

Demographic and ecologic analysis of traumatic injury transport  
outcomes and health care infrastructure in Northern Québec's  
rural communities

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Montréal, Québec

December 2013

Submitted to McGill University in partial fulfillment of the  
requirements of the degree of Master's of Science in Epidemiology

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## LIST OF ABBREVIATIONS

CCI: Charlson Comorbidity Index

WA: Western Australia

MUHC: McGill University Health Centre (houses Montreal General Hospital)

MGH: Montreal General Hospital

ARIA+: Accessibility/Remoteness Index of Australia

ED: Emergency Department

RUIS: Réseau universitaire intégré de santé de l'Université

ISS: Injury severity score

AIS: Abbreviated injury scale

PIVA: Population Isolation Vulnerability Amplifier

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## ACKNOWLEDGEMENTS

I would like to thank my supervisors Dr. Tarek Razek and Dr. Kevin Schwartzman for their continued enthusiasm, support, and patience. It is only through their careful guidance that I have grown not only as a researcher but also as a human being. They have taught me the meaning of dedication and I will always admire them.

I would like to extend my thanks to all the members of the Trauma Research Group and the Centre for Global Surgery at the MUHC: Dr. Dan Deckelbaum, Dr. Kosar Khwaja, Dr. Paola Fata, Dr. Marc Dakermantji, and Kerianne Boulva for sharing the better part of a year and half with me and for helping me in countless ways. I would like to thank my family, namely my mother Rawda El-Ali, my father Hani Odeh, and my brother Yazan Hamadani for their continued support and love. And to my best friends, Hussein Hamshari and Hussam Ayyad, goes my enduring loyalty and love. DK, here I come.

## ABSTRACT

**Introduction:** North American and international studies have shown mortality and morbidity rates from traumatic injury to be higher in remote and rural populations when compared to urban areas. Little research is explores the available health infrastructure and outcomes of traumatic injuries in such regions, which include Northern regions of Canada (especially British Columbia and Québec), the rural outback of Australia, remote regions in Norway, and very isolated areas in the U.S, amongst others. In isolated Northern Québec communities, transport to the McGill University Health Centre (MUHC), a level-I regional trauma centre is the only option for complex trauma care. This study aims to provide: (1) a demographic analysis of the Northern Québec region, with an emphasis on characterizing the available health care infrastructure; (2) the mechanisms and rates of injuries in the North that require transfer; (3) transfer times and outcomes in patients with traumatic injury from this region.

**Methods:** A manuscript focusing on trauma patient transport outcomes from Northern Québec is incorporated into this thesis. For this portion, quantitative data from trauma cases transferred to MUHC from Northern Québec was obtained from the MUHC trauma registry (Jan 1, 2005 to Dec 31, 2009). Demographic and health services data was obtained from the Réseau universitaire intégré de santé de l'Université McGill (RUIS), the administrative coordinator of health and trauma services in Northern Québec. We identified mechanisms of injury, transfer times, and survival results in trauma patients transported to the MUHC from Northern Québec and compared the results to a population of trauma patients transported from Montreal's local suburban hospitals.

**Results:** Pertinent literature was identified and summarized to provide an overview of rural and remote trauma experience. Emphasis was placed on

ecologic analysis of rural trauma outcomes, use of geographic mapping systems and other scores to quantify remoteness, and a descriptive comparison of rural trauma experiences in Canada, Australia, and Norway. Assessment of the Northern Québec trauma experience revealed that the MGH received 9952 traumas during the study period. 254 of these patients were from the North and had an ISS above 15. 1027 patients with an ISS above 15 were transported from local suburban hospitals. The mean age for the local transport groups was > 40 years and from the North it was > 30. Both groups had a predominantly male population, the majority of whom had sustained blunt trauma. Motor Vehicle Collision was the most common mechanism in the Northern Québec population, averaging 40%. Penetrating trauma was the cause of 21.7% of all transports from Northern Québec, whereas it represented 12.5% of the injuries seen in the local transport population. Patients transferred from the Northern region with an ISS > 15 had a significantly higher mortality rate.

Conclusion: Despite the selection and referral biases inherent in observational data of this type, the higher mortality rate observed in patients transferred from Northern Québec likely reflects challenges in timely transport and advanced care. Improved outcomes may result from enhanced/systematic training of local care providers, improved triage and rapid transport protocols.

## ABRÉGÉ

Introduction: L'Amérique du Nord et des études internationales ont montré des taux de mortalité et de morbidité de lésion traumatique à être plus élevés dans les populations éloignées et rurales par rapport aux zones urbaines. Très peu de recherches évaluent l'infrastructure de santé disponibles et les résultats de traumatismes dans ces régions, qui comprennent les régions du Nord du Canada (en particulier la Colombie-Britannique et du Québec), l'arrière-pays rural de l'Australie, des régions éloignées en Norvège, et des zones très isolées dans le États-Unis, parmi d'autres. Dans les collectivités isolées du Nord du Québec, le transport vers le Centre universitaire de santé de Montréal (CUSM), un centre régional de niveau-1, est la seule option pour les soins de traumatologie complexe. Cette étude vise à fournir: (1) une analyse démographique de la région du Nord du Québec, en mettant l'accent sur la caractérisation de l'infrastructure des soins de santé disponibles, (2) les mécanismes et les taux de blessures dans le Nord qui exigent le transfert; (3) les temps de transfert et les résultats chez les patients présentant une lésion traumatique de cette région .

Méthodes : Un manuscrit en se concentrant sur le traumatisme du patient résultats de transport du Nord de Québec est incorporé dans cette thèse. Pour cette partie , les données quantitatives des cas de traumatologie du CUSM transférés à partir du Nord du Québec ont été obtenues auprès du CUSM traumatisme registre (1 Janvier 2005 au 31 Décembre 2009 ). Les données démographiques et de santé ont été obtenues auprès des services du Réseau universitaire intégré de santé de l' Université McGill (RUIS) , le coordonnateur administratif des services de santé et les traumatismes dans le Nord du Québec . Nous avons identifié des mécanismes de blessure , temps de transfert , et les résultats de la survie chez les patients victimes de traumatismes transportés à CUSM de Nord québécois et comparé les résultats à une population de patients traumatisés transportés soit dans des

hôpitaux de banlieue locales de Montréal .

Résultats: La littérature pertinente été identifiés et résumés de donner un aperçu de l'expérience de traumatisme régions rurales et éloignées. L'accent a été mis sur l'analyse basée sur la population des résultats ruraux de traumatologie, l'utilisation de systèmes de cartographie géographique et d'autres partitions de quantifier l'éloignement, et une comparaison descriptive de l'expérience des traumatismes en milieu rural au Canada, en Australie et en Norvège. Évaluation de l'expérience des traumatismes du Nord québécois a révélé que le MGH a reçu 9952 traumatismes au cours de la période d'étude. 254 de ces patients étaient du Nord et avait une ISS au-dessus de 15. 1027 patients avec un ISS plus de 15 ont été transportés dans les hôpitaux de banlieue locales. L'âge moyen pour les groupes locaux était > 40 ans, pour les groupes Nord du Québec > 30, avec une population à prédominance masculine, dont la majorité avait subi un traumatisme contondant. Collision d'un véhicule automobile est le mécanisme le plus fréquent dans les groupes Nord du Québec, avec une moyenne de 40 %. Traumatisme pénétrant était la cause de 21.7 % de tous les transports en provenance du Nord, alors qu'elle représentait 12.5 % des blessures observés dans la population locale. Les patients transférés de la région du Nord avec un ISS > 15 avaient un taux de mortalité significativement plus élevée.

