Access to Trauma Systems in Canada

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Background: Trauma is a leading cause of morbidity, potential years of life lost and health care expenditure in Canada and around the world. Trauma systems have been established across North America to provide comprehensive injury care and to lead injury control efforts. We sought to describe the current status of trauma systems in Canada and Canadians' access to acute, multidisciplinary trauma care.

Methods: A national survey was used to identify the locations and capabilities of adult trauma centers across Canada and to identify the catchment populations they serve. Geographic information science methods were used to map the locations of Level I and Level II trauma centers and to define 1-hour road travel times around each trauma center. Data from the 2006 Canadian Census were used to estimate populations within and outside 1-hour access to definitive trauma care.

Results: In Canada, 32 Level I and Level II trauma centers provide definitive trauma care and coordinate the efforts of their surrounding trauma systems. Most Canadians (77.5%) reside within 1-hour road travel catchments of Level I or Level II centers. However, marked geographic disparities in access persist. Of the 22.5% of Canadians who live more than an hour away from a Level I or Level II trauma centers, all are in rural and remote regions.

Discussion: Access to high quality acute trauma care is well established across parts of Canada but a clear urban/rural divide persists. Regional efforts to improve short- and long-term outcomes after severe trauma should focus on the optimization of access to pre-hospital care and acute trauma care in rural communities using locally relevant strategies or novel care delivery options.

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There are few problems in public health that are more pressing than trauma. Each year, >100 million people are injured world wide, and >5 million people die as a result of injury.¹ Globally, trauma is the leading cause of death in the first 4 decades of life and accounts for the loss of more potential years of life than any other illness.^{2,3} Close to 200,000 Canadians are hospitalized due to acute injury each year, and Canadians spend \$19.8 billion annually in direct and indirect costs as a result of injury.⁴ Although the social costs and long-term consequences of injury are not yet completely understood, it is clear that injury places an enormous burden on individuals, families and society.

In 1966, while considering the impact of injury on society, the US National Academy of Sciences and the National Research council observed that "public apathy to the mounting toll from accidents must be transformed into an action program under strong leadership."⁵ Their recommendations for a national strategy for injury control, which included mobilization of public awareness, and wide and formal collaboration on injury prevention, emergency medical care and trauma research, transformed fatalistic attitudes about trauma into the perception of trauma as a public health problem with achievable solutions, and ushered trauma care into the modern era.⁶

As a result of the National Academy of Sciences recommendations and through the efforts of organizations such as the American College of Surgeons Committee on Trauma and the Trauma Association of Canada (TAC), the past 4 decades have seen great advances in injury control in North America. Mortality from unintentional injury in the

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United States has fallen from 55 per 100,000 population in 1965 to 37.7 per 100,000 in 2004,⁷ as innovative injury prevention strategies (including education, engineering, and legislative interventions) have been broadly implemented and access to sophisticated trauma care within an hour of injury has been extended to 84.1% of all Americans.⁸ Much of the work of injury control in the United States has centered on the development of trauma systems, which can be thought of as comprehensive, geographically based public health responses to injury, including prevention, timely and coordinated acute care, and rehabilitation.⁹ Trauma systems have set the standard for acute care delivery and have been described as "an astounding achievement of modern health care."¹⁰

In Canada, systems for the care of trauma patients have been developing rapidly as well. However, despite their pivotal role in injury control, the structure, capability, and performance of trauma systems across the country have not been completely characterized, and access to trauma services has not been systematically quantified to date. This study describes the current state of trauma systems in Canada and measures Canadians' access to acute trauma care.

METHODS

National Survey

A survey of the structure and function of trauma systems, including the capabilities of their component trauma centers, was designed by the Research Committee of the TAC and distributed to provincial trauma care leaders across the country. This mixed mode survey consisted of a written questionnaire followed-up with a standardized, taped, 1-hour telephone interviews. A second round of interviews was conducted to focus on specific questions and additional clarifications were made during group teleconferences and by email. Study participants were identified by TAC using a snowball sampling technique¹¹ and included trauma surgeons, emergency physicians, injury researchers, and trauma nurses from across the country with intimate knowledge of trauma system organization and with key roles as medical directors or managers in trauma systems. Pediatric trauma centers were not included in the study.

