion of the population that sustained a major trauma between 2001 and 2006 lived within one hour drive time of either a Level I or II trauma center. After presenting the results, which conflict with previous research, we conclude by discussing the implications of our findings.

2. Rationale for trauma center care

Although one half of all injury-related deaths occur at the site of the injury, the remaining 50% of deaths are potentially preventable through prompt access to appropriate medical care (Meislin et al., 1997; Rogers et al., 2005). Ideally, care of the severely injured should be provided in a designated trauma center that has undergone accreditation or verification by an external agency (Committee on Trauma, 2006; Trauma Association of Canada, 2011). Designated trauma centers are acute care hospitals that have a trauma team

* Corresponding author. Tel.: +778 782 3320; fax: +778 782 5841.
E-mail addresses: flawson@sfu.ca (F.L. Lawson), nadine@sfu.ca (N. Schuurman), lisa.oliver@statcan.gc.ca (L. Oliver), nathensa@smh.ca (A.B. Nathens).

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immediately available to assess patients, and all the resources required to provide definitive care to severely injured patients (Committee on Trauma, 2006; Trauma Association of Canada, 2011). Access to a trauma center is critically important for the severely injured patient, as care in this environment is associated with a 25% lower risk of death compared to care in non-designated centers (Liberman et al., 2005; MacKenzie et al., 2006).

3. Trauma center care in Canada

Because the provision of health care services is a provincial responsibility in Canada, trauma services have been implemented differently across provinces. These differences are the result of many factors, including varying operational budgets and structural organizations in each provincial health care system. For example, some provinces have multiple regional health authorities (e.g., British Columbia), whereas others are more centralized (e.g., Alberta). Canada's provinces also differ dramatically in terms of their physical landscape and overall size—making the delivery of trauma care much more challenging in some provinces than in others. The spatial distribution of the population within each province also has considerable impact on the provision of trauma services.

Overall, however, trauma system development in Canada is in its early stages. Although a few provinces have relatively mature trauma systems that optimize access to trauma center care, many provincial trauma systems are still missing essential components. For example, the majority of provinces and territories (all except British Columbia, Alberta, Ontario, and Nova Scotia) have yet to implement pre-hospital air transportation programs (Hameed et al., 2010). For a more detailed description of Canada's provincial and territorial trauma systems please refer to Hameed et al. (2010).

4. Data

4.1. Trauma centers

Since the majority of trauma centers in Canada have yet to be accredited or verified by an external agency, a national survey of trauma center personnel was used to identify all Level I and II trauma centers across Canada, regardless of their designation status. The survey used the Trauma Association of Canada (2011)Trauma System Accreditation Guidelines to categorize hospitals based on the resources they provide as well as other characteristics such as patient volume and training (Hameed et al., 2010). Because the purpose of this study was to measure access to expert care within resource-rich facilities by patients with life threatening injuries, only Level I and II trauma centers with full time neurosurgical capability were included. The neurosurgical requirement was used because Traumatic Brain Injury (TBI) is the most common cause of traumatic mortality and because TBI patients who are transferred directly to a trauma center capable of providing neurosurgical care have a much higher survival rate than those who are sent to centers without neurosurgical capacity (Hameed et al., 2010; Härtl et al., 2006). Once these hospitals were identified, their street addresses were geocoded using road network data from Desktop Mapping Technologies Inc. (DMTI) Spatial Canada v.2009.3.

4.2. Major traumas

Both Vital Statistics and Hospital Morbidity Database data were used to identify all major traumas that occurred between April 1, 2001 and March 31, 2006. A major trauma was defined as an injury that results in death prior to hospital admission or one that is assessed at a hospital and given an Injury Severity Score (ISS) greater than 15. ISS, the most frequently used method for quantifying injury severity, is derived from the Abbreviated Injury Scale, which provides an injury severity score ranging from one to six for each injury across all body regions (Association for the Advancement of Automative Medicine, 1998; Baker et al., 1974). Patients less than 16 years of age were excluded because severely injured children are often treated at pediatric trauma centers, which were not the focus of this study (Carr and Nance, 2010). Since cases were mapped using their full six digit postal codes and the province of Quebec only reports the forward sortation areas (i.e., the first three digits of the postal code) of patients who are hospitalized, Quebec was excluded from this study. All of the preliminary data preparation and extraction was conducted using SAS v.9.1 (SAS Institute, 2004).

4.2.1. Major traumas resulting in death prior to hospitalization

Major traumas that resulted in death outside of hospital were identified through Canada's Vital Statistics Death Database using the cause of death field.

4.2.2. Major traumas resulting in hospitalization

Major traumas that resulted in a hospitalization were identified through the Hospital Morbidity Database (HMBD), a national administrative discharge database containing demographic, administrative and clinical data on all inpatient hospitalizations in Canada. Health Person-Oriented Information (HPOI) was derived from the HMBD at Statistics Canada in order to link these records at the person level. HPOI includes information on the patient's age, sex, medical diagnoses, admission/discharge dates, and postal code of home residence. A recently developed and validated algorithm developed by Haas et al. (2012) was then used to derive ISS from the cases with injury-related (i.e., S00 to T79.0) International Classification of Diseases, 10th Revision (ICD-10) diagnoses codes. Injuries related to foreign bodies (T15–T19), burns and corrosion injury (T20–T32), poisoning (T36–T65), and environmental exposure (T33–T35, T66–T78), as well as those injuries resulting from medical complications and the late effects of injury (T80–T98) were excluded from our analysis.

Since Canada's provinces and territories transitioned from the ICD-9 to the ICD-10 at different times, this study was only able to use a full five years (2001/2002–2005/2006) of data for British Columbia, Newfoundland, Prince Edward Island, Nova Scotia, and the Yukon. As for the remaining provinces and territories, four years of data (2002/2003–2005/2006) was used for Alberta, Ontario, Saskatchewan, and the North West Territories, three years (2003/2004–2005/2006) for New Brunswick and Nunavut, and two years (2004/2005–2005/2006) for Manitoba. For consistency, these same date ranges were used when extracting injuries from the Vital Statistics database. To eliminate the double counting of patients who were transferred from one hospital to another for the same major trauma event, an individual discharged and admitted on the same day was considered a transfer, and only the initial hospitalization record was retained for our analysis (Oliver and Kohen, 2009).

5. Methods

5.1. Mapping major traumas

Individuals who sustained a major trauma were mapped according to their six-digit postal code of home residence using the geographic coordinates provided in Statistics Canada (2007)