Conclusion : Malgré les biais de sélection et d'orientation inhérentes aux données d'observation de ce type, le taux de mortalité plus élevé observé chez les patients transférés de Nord québécois reflète probablement les défis en matière de transport en temps opportun et les soins. Amélioration des résultats peuvent résulter d'une meilleure / formation systématique des prestataires de soins locaux, l'amélioration de triage et les protocoles de transport rapides.

## PREFACE

The following is a manuscript-based thesis assessing the outcomes of trauma patients who are transported from Northern Québec to the Montreal General Hospital for care. A population of trauma patients transported from local suburban Montreal hospitals is used as a comparison group. The work delineates the complex decision-making that takes place when it becomes necessary to extract a patient from Northern Québec. The study provides information on available trauma services in Northern Québec and how these are organized. The abstract was accepted for oral presentation at the Trauma Association of Canada annual meeting in April 2014 and was presented at the American College of Surgeon's Committee on Trauma paper competition in October 2013. It won this competition for the Province of Québec. The manuscript will be submitted to the World Journal of Surgery for publication consideration.

## CHAPTER 1

### BACKGROUND

#### 1.1 Rural Trauma

##### 1.1.1 Identifying the reasons for poor rural trauma outcomes

The North American land mass is defined by large rural environments, accounting 85% by some estimates.<sup>1,2</sup> Despite the large rural geographic land mass less than twenty percent of the population live in rural areas, yet they account for a disproportionate number of trauma related deaths.<sup>3,4</sup> The factors causing this higher mortality are many and include lower usage of protective gear<sup>5,6</sup>; Motor Vehicle Collisions are usually of greater severity due to poorer road conditions and higher speeds<sup>7</sup>; and discovery times are long, which is itself complicated by difficult access to definitive care.<sup>8</sup> Pre-hospital care is often limited by poor resources and lack of continuing training thus making the care delivered in the first crucial hours of a severe injury challenging.

These factors often lead to higher mortality rates from rural trauma despite the best efforts to introduce primary and secondary injury prevention efforts. This highlights the important need that interventions directed to the most severely injured, especially in the early hours, be effective and delivered efficiently. Interventions are often difficult to organize because of a lack of internationally recognized definition of what constitutes rural. This is in part due to rural areas being markedly different from each other. The Committee on Trauma of the American College of Surgeons defines rural as “an area where geography, population density, weather, distance or availability of professional or institutional resources combine to isolate the trauma victim in an environment where access to definitive care is limited.”<sup>9</sup> Baker defines rural as “an area not adjacent to a metropolitan area and has no settlement larger than 2,500 persons.”<sup>10</sup>

Injuries occurring in bigger cities, broadly known as urban trauma, has benefited from significant improvements in the organization of trauma care delivery. Improvements in the understanding of shock and resuscitation as well as advances in diagnostic imaging and surgical technology have improved the survival of severely injured patients. The effectiveness of these developments and improvements are often not within the reach of rural areas due to the factors mentioned above, meaning that these advances are often not accessible to the rural injured. Regional and international variation exists in both urban and rural trauma systems. To quote Nathens “organization of the process of trauma-care delivery is crucial to optimize outcomes. There is much regional and international variation in trauma-care delivery. To focus on a single system would be inappropriate because there is no clear evidence that one system is superior to another.”<sup>11</sup>

### 1.1.2 Development of effective trauma systems

An effective trauma system amounts to more than just having the resources needed to care for injured patients. The question of access to definitive trauma care is essential. The purpose of a trauma system is to ensure a mechanism is in place by which critically injured patients are identified and transported rapidly to proper centres. In recent years this realization led to a shift in emphasis from the trauma centre to the importance of a systematically organized system of trauma care that encompasses a variety of geographic locales. Several essential characteristics of trauma systems have been identified in recent work.<sup>12,13</sup> Several authors have also suggested that injury prevention, pre-hospital care, and post-hospital care (e.g., rehabilitation and societal reintegration) need to be included under the spectrum of a trauma system, as it conforms to the continuity of trauma care.<sup>14</sup>

There is emerging evidence that regional organization of trauma systems reduces trauma mortality, even in remote or rural settings.<sup>15</sup> In a



recent US study assessing the effect of regionalization on mortality from Motor Vehicle Collisions there was an 8% overall reduction in areas with regional trauma care.<sup>16</sup> It is important to note that these types of observations may be confounded by other factors, such as the fact that areas with more skilled/experienced care providers available may be those most likely to organize a regional system. Improvements in pre-hospital care have also been assessed in a wide variation of geographic locales, both urban and rural, and this was found to improve trauma mortality outcomes by several mechanisms: appropriate patients are identified, triaged, and directed to centres with necessary resources to treat them; trauma centres are left to treat the most complex injuries and thus save resources; and expertise in the field of pre-hospital care begins to improve as more resources become available for training and improving protocols.<sup>17,18</sup>

### 1.1.3 Trauma access in the context of regionalization

Organizing trauma care into systems based on geographic regions has been an effective strategy for reducing mortality from trauma.<sup>15,16,19,20,21</sup> Central to regionalization is timely access to a primary trauma centre equipped to treat severe injuries, with a need to verify that these hospitals are equipped to treat such injuries. Regionalization is the strategy by which access to such trauma centres is ensured through the development of a pre-hospital protocol that integrates the services of the centre when it is needed. In the United States the overall number of trauma centres has increased in recent years but recent studies have shown that their geographic distribution varies widely. The same studies also suggest that access to these centres remains poor, with this unequal geographic distribution leading to too many centres in some locales, which in turn have resulted in lower patient volumes per centre, inefficiencies in training, and reduced quality of care.<sup>12,22,23,24,25,26</sup>

In Canada, seminal work by Hameed et al set out to measure access

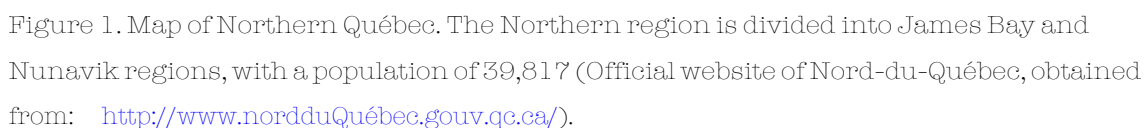
to trauma systems across the whole of the country.<sup>27</sup> This study, the only one to characterize access to definitive trauma care across the whole of Canada's geographic landmass, found that significant variations in trauma system structure and access exist and disparities in access persist in rural and remote communities. Beyond this, the study was able to determine that depending on the specific context of each region's needs, access to critical trauma care could be improved by reducing pre-hospital response times, expanding the use of air transport, and increasing support to and the role of non-Level-I trauma centres in the flow of regional trauma care.<sup>27</sup> 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 less specialized Level-III and Level-IV trauma centres within regional trauma systems (see Appendix A for description of each trauma centre level).<sup>27</sup>

## 1.2 Northern Québec

### 1.2.1 Introduction to the region's administration and demographics

The region of Nord-du-Québec (Northern Québec) is the largest of the seventeen administrative regions of Québec, Canada, covering 55 percent, or 839,000 squared kilometers of the geographic landmass of the province. It is divided into the Jamésie region in the South and the Nunavik region in the North, with a shared total population of almost 54 000 inhabitants (2011 census). The population is made up of about 13 000 Cree inhabiting the Jamésie region and 9 000 Inuit in the Nunavik region, making up most of the Northern population.<sup>28</sup>