The survey adapted TAC guidelines on trauma center designation (Table 1, www.traumacanada.org) to classify all hospitals participating in adult trauma care. The primary analyses on access to definitive acute trauma care focused on adult Level I and Level II trauma referral centers with 24/7 neurosurgical capability. Specification of neurosurgical capability was supported by the fact that traumatic brain injury (TBI) is a leading cause of traumatic mortality, and by the finding that mortality from TBI is 50% higher in patients who are not directly transferred to trauma centers with neurosurgical availability. For each trauma center, characteristics of prehospital care (training, organization, and helicopter access), acute trauma care (availability of trauma team leaders, trauma teams, and designated trauma services), severe trauma volume, referral patterns, and research and administrative structure (availability and use of trauma registries) were determined.

TABLE 1. Trauma Center Designation

Central role in the provincial trauma system, and majority of tertiary/quaternary major trauma care in the system. Academic leadership, teaching, research program
Provides care for major trauma. Some trauma training and outreach programs. Similar to Level I without academic and research programs
Provides initial care for major trauma patients and transfers patients in need of complex care to Levels I and II trauma centers
Major urban hospital with a nearby major trauma centre (Levels I–III). Does large volume of secondary trauma care. Bypass and triage protocols are in place diverting major trauma patients to level I and II centers
Small rural community hospitals or treatment facilities with little to no immediate access to Level I, II, or III Trauma Centers. Most trauma patients are stabilized, if possible and rapidly transferred to higher level trauma care

Available at: http://www.traumacanada.org/accreditation_committee/Accreditation_ Guidelines_Jun_07.pdf.

Measurement of Trauma System Access

Once Level I and Level II centers (and their equivalents in instances where trauma center accreditation/verification or designation had not yet been completed) were identified, geographic information science (GIS) methods were used to assess access by road by the surrounding population.

To calculate road travel times from each residential postal code to Level I and Level II trauma hospitals, a network analysis was performed using GIS. This is an approach of routing where distance optimization decisions within the network are dependent on roads, barriers to travel (e.g., elevation and water), cost friction (e.g., stop lights and speed limits), and directionality (e.g., one-way streets) as well as road capacity.¹² Network analysis uses road network data characterized as a series of segments or links that are joined by nodes (intersections), where each link is assigned a travel cost (or impedance). Each hospital is linked to a road as is the geographical center of each postal code.

The 1-, 2-, and 4-hour travel time catchments were created using DMTI Spatial Inc.—CanMap Route Logistics v2008.3. Postal code centroids located within a 2,500-m radius of a road were attributed to specific road segments. Travel cost attributes were created using line segment distance, speed limit, and friction barriers to road travel. The cost to travel each way along a line segment was assigned a cost in minutes based on the segment's length and speed limit, but additional penalty cost in minutes was calculated separately for each direction based on the presence and type of travel impediments when traveling "to" or "from" the segment. There is no exact method for determining the cost of travel friction impediments. In this analysis, for instance, stop signs were assigned a 30-second penalty cost, whereas traffic lights 1 minute.

The resulting network dataset was then loaded into ESRI's ArcMap (the mapping and analysis portion of ArcGIS

9.1) along with the hospital locations and Census Block spatial layers. Each scenario was calculated using ESRI's Network Analyst extension 'create new service area' tool for 1 hour, 2 hours, and 4 hours, respectively. In each case, this produced a layer that included only the road network line segments that were within 1 hour, 2 hours, or 4 hours of a hospital. Each line segment in the resulting layer also included the facility ID of the segment's nearest hospital, which could then be used to aggregate individual road segments into organized catchments.

To link populations to the 1-hour, 2-hour, or 4-hour travel time catchments, a 2,500-m buffer was created around each road segment. Population values for each road travel catchment area were determined using Statistics Canada 2006 Census Dissemination Blocks, the basic unit of Canadian census geography.^{13–16}

The primary measurement of this study, population within 1-hour drive of definitive trauma care, was selected in keeping with the widely acknowledged Golden Hour concept: that survival improves with prompt care.¹⁷ Furthermore, outside 1-hour road travel boundaries, helicopter transport becomes time saving and is often the preferred method of prehospital transport for severely injured patients where available.¹⁸

RESULTS

Characteristics of Canadian Trauma Systems

A total of 32 trauma centers across Canada (16 Level I and 16 Level II) provide definitive trauma care (Table 2, Figs. 1–4). Of these, centers, all have provincial designation and funding to serve in the role of lead or referral trauma hospitals. Only 18 (56%) have been formally reviewed by an external agency such as TAC for purposes of accreditation or external review, and some regions of the country lack key components of trauma systems. The three busiest trauma centers in Canada are the Foothills Medical Centre in Calgary, the Sunnybrook Health Sciences Centre in Toronto, and the University of Alberta Hospital in Edmonton with 1,103, 988, and 798 admissions resulting from severe multisystem injuries (Injury Severity Score >12) in 2008.