The administrative structure of the region is divided amongst two native semi-autonomous governments and 5 municipalities, with the Grand Council of the Crees (encompassing the Cree Regional Authority) representing the 9 Cree villages, and the Kativik Regional Government



Between 1991 and 2006, while Québec's population increased by nearly 10 percent, that of Northern Québec declined by nearly 3 percent, from 124 500 to 121 000 inhabitants. At the same time, the Aboriginal population grew markedly and its proportion rose from 17.7 percent to 27.1 percent of the total population in the Northern Québec. In the Aboriginal communities, young people up to the age of 14 are twice as numerous,

while the proportion of individuals 65 or over stands at 4.5 percent, half that in Québec overall (13.2 percent).<sup>28</sup>

Analysis of demographic statistics for the region reveals that communities in the Nord-du-Québec region are aging. The proportion of the population made up by those aged 65 and above rose 1.1% from 2001 to 2006. Another indicator of population aging is that the average age of people living in the James Bay area has risen from 28.8 years to 32.3 years since 1996. The average age in Nunavik has increased from 23.7 years to 25.9 years. Despite an aging population, the average age in the region remains significantly lower than for Québec as whole, which stands at just under 40 years old.<sup>29,31</sup>

### 1.2.2 Geography and climate of Northern Québec

Nunavik is located in the northernmost part of Québec. It lies in both the Arctic and subarctic climate zones. Nunavik is separated from Nunavut Territory by Hudson Bay to the west and Hudson Strait and Ungava Bay to the north. Nunavik shares a border with the Côte-Nord region of Québec and the Labrador region of the province of Newfoundland and Labrador. The Ungava Peninsula forms the northern two-thirds of the region. The principal village and administrative centre in Nunavik is Kuujuaq, on the southern shore of Ungava Bay; the other villages are Inukjuak, Salluit, Puvirnituq, Ivujivik, Kangiqsujuaq, Kangiqsualujuaq, Kangirsuk, Tasiujaq, Aupaluk, Akulivik, Quaqtaq, and Umiujaq. The village population (2011 census) ranges from 2375 (Kuujuaq) to 195 (Aupaluk). There are no road links between Nunavik and southern Québec, although the Trans-Taiga Road of the Jamésie region ends near the 55th parallel on the Caniapiscau Reservoir, several hundred kilometers south of Kuujuaq. There is a year-round air link to all villages and seasonal shipping in the summer and autumn. Parts of the interior of southern Nunavik can be reached using several trails which head north from Schefferville.<sup>30,31</sup>

Eeyou Istchee comprises numerous communities within the region known as Eeyou Istchee/Baie-James Territory. There was a combined population of 14,131 persons as of the Canada 2006 Census, but its total population now exceeds 18,000 Cree. Its largest community is Chisasibi, on the south bank of La Grande River, near the northeast shore of James Bay. Eeyou encompasses the Cree reserved land of Whapmagoostui and the Cree village municipality of the same name. These are the only municipalities in Québec lying north of the 55<sup>th</sup> parallel. Although there are villages North of James Bay in Nunavik, the government structure of Nunavik does not use municipalities, but rather is represented by councils.<sup>32</sup>

Given the immensity of the Nord-du-Québec region, the climate varies significantly from north to south. The most densely populated areas between the 49<sup>th</sup> and 50<sup>th</sup> parallels boast a climate that can be described as “dry continental,” with short, hot summers and quite cold winters with less snow than in the province’s southern areas. The average temperature in summer months is about 21 °C during the day and 9 °C at night, whereas temperatures in the cold months vary between -10 °C and -23 °C.<sup>12</sup> Precipitation is relatively heavy, and 45% of the average annual 920 mm falls in summer months.<sup>29,30</sup>

The Ungava Peninsula in the north is located in a polar climate zone. In warmer months, the temperature reaches only about 10 °C during the day and 5 °C at night. Icy winter temperatures vary between -19 °C by day and -28 °C at night. At this latitude, the cold generates a very dry climate in which only 510 mm of precipitation falls on average every year. This harsh climate has a notable effect on the growing season, which is about 40% shorter than in the south.<sup>29,30</sup>

### 1.2.3 Brief overview of population-health of Canadian Aboriginal and Inuit communities

Aboriginal persons in Canada number more than 1.2 million and are

the fastest growing segment of the Canadian population. An equal number of this population resides in urban centres on one hand, and on Indian reserves, Inuit communities and other rural and remote areas. Compared to the rest of the Canadian population, Aboriginal Canadians experience lower life expectancy, higher incidence of chronic diseases (e.g. diabetes), higher rates of infectious diseases, and higher rates of substance abuse, suicide, and addiction. The latter three all contribute to trauma epidemiology.<sup>33,34</sup>

## 1.3 Trauma Transport

### 1.3.1 Outcomes of trauma patient transports in trauma systems

Trauma systems are a strategy to improve the treatment and outcome of severely injured patients, by organizing and coordinating response efforts for a defined geographic area. The goal of these systems is to deliver the full spectrum of care to an injured patient, from the time of injury to transport to an acute care facility and to rehabilitative care.<sup>35</sup> Level-I trauma centres receive their designation when they are deemed to meet the requirements of providing the full spectrum of trauma care. Studies assessing the performance of Level-I trauma centres in the United States and Canada have shown evidence of a survival benefit for trauma patients treated there.<sup>36,37,38,39</sup>

Ideally all patients with severe injuries would be transported directly to a Level-I trauma centre from the site of discovery. This may not always be possible due to practical and geographic limitations. Some studies have assessed the role that transport plays in the care of injured patients with varying results. Some found no difference in mortality outcomes; while other studies found that when treatment was initially received at a lower-level facility (Level III or IV), mortality was higher.<sup>40,41,42,43,44,45,46</sup> Although they represent a good effort to describe the early experience from trauma

transports, these studies suffer from important limitations. For one, these studies did not take into account factors at the scene of injury that might influence the decision to transport in the first place. As such, often the most severe patients were deemed to be too unstable for transport and ended up receiving initial stabilization at a lower level facility. As such, there is a selection bias in these studies for transported patients whose prognosis was much better than the more severely injured population.<sup>47</sup>

The study of trauma transport to date has also been complicated by variations in patient baseline characteristics, the injury severity and mechanisms, and differences in the structure and maturity of the different trauma systems that were assessed and compared. Comparing results in a well formed, geographically cohesive network is very different from systems covering wider geographic regions, including remote areas with poor access to even Level-III or level-IV centres.

### 1.3.2 The McGill University Health Centre (MUHC) Trauma System

It is important to understand the current trauma system in place in Montreal and its surrounding areas, which also encompasses the catchment area of Northern Québec. The Montreal General Hospital (MGH) serves as one of two Level-I trauma centres in Montreal, the second being the Sacré-Coeur Hospital. The MGH, a 479-bed quaternary facility, is the Level-I trauma centre in this network, capable of delivering the full spectrum of trauma care, incorporating comprehensive surgical services (including neurosurgery), rehabilitation programs, and reintegration support. The hospital sees more than 800 trauma cases every year.

The MGH serves the following catchment area: the Greater Montreal Area (GMA) including the island of Montreal below the autoroute-40 (trans-Canada highway); the Montérégie, an administrative region in southwest Québec, including the cities of Boucherville, Brossard, Granby, Longueuil, Salaberry-de-Valleyfield, Saint-Jean-sur-Richelieu, Saint-Hyacinthe, Sorel-

Tracy, and Vaudreuil-Dorion; and the Greater North, which includes the region of Northern Québec above the 55<sup>th</sup> parallel North latitude. The Sacré-Coeur Hospital serves the Northern part of the island of Montreal above the autoroute 40, Laval, Lanaudière, and Laurentides.

The MGH network includes one level-I centre and 7 level-II and level-III centres that are distributed both on and off the island. An ambulance transports patients requiring transfer to the MGH, because the hospital does not have access to a formal rotary wing program. Transfers requiring air evacuation are transported using jet airplane travel to the local Montreal airport. Air evacuations are usually reserved for patients from Val-d'Or and Northern Québec. No study to date has assessed the trauma care infrastructure in Northern Québec or described the current mechanism used to transport patients from Northern Québec to the MGH.

This study aims to provide: (1) a demographic analysis of the Northern Québec region, with an emphasis on characterizing the available trauma care infrastructure; (2) the mechanisms and rates of injuries in the North that require transfer; (3) a comparison of outcomes, for the same injury severity score (ISS), between patients arriving directly to the MUHC and those requiring transport from the North.



## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 International rural trauma experiences

Presenting the following international experiences is not done with the purpose of a direct comparison between any of the regions, but to describe the evolution of rural trauma care over the last few decades. It is important to highlight how the process of regionalization, which is easier in the urban context due to more available resources, may be very difficult in rural environments due to difficult geography, weather, complex population dispersion, and limited resources. The field of rural trauma systems is relatively new, and the literature is not very mature yet. This review will try to summarize the international experience, summarize the tools available to define rural vs. suburban or urban settings, and provide an overview of the international rural trauma epidemiology.

##### 2.1.1 Australia

The Australian experience with delivering care to patients from the region of Western Australia (WA), a largely rural area, provides an overview of the complexities of organizing effective regional strategies in under-resourced areas with difficult geographic terrains. The Australian rural trauma literature also served to further develop the process of quantifying remoteness by use of geographic mapping technology. The use of this technology has been helpful in identifying regions with difficult access and made it possible to link this to poor outcome evaluation.

Danne et al. described the experience of trauma transfer in WA, focusing on the vast distances between locales.<sup>48</sup> WA represents the western third of Australia with an area of 2.5 million squared kilometers bordering a large coastline of over 20,000 kilometers. The weather is

defined by a tropical-temperate climate, and the terrain is mostly flat. This area has a very low population density with the exception of the southwest region, home of the state's capital city of Perth, and several coastal communities in the north. These settlements make up over 70% of the areas 2 million inhabitants. According to the Geographical Association of WA, Perth is the most isolated capital city in the world.<sup>48,49</sup>

The WA trauma experience is a unique one, highlighted here because of many similarities with Northern Québec. Aside from the weather, which is harsher in Québec, WA is similar to Northern Québec in its large area, sparse population centered in difficult to reach areas, and the isolation of the capital city. The region does have some advantages to Northern Québec though, namely that the geographic terrain is easier to access (no mountains or large bodies of water), and the infrastructure of the region is more developed.<sup>50,60</sup> Furthermore, Perth, the capital of the state, does have a tertiary hospital capable of delivering the full spectrum of trauma care.

Gupta et al. focused on the transfer process of trauma patients in WA.<sup>51</sup> Often patients have to be transferred distances over 2500 kilometers, but some areas, such as Kununurra are as far 3300 kilometers away from Perth. This study also quantified the surgical capacity as 14 surgeons who work in 74 nonmetropolitan hospitals in rural WA. These hospitals exist in communities with small populations of several thousand. Of the 14 surgeons, 6 work in Bunbury, 185 kilometers from Perth. As a result, Gupta concludes that surgical expertise is almost nonexistent outside of Perth, which is also the only hospital with an intensive care unit. An important concept that emerges from work by Croser et al. in 2003, as it relates to traumas from WA, states, “the patient has undergone a trial of survival before reaching any medical facility.”<sup>52</sup>

Croser et al. published “Trauma care systems in Australia” in 2003, and this was the first study to describe the flow of trauma patients from WA. When a trauma is identified, the patient(s) is/are initially retrieved by road. If the region is more than 200 kilometers away from Perth then air

evacuation is employed, but both fixed wing and rotary aircraft. Often at the time of discovery the distances are in excess of 1 000 kilometers from a nonmetropolitan trauma facility, and a further 1 000 kilometers from Perth. When an injury is discovered in Kununurra the patient is initially transferred by road to Darwin, which is 825 kilometers away, for initial care. All severely injured patients will eventually be transferred to Perth.<sup>52</sup>

Gupta et al described the type of care that injured patients from WA receive during their journey.<sup>51</sup> This consists of first aid delivered in rooms that have been set up for this purpose. Often this care is delivered by nonmedical individuals who have to rely upon help from a healthcare provider with the Royal Flying Doctor Service. This help is delivered via telephone or satellite radio.<sup>52</sup> The patient is then transferred to a regional hospital without thoracic or neurosurgical capabilities or an intensive care unit. The Royal Flying Doctor Service then transports the patient to Perth, which often takes 1.5-2 hours.<sup>48,51,52</sup>

The WA experience revealed that the conventional wisdom of the “golden hour” in trauma is often not achieved in rural trauma systems, as it often takes several hours to reach definitive care. Fatovich et al discuss the need to better train local personnel in the life-saving measures that are essential in the early period after a severe injury. They also call for improved health capacity locally.<sup>48,49,51,52</sup>

### 2.1.2 British Columbia and Canada

British Columbia (BC) is the westernmost province in Canada, bordering the Pacific Ocean. By area, it is the fifth largest province in Canada and has a population of over 4.4 million according to the 2011 census.<sup>53</sup> BC has many rural and remote areas in its Southeast, North, and Northeast regions, characterized by vast distances between communities, limited road networks, and difficult access to level-I and level-II trauma centres.<sup>53</sup>

A very important study came out of BC in 2008, authored by Schuurman et al. This work represents the first time an attempt was made to quantify rural communities in British Columbia by distance from a level-I or level-II trauma centre. This was the first such study in Canada, although earlier works from the US had used distance from a key trauma centre as a means of quantifying access.<sup>54</sup> The importance of this study goes beyond the geographic aspect by presenting a quantification of overall vulnerability of each rural area in BC. By factoring in socioeconomic, social deprivation, and spatial information on access to trauma centres, the authors were able to generate a single index, called the Population Isolation Vulnerability Amplifier, or PIVA.<sup>54</sup>

Applying PIVA to the regions of BC, the authors identified ten areas that were most in need of more accessible trauma care. The PIVA was then verified by comparing the PIVA score to the records of trauma service utilization from the British Columbia Trauma Registry. The application of this index did add predictive value when trauma outcomes were examined, thus validating it as a measure. The use of such a model is an important development in rural trauma research, especially when the PIVA can be used as a tool to predict where to place new services. This has relevant extensions in rural trauma system development and regionalization when trying to allocate limited resources. It would be more effective to direct these services to the most vulnerable populations who need them the most.