Access to Trauma Systems in Canada

British Columbia has five lead trauma centers capable of providing definitive trauma care across five health regions (Fig. 3). These centers are supported in rural and remote corners of the province by local trauma hospitals. Prehospital transport is provided by a provincially integrated system of ground ambulances, helicopters, and fixed wing air transport. The trauma system in Alberta is composed of three trauma referral centers in Edmonton and Calgary and a series of Level III hospitals outside large metropolitan areas (Fig. 4). Prehospital care is provided, in part, by a highly effective and far-reaching helicopter emergency medical system. In Saskatchewan and Manitoba, Level I and Level II centers in southern cities provide definitive trauma care for their entire respective provinces, and in the case of Winnipeg Health Sciences center, for Nunavut as well (Fig. 2). Ontario's trauma system is composed of nine (Level I and Level II) lead

trauma centers, which provide definitive care to large local catchment populations. Because of prompt direct access by local populations to these centers via a sophisticated system of prehospital ground and helicopter transport, there appears to be less reliance on Level III or Level IV centers for early stabilization and triage than in other provinces (Fig. 3). In Quebec, many hospitals participate in initial trauma care, but definitive care is often provided at eight Level I or II referral trauma centers in major cities. The absence of helicopter transport in the province leaves a significant number of inhabitants of suburban communities outside 1-hour road travel catchment times, and the long distances in the province leave a substantial rural and remote population similarly vulnerable. In Nova Scotia, shorter distances and extremely organized and evidence based trauma systems including integrated ground, fixed wing, and helicopter prehospital transport have ensured prompt access to initial and definitive trauma care for the majority of the province. New Brunswick's trauma system, still in development, has more than half of the population outside a 1-hour ground transport catchment area without regular helicopter access. Newfoundland faces a similar situation in which access to definitive care is often delayed. In these provinces, potentially long transport distances are compounded by nonuniform ground transport, the absence of central dispatch and no formal rotor wing capacity (Fig. 2). Prince Edward Island sends its major trauma patients by air to Nova Scotia or by ground to New Brunswick and Newfoundland. At the time of this study, Prince Edward Island was in the process of a province wide reorganization of its emergency medical services (EMS) system.

Overall, 77.5% of Canadians live within a 1-hour drive to a Level I or Level II trauma center, but 22.5%, or >7million, Canadians remain outside this distance and time to definitive care (Fig. 1). As catchment boundaries widen to 2 hours and 4 hours, progressively larger proportions of Canadians are included (Table 3).

Interpretation

Throughout their spectrum of activity, from prevention to prehospital care, resuscitation, early acute care, complex multidisciplinary care, and rehabilitation, there is substantial evidence that dedicated trauma care and trauma systems save lives.¹⁹ Injury deaths have classically been reported to occur in a trimodal pattern: immediate deaths at the scene of injury, deaths within the first few hours after injury, and delayed deaths a few weeks after injury.²⁰ Trauma systems have reduced the profile of each of these mortality peaks by informing evidence-based injury prevention and providing access to prompt and aggressive resuscitation, early definitive care, rehabilitation, and follow-up.