In 2010 Hameed et al. expanded the BC experience of measuring access to trauma centres, with a benchmark of one-hour (“golden hour”) access to a level-I or level-II trauma centre, to the whole of Canada. The study consisted of identifying the major adult trauma centres in Canada (level-I and level-II) and the catchment areas that each centre serves. Geographic software was then used to generate a map of available definitive trauma centres with one-hour road travel time areas defined around each centre. Combining the geographic information with population data from

each 1-hour access area, the authors were able to find “a clear urban/rural divide.”<sup>27</sup>

The results of the study showed that 77.5% of Canadians reside within the one-hour catchment areas of Canada’s 32 level-I and -II trauma centres, with 100% of the 22.5% outside of this access range being in rural and remote areas. Therefore for a large proportion of the Canadian population, the “golden hour” is not within reach.<sup>27</sup>

### 2.1.3 Norway

The Norwegian rural trauma experience is described by several recent studies, which focus more on the epidemiology of rural trauma. In 2003, Wisborg et al. published 5 years of rural trauma experience in Finnmark, a rural and remote area in Norway with a sparse population and long distances.<sup>55</sup> In 2002, Laflamme and Engström, in their important study published in the *British Medical Journal*, established that the mortality rates from rural trauma in Scandinavian countries were well above the national average over the last 20 years.<sup>56</sup> Wisborg et al. undertook their analysis to identify the temporal-spatial relationship to trauma mortality with the goal of developing a regional rural trauma system.<sup>55</sup>

They undertook a large retrospective analysis of all mortalities originating from Finnmark between 1991-95 using data from the Norwegian National Registry of Death. Of the 183 deaths in the region during the period, 130, or 71 percent were due to trauma. Of these deaths, 85 percent occurred during the pre-hospital phase during transport. 72 percent of deaths occurred in the first hour after injury. The authors recognized the high death rate (77 per 100 000 inhabitants) but concluded that the only to change this would be to focus on prevention of injury.<sup>55</sup>

Sollid et al. provided a more comprehensive overview of the transfer process utilized in Norway for rural traumas.<sup>57</sup> In their assessment of the time it takes for patients with severe traumatic brain injury to reach the

level-I trauma centre in North Norway, the University Hospital of Northern Norway, the authors discovered that the median time to arrive to the emergency was 5 hours (range 1-44 hours). The majority of patients (81 percent) were transported using the air evacuation service, which utilizes both fixed and rotary wing aircraft. The study uncovered two mechanisms of transport: patients were either transported to the level-I trauma centre directly, or were transferred to a regional hospital without neurosurgical capabilities first. The direct group arrived at definitive services significantly faster than the transfer group, often with effect on mortality outcomes. A group analysis performed by the authors found that the level of injury and other patient characteristics between both groups were very similar, and so no clear rationale could be found for why the journey was divided into two phases for the transfer group. They concluded that despite a well-developed air evacuation service, it was not well utilized.<sup>57</sup>

## 2.2 Quantifying remoteness

There is no internationally agreed upon definition of rural, making it difficult to directly link remoteness to trauma deaths. The organization of trauma care systems tends to evolve differently in the unique context of each nation or region, as summarized in the sections above. Geography, weather conditions, access to definitive care, the socioeconomic status of rural communities, and the presence of a mature medical evacuation system with well-trained personnel capable of delivering crucial life-saving procedures in the earliest hours are all factors that influence rural trauma outcomes. In the next three sections the literature will be reviewed for the use of strategies to quantify remoteness and directly link these findings to mortality from trauma deaths, ranging from the earliest use of ecologic strategies to more modern methods combining population measures with geographic information science and social vulnerability indices.

### 2.2.1 Use of ecologic approaches to quantify rural trauma

The earliest and least resource-intense approach to quantifying remoteness that emerged in this review of the literature was the use of purely ecologic approaches and epidemiological analysis to reach conclusions about rural trauma outcomes. There are several examples in the literature of the use of this approach, such as the work by Nathens et al.<sup>11</sup> and the study by Gomez et al, “Identifying Targets for Potential Interventions to Reduce Rural Trauma Deaths: A Population-Based Analysis.”<sup>58</sup> In this work, the authors conducted a ecologic retrospective cohort study evaluating all trauma deaths occurring in the province of Ontario, Canada, over the interval 2002 to 2003. Patient cohorts were defined by their potential to access trauma centre care using two different approaches, rurality and timely access to trauma centre care. Analyzed this way, the authors found an overall injury mortality of 14.6 per 100 000 person-years. More than 50 percent of the deaths had occurred en route to definitive trauma care, with rural injuries being twice as likely to suffer this fate.<sup>11,58</sup>

Ecologic approaches have several limitations, including the inability to link specific travel distances to trauma outcomes. There is a lot of selection bias, as often data is only available from patients who have survived long enough to be discovered. Furthermore, these approaches are not able to accurately determine geographic zones that are most vulnerable or that need specific interventions.

Despite the crude information ecologic approaches deliver, and the lack of direct geographic information, they serve as important tools for the initial, descriptive phase of any rural trauma experience, and is in fact the tool used in the study of Northern Québec’s rural trauma system, serving as the initial description of injury in this region.

### 2.2.2 Geographic Mapping Systems

One of the earliest experiences of using maps to quantify remoteness was by Baker et al in 1987.<sup>59</sup> The authors calculated ecologic death rates of occupants of motor vehicle crashes from 1979 to 1981 and mapped them according to county for 48 states of the U.S. They found that predictors of mortality were low population density, and low per capita income. Furthermore, their work served as the first example of using geographic maps and morality data to pinpoint regions with poor road conditions, unregulated travel speeds, and weak or nonexistent seat belt laws. This is an important study as it caused a paradigm shift in how rural trauma is assessed.<sup>59</sup> Beyond just the use of registries, this study introduced the importance of geographic mapping and socioeconomic factors.

Fatovich and Jacobs utilized one of the most developed geographic approaches to quantifying remoteness and linking it to rural trauma mortality in Australia. In their paper assessing remoteness and trauma deaths in WA, the authors made use of the Accessibility/Remoteness Index of Australia (ARIA+), a tool that quantifies accessibility and remoteness as two ends of a continuous spectrum.<sup>49</sup>

ARIA+ was developed by the National Centre for Social Applications of Geographic Information Systems, as a standard national measure of remoteness.<sup>9</sup> It is a geographic accessibility index that aims to reflect the ease or difficulty people face accessing services in nonmetropolitan Australia.<sup>60</sup>

It measures remoteness in terms of access along the road network from over 10,000 localities to five categories of service centres.<sup>9</sup> Areas that are more remote have less access to service centres; areas that are less remote have greater access to service centres.<sup>9</sup> ARIA+ is based on the road distances people have to travel to obtain services.<sup>9</sup> Localities are where people are coming from, and service centres are where they are going to.<sup>9</sup> ARIA+ is a continuous variable with values ranging from 0 (high



accessibility) to 1.5 (high remoteness).<sup>60</sup> It is a purely geographic measure of remoteness, which excludes any consideration of socio-economic status, rurality, and population size factors.<sup>60</sup>

The authors applied 2001 census data that they obtained from the Australian Bureau of Statistics to the ARIA+ index and found a disproportionately higher mortality rate as the ARIA+ index increased. These findings were expected, but when the authors assessed the time of death, a majority of deaths occurred during the transport process itself, which led them to recommend changes to the training of pre-hospital personnel.<sup>49</sup>

A limitation of the ARIA and all purely geographic systems is that they fail to factor important socioeconomic parameters from the rural populations, and this could be an important confounding factor that would need controlling in any analysis.