The issue of access is central to the performance of trauma systems.^{17,21} Patient outcomes from severe injuries such as hemorrhagic shock and TBI, which are leading contributors to injury related morbidity and mortality, are highly time dependent. Delays in reversal of shock and appropriate resuscitation and treatment of head injured patients can result in adverse outcomes.^{22,23} Since World War I, many advances in trauma care (including emergency medical

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TABLE 2. Cana	dian Trauma Systems							
	Designation Level (or Functional Level for Nondesignated Centers)	Accrediting Body and Year	TTL 24/7	Full Clinical Services	Dedicated Program Funding (TD, TPM, Registry)	Data for QA and Research, i.e., Trauma Registry	Formal Prehospital Rotary Wing Program and Access	Major Trauma Volume ISS >12; ISS >15 Adult Age (yr) for Fiscal Year 2007–2008
British Columbia and	Yukon Territory							
Vancouver General	, -	TAC 2005	Υ	Υ	Υ	Υ	Υ	Age ≥16; ISS >12:757; ISS >15:675
Royal Columbian New Westminster	2	Z	Y	Y	Υ	Υ	Υ	Age ≥ 16 ; ISS >12:492; ISS >15:427
Victoria General/ Royal Jubilee	2	TAC 2009	Y	Υ	Υ	Υ	Υ	Age ≥ 16 ; ISS $> 12:387$; ISS $> 15:322$
Royal Inland Kamloops	2	Z	Y	Υ	Υ	Υ	Ν	Age ≥16; ISS >12:224; ISS >15:175
Kelowna General Hospital	2	N	Υ	Υ	Υ	Υ	N	Age ≥16; ISS >12:176; ISS >15:155
Alberta and Northwes	st territories							
University of Alberta Edmonton	-	TAC 2002	Y	Y	Y	Y	Y	Age ≥17; ISS >12:798; ISS >15:700
Foothills Medical Centre Calgary	1	TAC 2004	Y	Υ	Υ	Υ	Υ	Age ≥15; ISS >12:1103; ISS >15:950
Royal Alexandra Edmonton	2	Z	Y	Υ	Υ	Υ	Y	Age ≥17; ISS >12:476; ISS >15:416
Saskatchewan Saskatoon General	Т	Z	N	Υ	N	Z	N	Estimated; ISS >12:290;
RQAH Regina	2	Z	Z	Υ	N	Z	Z	ISS > 16:250 Estimated; ISS > 12:240; ISS > 16:200
Manitoba and Nunavut								
Winnipeg Health Sciences	1	Z	Z	Y	Υ	Υ	N	Age ≥17; ISS >12:302; ISS >15:253
Ontario Homilton Hoolth	-	N	~	~	>	~	>	A ~ > 19. ICC > 17.545.
Sciences	Т	2	I	I	П	г	I	ISS >15:508
								(Continued)

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	Designation Level (or Functional Level for Nondesignated Centers)	Accrediting Body and Year	TTL 24/7	Full Clinical Services	Dedicated Program Funding (TD, TPM, Registry)	Data for QA and Research, i.e., Trauma Registry	Formal Prehospital Rotary Wing Program and Access	Major Trauma Volume ISS >12; ISS >15 Adult Age (yr) for Fiscal Year 2007–2008
London Health Sciences	1	TAC 2006	Y	Y	γ	γ	γ	Age ≥18; ISS >12:529; ISS >15:487
Ottawa Civic	1	Ν	Y	Y	Υ	Υ	Υ	Age ≥16; ISS >12:625; ISS >15:559
St. Michaels Toronto	1	TAC 2006	Y	Y	Υ	Υ	Υ	Age ≥ 16 ; ISS >12:636; ISS >15:575
Sunnybrook Health Sciences Toronto	1	Z	Y	Y	Y	Y	Y	Age ≥16; ISS >12:988; ISS >15:922
Hotel Dieu Grace Windsor	1	TAC 2006	Υ	Y	Υ	Υ	Υ	Age ≥16; ISS >12:222; ISS >15:195
Kingston General	2	Z	Y	Y	Υ	Υ	Υ	Age ≥18; ISS >12:208; ISS>15: 183
St. Josephs Health Centre Sudbury	7	Z	Y	Y	Υ	Υ	Υ	Age ≥16; ISS >12:186; ISS >15:174
Thunder Bay Regional Health Sciences	0	Z	Y	Y	Υ	Y	Y	Age ≥18; ISS >12:134; ISS >15:124
Hôpital de l'Enfant-Jésus, Quebec	П	FECST 2009	Z	Υ	Y	Y	Z	Age ≥16; ISS >12:572; ISS >15:503
Hôpital du Sacré- Coeur de Montréal	-	FECST 2009	Y	Y	Y	Y	Z	Age ≥16; ISS >12:551; ISS >15:487
Montreal General	-	CCHSA 2007; FECST 2009	Y	Y	Y	Y	Z	Age ≥16; ISS >12:603; ISS >15:519
Hopital de Chicoutimi	2 Regional	CCHSA 2006	Z	Y	Z	Υ	Ν	Age ≥16; ISS >12:103; ISS >15:84
Pavillon Sainte- Marie-Centre Hospitalier Regional de Trois Rivieres	2 Regional	CCHSA 2008; FECST 2009	¥	¥	Y	Y	z	Age ≥16; ISS >12:205; ISS >15:153
Cente Hospitalier Universitaire de Sherbrooke- Hopital Fleurimont	2 Regional	TBI Consortium 2007	Z	¥	×	¥	Z	Age ≥16; ISS >12:225; ISS >15:183
								(Continued)

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IABLE Z. (Conti.	nued)							
	Designation Level (or Functional Level for Nondesignated Centers)	Accrediting Body and Year	TTL 24/7	Full Clinical Services	Dedicated Program Funding (TD, TPM, Registry)	Data for QA and Research, i.e., Trauma Registry	Formal Prehospital Rotary Wing Program and Access	Major Trauma Volume ISS >12; ISS >15 Adult Age (yr) for Fiscal Year 2007–2008
Hopital de Hull- CSSS de Gatineau	2 Regional	Ministry 2007	Z	Y	Z	U	Z	Age ≥16; ISS >12:108; ISS >15:87
Hoptial Charles Lemoyne Greenfield Park	2 Regional	FECST 2002, 2007 CCAES 2008	Z	Y	Y	Z	Z	Age ≥16; ISS >12:231; ISS >15:204
Nova Scotia and PEIN min by ground)	ote: PEI sends major traun	na patients to Nova	ı Scotia by air	(usually helicop	ter but with fixed wing l	back up). Transport tii	ne from Charlottetown t	to Halifax is 46 min (180
Queen Elizabeth II Halifax New Brunswick	1	TAC 2005	Y	Y	Y	Y	Y	Age ≥16; ISS >12:599; ISS >15:531
Saint John Regional	1	TAC 2002	Ν	Y	Y	Υ	Z	Age >16; ISS >12:13; ISS >15:83
Moncton City Newfoundland	2	Z	Z	Υ	Z	Z	Ν	No data 2007–2008
Health Sciences Centre, St. John's	1	TAC 1997	Y	Y	Z	Y	Z	Age >16; ISS >12:97; ISS >15:74
FECST, Continuum de plastic surgery, burns, ICL 12 usually denotes multi s *Adult trauma centers At the heart of trauma	 Service en Traumatologie; TT J. ISS, Injury Severity Score (I ystem injuries requiring compl listed. systems, trauma centers care fi 	L, Trauma Team Lea SS is an anatomical s lex trauma care); PEI or a high volume of t	der; TD, Trauma coring tool that , Prince Edward auma patients in	Director; TPM, Tr provides an overall Island; N, no; Y, neluding those with	auma Program manager; All score for patients with sing yes. the most complex injuries, I	clinical services, General le system or multiple inju nanage data on injury an-	surgery, cardiac surgery, tri ries. The higher the ISS, the d outcomes, engage in perfo	auma orthopedics, neurosurgery, e more serious is the injury. ISS rmance improvement processes,
serve as hubs and resource	es for trauma research, educati	on and injury prevent	ion, and coordir	nate the efforts of c	ther hospitals in the system	to streamline the care of	trauma patients throughout	the geographic region.

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Figure 1. Trauma systems in Canada. Geographic locations of Canada's Level 1 and Level 2 trauma centers and surrounding 1 hour catchments. Overall, 20% of the Canadian population, including 100% of the residents of the 3 territories, lives beyond 1 hour by road from definitive trauma care.

systems, helicopter transport, resuscitation and transfusion protocols, hospital trauma teams, and early access to operative intervention) have been geared toward minimizing delay and maximizing access.

Although regional trauma systems frequently examine local access issues as part of their quality assurance processes, to our knowledge there have been no national comparisons of trauma system access in Canada to date. In the United States, Branas et al.⁸ recently estimated that 69.2% and 84% of all US residents have access to Level I or Level II trauma centers within 45 minutes and 60 minutes of injury, respectively. Over 46 million US residents, mostly in rural areas, do not have 1-hour access to definitive trauma care. The authors suggested increased roles for Level III trauma centers, more interstate cooperation in managing the flow of injured patients, and wider application of medical helicopter flight programs as potential strategies for extending access to trauma centers.