### 2.2.3 Combining geographic information with social vulnerability indices

As reviewed in section 2.1.2, the PIVA score is an important tool to quantify both geographic access and social vulnerability. This tool could serve an important role in rural trauma system development by identifying where crucial services can be placed. It is described in detail in section 2.1.2, but is noted here as it presented an important node in the development of tools that went beyond just geographic mapping and integrated important vulnerability indices.<sup>54</sup>

CHAPTER 3  
MANUSCRIPT

Characterizing Northern Québec's Trauma "System" - Services,  
Transport, and Survival

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Manuscript slated for submission to World Journal of Surgery in January 2014.

Some modifications have been made to the manuscript for the purposes of  
integrating into this manuscript-based thesis.

### 3.1 Manuscript Abstract

**OBJECTIVE:** Studies have shown mortality and morbidity rates from traumatic injury to be higher in remote and rural populations compared to urban areas. In remote North Québec communities, transport to the McGill University Health Centre (MUHC), a level-1 trauma centre, is the only option for complex trauma care. This study aims to provide: (1) a demographic analysis of the Northern Québec region, with an emphasis on characterizing the available trauma care infrastructure; (2) the mechanisms and rates of injuries in the North that require transfer; (3) a comparison of outcomes, for the same injury severity score (ISS), between urban trauma patients arriving to the MUHC and those requiring transport from the North.

**METHODS:** A retrospective analysis of all trauma patients with an injury severity score of 16 or more who were entered into the MUHC trauma registry from Jan 2005-December 2009 was performed, identifying patients transported from the North separately. Data collected from both groups was analyzed to derive frequencies, means and percentages for the various parameters, which were then used to calculate mortality rates for both populations. A student's t-test was used to compare means and percentages. The level of significance was set at  $p < 0.05$ . A multivariate logistic regression model examined mortality in relation to geographic location, controlling for age, ISS, and patient co-morbidities.

**RESULTS:** An assessment of available health and trauma services in Northern Québec was performed and is summarized. The MGH received 9952 traumas during the study period. 254 of these patients were from the North and had an ISS above 15. 1027 patients with an ISS above 15 were transported from local suburban hospitals. The mean age for the locally transported cohort was > 40 years. The Northern Québec cohort was on

average 32.3 years old. Motor Vehicle Collision was the most common mechanism in the Northern Québec group, whereas falls were the most common mechanism in the local group. Penetrating trauma was the cause of 21.7% of all transports from the North, whereas it represented 12.5% of the injuries seen in the local population. Patients transferred from the Northern region with an ISS > 15 had a significantly higher mortality rate at 9% compared to 3% for patients transferred from local hospitals ( $p=0.023$ ). The multivariate logistic regression model assessing origin of transfer to mortality outcome revealed an adjusted odds ratio of 1.24 (95% CI 1.13-1.35,  $p=0.008$ ) for patients arriving from the North, controlling for age, ISS, and co-morbidities.

CONCLUSION: The study is a comparison between remote and urban populations in a single trauma network. Trauma patients from this remote area in Northern Québec with ISS > 15 had a significantly higher mortality rate than those from the urban environment.

### 3.2 Introduction

The region of Nord-du-Québec (Northern Québec) is the largest of the seventeen administrative regions of Québec, Canada, covering 55%, or 839,000 km<sup>2</sup>, of the geographic landmass of the province. It is divided into the Jamésie region in the South and the Nunavik region in the North, with a shared total population of almost 40,000 inhabitants (2001 census). The population is made up of about 13,000 Cree inhabiting the Jamésie region and 9,000 Inuit in the Nunavik region, making up most of the Northern population, with inhabitants of the Southern region being of mostly European descent.<sup>28,61</sup>

The administrative structure of the region is divided amongst 2 native semi-autonomous governments and 5 municipalities, with the Grand Council of the Crees (encompassing the Cree Regional Authority) representing the 9 Cree villages, and the Kativik Regional Government providing services to the 14 villages of the Nunavik region, both Inuit and nonlevel-Inuit. Baie-James (James Bay) represents the largest of the 5 municipalities and encompasses most of the geographic region of Jamésie.<sup>31,61</sup>

The Northern Québec region as a whole has a very rugged and varied geographic terrain, with 121,000 km<sup>2</sup> of the geographic landmass being covered by water. There is a limited network of roads in the Jamésie region reaching most of the few, small communities, and there are no roads to connect the south to the Nunavik region. Within Nunavik itself, there are few isolated roads in and around villages, and access to this region is limited to air travel, sea travel, or hiking long distances in tumultuous weather and terrain conditions. All villages have their own airport, with the regional hub at Kuujuaq, the largest community in Nunavik. Air travel continues to be the main lifeline of the region.<sup>30,32,61</sup>

The road system is sparse in Northern Québec. As such, there are no roads connecting villages in Nunavik. The James Bay and Eeyou Istchee region on the other hand has a few roads. A graveled road connects the coastal villages of Waskaganish, Eastmain, and Wemindji to the Route du Nord, which connects Matagami to Chisasibi. In the interior, Nemaska, Mistissini, and Waswanipi have road access to the towns of Chibougamau and Val d'Or. Travel to Montreal from these communities is possible by plane, bus or personal vehicle.

Transport within communities is mostly done by snowmobile in the winter months or by all-terrain vehicle. Between communities, people travel by small Twin Otter planes. Commercial companies in Dash-8 airplanes and occasionally in Boeing 737 airplanes provide transport to and from the urban areas. Air Inuit and First Air fly to villages along the coasts of Ungava Bay and Hudson Bay, whereas Air Creebec services the James Bay and Eeyou Istchee region.

Few studies outside of some governmental reports have outlined the health care infrastructure of this isolated area, which is heavily dependent on health care professionals cycling through the few clinics, community health centres, and small hospitals that are distributed throughout. Available resources are limited compared to those of urban hospitals, which often places the communities in this region at an increased risk of morbidity and mortality. Trauma, a major public health burden in this region, represents a unique challenge and strain on the available poor health care infrastructure, with all moderate-to-major trauma injuries requiring transfer to the McGill University Health Centre (MUHC) in Montreal, a regional level-1 trauma centre. Transportation of the injured through air travel remains the only option in the management of life-threatening injuries. There have been no studies to assess the outcomes of transporting trauma patients, to elucidate the mechanisms of injury, initial life-saving resuscitative measures (intubation, chest tube placement, etc.), or the limitations to transporting patients to Montreal (weather conditions,

recognition of need to transfer, etc.) facing health care providers in the North.

The MUHC maintains a full database of patients with injuries who are transported to its site from the North, with detailed information on the above-mentioned parameters, including transport times. This data was tapped for the purposes of identifying patterns, challenges, and limitations in the current practice of transporting trauma patients from the North to Montreal. To gain a better perspective of the trauma model in the North, enumeration of the available health care services is necessary, and the MUHC lies in a unique position to obtain this detailed information, as it houses the main administrative coordinator of Northern Québec's health care services, the Réseau universitaire intégré de santé de l'Université McGill (RUIS). This important organization has a mandate from the Ministère de la Santé et des Services Sociaux (Ministry of Health and Social Services) in Québec to map the social and health services available in the North, in addition to providing continuing education and professional development courses to the health care providers working in Northern Québec.