In general, we observed that access to trauma systems in Canada appears to be similar to that seen in the United

States. Most trauma systems in Canada are designed to provide prompt prehospital response, rapid transfer to hospital for initial resuscitation and stabilization, and early referral for definitive trauma care when appropriate. This requires careful integration of the EMS response, active participation in the trauma system by local hospitals, especially when distances to larger trauma centers are significant, and strong clinical and administrative leadership from Level I and Level II trauma centers. This system of clinical trauma care is often complemented by careful data collection for performance improvement and research initiatives, and broad trauma education efforts. These components are seen in many Canadian trauma systems.

However, significant disparities in access persist across the country and between rural and urban environments (Fig. 2). This is consistent with US findings of a significant increase in mortality associated with rural trauma.^{24,25} Although access to definitive trauma care in British Columbia, Alberta, Ontario, Quebec, and Nova Scotia is good, other provinces and territories have less reliable access. In partic-



Canadians in several provinces including BC, Alberta, Ontario, Québec and Nova Scotia enjoy excellent access to trauma care. In Ontario, for instance, 85%, 95% and 99% of the population have access by road to definitive trauma care within 1, 2 and 4 hours. But there is a pronounced urban/rural divide across the country. Manitoba, by contrast, has only 69% of its population with 1 hour of trauma services. And 9.3% remain outside 4 hours. Manitoba serves as the point of access for trauma services for the Territory of Nunavut where 100% of the population is outside of a 4-hour access catchment. In Newfoundland and Labrador. problems of access are intensified with 60% of the population outside of a 1-hour catchment and 42% outside 4 hours. Residents of Labrador are all outside 4 hours to trauma services. In New Brunswick, a compact province with a well-developed road network, 53% of the population remains outside a 1 hour catchment while 5% are outside 4 hours. Access to trauma services exemplifies the long-standing urban rural divide in Canada - and calls to our attention the need to address rural and remote access.

One, Two and Four Hours Trauma Catchments in New Brunswick



Figure 2. Inequity of access across Canada.

ular, the Yukon Territory, Northwest Territories, Nunavut, and Labrador, primarily populated by Canada's First Nations, are all outside 4-hour catchments of Level II trauma centers, and may therefore be especially vulnerable to the consequences of severe injury. In northern areas, severe weather and geography often amplify delays to definitive care of severely injured patients. These issues highlight the need for trauma systems to develop locally relevant solutions to con-

375 (20.6%)

40142 (60.3%) 618226 (84.7%)

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Level1

Level2

A Major To

Two Hours Four Hours





Figure 3. Inclusive and exclusive trauma systems. The evolution of trauma systems has closely paralleled local population and geographic considerations. In BC, where access to high-level trauma care can be limited by geographic isolation, an inclusive trauma system has developed in which an integrated network of local hospitals (level 3 and 4 trauma centers) provides early trauma care and triage to level 1 centers for definitive care as needed. In many areas of Ontario, where population density is high and transport distances are relatively short, much of the population has direct, early access to level 1 trauma centers. This type of access, where there is less reliance on a network of trauma hospitals for early and comprehensive care is more in keeping with exclusive trauma systems. For populations in these regions, investment in pre-hospital care may provide more benefit than creation of new centers.

front access disparities. These may include measures such as improving EMS response times through the creation of universal 911 telephone access, repositioning or creating new ambulance and helicopter depots, introducing or expanding helicopter programs, using novel care delivery methods such as telemedicine and telementoring, and creating Level III and Level IV trauma centers that are closely integrated into regional trauma systems. The role of legislation in improving access could also be considered. It is notable that Canadian EMS systems are not part of the Canada Health Act as are hospital-based trauma services and this has led to a different paradigm for EMS development and great variations in EMS standards across the country.

British Columbia, Alberta, and Ontario provide examples of successful local adaptations for the optimization of access. In British Columbia, where populations can be isolated by geography and climate, an inclusive system of trauma care has evolved, where local hospitals are encouraged to participate in early trauma care and triage. The Prince George Regional Hospital, which is hours away from the nearest Level I or Level II trauma center (Fig. 3), is a Level III trauma center that plays a lead role in acute and life

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One Hour Trauma Catchments in Alberta and Northwest Territories

Hospital Name	One Hour Road Catchment Population		
Calgary Foothills Medical Centre	1,162,679		
Royal Alexandra Hospital	511,857		
University of Alberta Hospital	563,490		
Total*	2,238,026 (68.02%)		
Alberta Population outside	1,052,324 (31.98%)		
NWT Population (all outside)	41,464		

* Percentages consider Alberta population only. Royal Alexandra Hospital in Edmonton is considered level 2 but it does not have neurosurgery.





Figure 4. The impact of helicopter emergency medical services on access to definitive trauma care.

threatening trauma in the region. There, general surgeons routinely provide advanced trauma care, including stabilization of neurosurgical injuries, damage control surgery, and triage and transfer to predesignated Level I centers when necessary. Across the country, similar Level III centers have been developed to provide an essential link in acute trauma care. In Alberta, a new provincial trauma system focuses on improving capacity at the Level III centers through dedicated funding and appropriate infrastructure support and improving communication and access throughout the network of Level I, II, and III hospitals. In Southern Ontario, where population density is high, and helicopter programs are advanced, Level I and Level II trauma centers are highly accessible, and shoulder a higher proportion of the burden of acute trauma. This more exclusive trauma system model, increases trauma volumes at trauma centers and potentially improves volumeoutcome relationships, but runs the risk of over triage, or overcrowding of trauma centers with minimally injured patients. The heterogeneity of trauma systems across the country can be a powerful driver of improvement. The experiences and outcomes of different systems can be shared and implemented across a national trauma network. This process will be highly dependent on the analysis of injury data. GIS methods, combined with patient level data on the circumstances and outcomes of injury, can provide important insights about vulnerability to injury, access to care, and performance of trauma systems. Unfortunately, access to national patient data, though essential, is limited. At present, only British Columbia, Alberta, Ontario, Quebec, and Nova Scotia provide detailed data to the National Trauma Registry and access to this source has proven to be difficult. A new national data strategy is a priority for Canadian injury control.

Our study has several important limitations. Road travel times modeled in the study may underestimate true transport times as they do not account for EMS response time or scene time. It is possible that inclusion of these times

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	Dogular Prohospital	One-Hour Roa	nd Travel (%)	Two-Hour Road Travel (%)		Four-Hour Road Travel (%)	
	Helicopter Access	Inside	Outside	Inside	Outside	Inside	Outside
British Columbia	Y	3,137,525 (75.7)	1,006,334 (24.3)	3,406,793 (82.2)	737,066 (17.8)	3,636,979 (87.8)	506,880 (12.2)
Yukon	Ν	0 (0)	30,372 (100)	0 (0)	30,372 (100)	0 (0)	30,372 (100)
Alberta	Y	2,238,036 (68)	1,052,324 (32)	2,611,302 (79.4	679,048 (20.6)	3,060,685 (93)	229,665 (7)
NWT	Ν	0 (0)	41,464 (100)	0 (0)	41,464 (100)	0 (0)	41,464 (100)
Saskatchewan	Ν	495,256 (51.2)	472,901 (48.8)	666,239 (68.8)	301,918 (31.2)	911,732 (94.2)	56,425 (5.8)
Manitoba	Ν	787,340 (66.8)	390,535 (33.2)	900,425 (76.4)	277,450 (23.6)	1,041,185 (88.4)	136,690 (11.6)
Nunavut	Ν	0 (0)	29,474 (100)	0 (0)	29,474 (100)	0 (0)	29,474 (100)
Ontario	Y	10,311,506 (84.8)	1,848,776 (15.2)	11,592,248 (95.3)	568,034 (4.7)	11,998,476 (98.7)	161,806 (1.3)
Quebec	Ν	6,550,739 (86.8)	995,392 (13.2)	6,948,979 (92.1)	597,152 (7.9)	7,147,772 (94.7)	398,359 (5.3)
New Brunswick	Ν	339,896 (46.6)	390,101 (53.4)	513,620 (70.4)	216,377 (29.6)	691,667 (94.7)	38,330 (5.3)
Newfoundland	Ν	200,660 (39.7)	304,809 (60.3)	244,246 (48.3)	261,223 (51.7)	291,642 (57.7	213,827 (42.3)
Nova Scotia	Υ	436,599 (41.6)	612,714 (58.4)	652,540 (62.2)	396,773 (37.8)	907,984 (86.5)	141,329 (13.5)