### 3.3 Methods

#### 3.3.1 Study Design

This is retrospective ecologic cohort study evaluating trauma deaths in one trauma network from 2005-2009. All trauma patients with an injury severity score of 15 or more that were received at the MGH were examined. The MUHC maintains a full database of the injuries transported to its site from the North, with detailed information on age, mechanism of injury, geographic origin of injury, travel time to the MGH, injury severity, and patient outcomes. This data was analyzed for the purposes of identifying patterns, challenges, and limitations in the current practice of transporting trauma patients from the North to Montreal.

#### 3.3.2 Data sources and inclusion/exclusion criteria

The MGH trauma registry was used to identify all traumas received between January 2005 and December 2009. All injuries with an Injury Severity Score  $< 15$  (see Appendix B) were excluded regardless of patient origin. Patients who died prior to arrival to the ED of the MGH were also excluded. Patients were then categorized according to first point of contact with trauma care. Patients whose first point of contact was with the MGH were identified and data collected from this population was used as the reference in the model used to compare transport outcomes between patients from Northern Québec and patients who were transported from a suburban hospital. Patients who were transferred to the MGH from any of the hospitals in the local Montreal network (i.e. excluding Northern Québec) were classified as “local transports” and patients who came from any of the areas in Northern Québec were classified as “Northern transports.”



To describe the trauma model in the North, information on available trauma care services was obtained through the Réseau universitaire intégré de santé de l'Université McGill (RUIS). This organization houses many personnel who have mapped the available health care infrastructure in Northern Québec. Through interviews with local staff and health professionals who work in Northern Québec we were able to obtain information on health and trauma services in each area.

### 3.3.3 Study Parameters

The following baseline patient characteristics were recorded: age, sex, mechanism of injury, injury severity, origin of trauma location, travel time to the MGH, and comorbidity status using the Charlson Comorbidity Index (CCI).<sup>62</sup> The CCI is a weighted score of 23 conditions, with varying weights of 1, 2, 3, or 6 allocated depending on the risk of dying from each condition; it has been shown to predict prognosis and health service use.<sup>62</sup> Injury severity was quantified using the injury severity score (ISS) and the abbreviated injury scale (AIS).<sup>63</sup> The AIS is an anatomically based consensus-derived global severity scoring system that classifies each injury in every body region according to its relative severity on a six point ordinal scale, using 9 anatomic body regions. The ISS is then calculated by adding the AIS from each body region (for more details see Appendix B). Patient outcomes, such as length of stay, mortality, and the number and type of complications for each patient were also extracted from the database or by chart review when this information was not available in the database. Complications were classified as wound, pulmonary, urinary, cardiac, or other including bleeding, thrombosis, and sepsis.

### 3.3.4 Statistical Analysis

Patient baseline characteristics (age, sex, CCI, mechanism of injury,

travel times), length of stay, mortality, and number of complications were summarized for the sample. A multiple logistic regression model was fitted to the data to test the association between geographic origin and mortality. Confidence intervals excluding 0 were deemed statistically significant. Means and standard deviations are presented for continuous variables when the data was distributed normally, whereas medians are used as a measure of centrality when the data was skewed. Absolute and relative frequencies are presented for discrete variables. Means were compared using the t test and p-values are presented. Analysis was conducted using Stata© version 12.<sup>64</sup>

### 3.3.5 Choosing the best multivariate logistic regression model for prediction

The analysis plan consisted of using several variables as predictors of mortality for 2 populations: 254 patients with ISS>15 transferred to the MGH for trauma care from Northern Québec, whom we compared to 1027 patients also with ISS>15 transferred to the MGH from local, suburban Montreal hospitals. We chose the following variables based on their validation in previous studies as good predictors of prognosis in traumatic injury: age, injury severity score, number of emergency department visits for trauma or acute surgery in the year prior to the injury, the number of hospital admissions for trauma-related issues in the year prior to the injury, the rural status of the patient, intubation status upon arrival to the ED of the MGH, and the Charlson Comorbidity Index. See Appendix D for a more detailed description of each variable.

The primary outcome of our study is whether the patient died within the same admission after transport to the MGH for a traumatic injury. Given the binary outcome, a logistic regression model was chosen for the analysis of the data and estimation of the adjusted odds ratios for each predictor. Furthermore, we have utilized the Bayesian Information

Criterion (BIC)<sup>65</sup> in order select the most parsimonious logistic model that fits our data, based on the following criteria: backward selection process whereby each variable is removed from the full model including all variables until the lowest BIC score is obtained (see Appendix D for details). For comparison purposes, we also conducted the frequentist model selection process using the Akaike Information Criterion (AIC) method.<sup>66</sup> (reference) This process is less conservative than BIC but operates the same way, removing one variable at a time from the model and finding the combination of variables that give the lowest AIC score. (see Appendix D for details).

We summarized the inferential results and conducted a comparison of each variable estimate and standard error in both a univariate model and multivariate model. See Appendix D for a side-by-side comparison of odds ratios and confidence intervals in both a univariate and multivariate model for each variable.

--Chosen variables based on univariate vs. multivariate logistic regression analysis: age.cat (age), iss (injury severity score), er.visit (number of ED visits), rur.access (geographic origin of patient), and cci (Charlson Comorbidity Index).

--Dropped variables: adm (number of hospital admissions), intub.stat (intubation status). These variables were dropped because of colinearity between adm and er.visit, and between intub.stat and iss.

After executing the BIC and AIC method, er.visit was not included in the selected models, because the model not including er.visit had the lowest BIC and AIC scores. Both model selection methods include age category (age.cat), injury severity (iss), transport origin (rur.access), and comorbidity status (cci) as predictors in the best fitting model. (see Appendix D)

### 3.4 Results

#### 3.4.1 Health Services

In Nunavik, James Bay and Eeyou Istchee, each village has a Local Community Service Centre (CLSC), a publicly funded clinic run by the provincial government, responsible for providing primary health care services to the population. Table 1 enumerates the number of nurses and physicians allocated to each CLSC. As demonstrated, there are many more nurses than physicians in all three regions. Nunavik has a total of 119 nurses and 19 general practitioners, whereas the James Bay and Eeyou Istchee region has a total of 59 nurses and 12 general practitioners. Furthermore, not all CLSCs have a physician on site. Nurses therefore take on an important role in the provision of primary health services to the inhabitants of each village. Amongst their many responsibilities, they are on call 24/7, act as first responders, and consult physicians by satellite telephone as needed when none are on site (Table 1).

Three regional hospitals provide secondary and limited tertiary care services to Northern Québec's population. Nunavik has two health institutions, one on each coast. On the Coast of Ungava Bay, the Ungava Tulattavik Health Centre boasts an emergency room, a maternity ward, outpatient surgery, 15 short-term care beds, 10 long-term care beds, outpatient specialist clinics, a pharmacy, laboratory services, medical imaging (x-ray, ultrasound), electrocardiography, electroencephalography, and teleconferencing. The Health Centre's full time medical personnel is comprised of 7 general practitioners, 39 nurses, a pharmacist, 2 x-ray technicians and 3 medical technologists.

On the Coast of Hudson Bay, the Innulitsivik Health Centre is equipped with an emergency room, a maternity ward, one-day surgery, 17 short-term care beds, 8 long-term care beds, outpatient specialist clinics, a pharmacy, laboratory services, medical imaging (x-ray, ultrasound),

electrocardiography, and teleconferencing. The Centre's full time personnel includes 8 general practitioners, 48 nurses, a pharmacist, 2 x-ray technicians and 3 medical technologists.