Access to Canadian trauma centers by road and air. The presence of regular prehospital helicopter access would improve access in rural areas where available.

would move a large proportion of the population, such as those in suburban locations around Montreal, outside the 1-hour catchments determined in this study. Transfer and referral process issues are known to further delay transport to definitive care. However, when validated against actual mean ground transport times to definitive care in Newfoundland, transport times from the model were found to only slightly underestimate actual transport times. We restricted our analyses to Level I and Level II trauma centers with full time neurosurgical capability, as our main interest was in determining access to high-level care by patients with acutely life threatening conditions. The presence of neurosurgeons may be a general marker for greater hospital capability, and also would increase the likelihood of prompt neurosurgical care for patients facing the potentially devastating consequences of TBI. Although this focus clarified the analysis, it prevented us from recognizing the critical role of Level III trauma centers such as Prince George. Our study, which used rigorous analyses of road travel times, did not account for the presence of helicopter transport. This is an important consideration, since the presence of helicopter programs greatly expands the range of trauma systems (Fig. 4).¹⁸ However, the analysis is still highly relevant in jurisdictions such as Quebec or New Brunswick that do not as yet have medical helicopter programs (Table 2). Finally, our study primarily measured access to trauma care and focused less on quality of care. A complete understanding of Canadian trauma systems will depend on ongoing efforts of agencies such as TAC to measure indicators of process and outcome within trauma centers and systems.

CONCLUSION

Trauma systems have been implemented across Canada. However, significant variations in trauma system structure and access exist and disparities in access persist in rural and remote communities. Depending on the local context and needs, access to critical trauma services can be improved by reducing EMS response times, expanding the use of helicopter transport, and increasing the role and integration of Level III and Level IV trauma centers within regional trauma systems. In addition, the use of telemedicine and teleultrasound may potentially enlarge the geographical extent of trauma systems. Further advances may result from intensified efforts to acquire and apply injury data to measure and standardize processes of trauma care within trauma systems across the country and further develop national benchmarks for trauma care. It will also be compelling to explore regional differences in trauma outcome as a means of assessing and raising the standards of trauma care across Canada.

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EDITORIAL COMMENT

Access to healthcare is of paramount importance. Trauma remains a significant public health problem, and, no less than cancer or cardiovascular disease, access to skillful and timely intervention for injuries is necessary for optimum patient outcome. To that end, the article by Hameed et al.,¹ in this issue of *Journal of Trauma, Injury, Infection, and Critical Care* is both relevant and provocative. The challenges of access to trauma care are highlighted by the variability of geography and population density in Canadian provinces and serve to illustrate the impediments to rural trauma care. There is no secret that remoteness from trauma resources has substantial impact on survival. Both Emergency Medical

Services response² and timely access to trauma centers³ continue to affect survival, just as described in the early work of Baker et al.⁴ some 20 years ago.

As an inventory assessment of Canadian provinces, this study by Hameed et al. does not only detail solutions but also emphasize the importance of local systems of trauma care. As the authors indicate, effective trauma system planning will vary from one geographic region to another and depends on factors such as terrain, weather, population density, actual travel time, and even socioeconomic status. This culminates in a determination of a "vulnerability" factor, which can influence the need for more or less trauma resources in a given population, as the authors alluded to in a previous publication.⁵ In some more remote areas, inclusive trauma systems, where every hospital has the mandate to assess and stabilize, and then transfer, can improve care, whereas in population dense areas, exclusive trauma systems provide the ready availability of trained trauma personnel to deliver definitive care without the potential delays and redundancies of an inclusive system.

In essence, one size does not fit all in trauma care. The lessons of this Canadian study should be kept in mind when determining the proper configuration of rural trauma systems in the United States. Thoughtful planning at the state level with sensitivity to local conditions and flexibility in trauma center designation may indeed define the best access. In that sense, regional networks of trauma care may be more practical than state or national directives. Let us use this article by Hameed et al. as a springboard for further investigation of regional differences of injuries and trauma care in the United States and the ultimate mapping and implementation of trauma resources to truly match demand.

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