The James Bay and Eeyou Istchee region has one hospital. Chisasibi Regional Hospital has 25 short-term care beds, 7 long-term care beds, a 6-bed hemodialysis unit, an emergency room, outpatient specialist clinics, and an operating room. It is also equipped with electrocardiography machines as well as modern digital radiology and ultrasound equipment. The hospital's full time personnel consist of 6 general practitioners and 24 nurses.

Tertiary health services in a variety of specialties (obstetrics and gynecology, surgery, pediatrics, orthopedics, internal medicine, ophthalmology, ENT, psychiatry) are available at all times by telephone and during periodical visits, at all regional hospitals.

All three hospitals' medical imaging services are linked to the McGill University Health Centre by teleradiology; images are sent to Montreal for interpretation by a Montreal-based radiologist. Because of bandwidth limitations, images are sent to Montreal overnight so as to avoid shutting down internet services for the entire village.

**Table 1: Demographic and health services data of Northern Quebec**

Demographic information		Health services		
Village	Population	Facilities	Nurses	General practitioners
Nunavik				
Coast of Ungava Bay				
Kangiqsujaq	605	CLSC**	2	-
Quaqtaq	315	CLSC	2	-
Kangirsuk	466	CLSC	3	-
Aupaluk	174	CLSC	1	-
Tasiujaq	248	CLSC	1	-
	735	CLSC	3	-
Kangiqsualujuaq	2,132	Ungava Tulattavik Health Centre	39	7
Kuujuuaq				
Coast of Hudson Bay	1,241	CLSC	5	1
Salluit	349	CLSC	2	-
Ivujivik	507	CLSC	3	-
Akulivik	1,457	Innulisivik Health Centre	48	8
Puvirnituq	1,597	CLSC	5	2
Inukjuak	390	CLSC	2	-
Umiujaq	568	CLSC	3	1
Kuujuarapik				
James Bay & Eeyou Istchee				
Coast of James Bay	3,972	Chisasibi Regional Hospital	24	5
Chisasibi	1,864	Dispensary of CLSC de la Côte	5	-
Waskaganish	650	Dispensary of CLSC de la Côte	3	-
Eastmain	1,215	Dispensary of CLSC de la Côte	4	1
Wemindji	812	Dispensary of CLSC de la Côte	4	2
Whapmagoostui	642	Dispensary of CLSC de l'Intérieur	3	½*
The Interior	2,897	Dispensary of CLSC de l'Intérieur	8	3
Nemaska	1,473	Dispensary of CLSC de l'Intérieur	5	½*
Mistissini	606	Dispensary of CLSC de l'Intérieur	3	-
Waswanipi				
Oujé-				
Bougoumou				

- ½: permanent part-time physician.
- \*\*CLSC: local community service centre

### 3.4.2 Transport and Medical Evacuation

In Northern Québec, patients suffering trauma injuries that require tertiary care services must travel from their village to the closest Health Centre or Hospital before being transported to the MUHC (Figure 2). For example, when a trauma occurs in the village of Salluit, along the coast of Hudson Bay, a patient must first be transported by prop plane (Twin Otter) to Puvirnituq Regional Hospital. Once in Puvirnituq, a patient is further transferred to the Montreal international airport by small jet (Dash-8) or Medivac plane, then by ambulance to the MUHC. As first responders, nurses are on call at all times for such medical evacuations and, in the absence of an on-site physician, are responsible for the patient evaluation and decision making process that culminates in the patient's transfer.

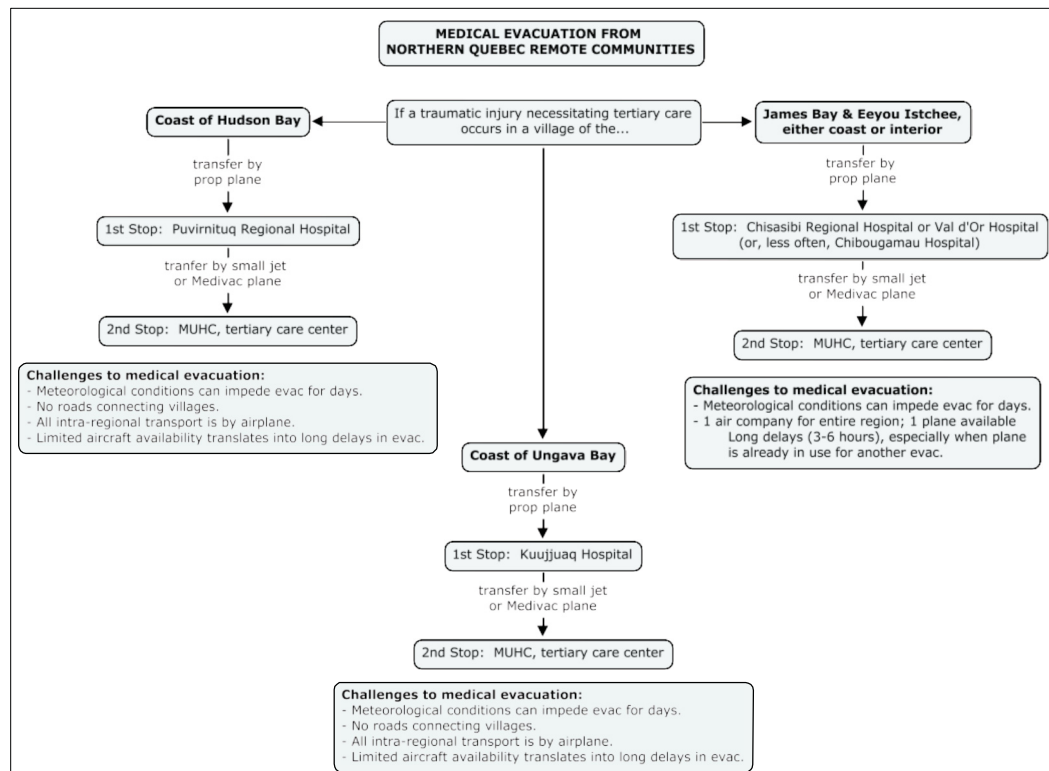


Figure 2: Medical evacuation scheme for trauma patients who need extraction from Northern Québec's remote communities.

There exist many challenges to medical evacuation of trauma injuries from Northern Québec's remote communities. Due to lack of roads between villages in Nunavik and long distances between villages in James Bay and Eeyou Istchee, air transport is the only option for inter-community transport. This being said, aircraft availability is limited; the James Bay region is serviced by one Airline Company, which only has one available airplane. Nunavik has similarly limited resources. This translates into long delays in evacuation, made longer when the single plane is used for another evacuation elsewhere in the region. Furthermore, unpredictable meteorological conditions such as blizzards or fog can impede evacuation, at times for days.

### 3.4.3 Trauma Epidemiology

From January 2005-December 2009 the MGH received 9952 traumas. Of these, 392 were from Northern Québec, representing 3.9 percent of all transports. 254 of these patients had an ISS above 15, representing 65 percent of all trauma patients from the North. 4016 were transported from the local suburban Montreal hospitals; representing 40.3 percent of all trauma patients, and 1027 of these, or 25.5 percent had an ISS above 15.

Table 2 compares some of the main parameters used to assess the two populations. The population from the North is younger at 32.3, and the majority are males. The injury severity was higher in the Northern population compared to the local transport population, with more anatomic regions injured on average (AIS 1.87 compared to 1.32). Of the 254 patients from Northern Québec who had an ISS > 15, 23 died, a mortality rate of 9%, compared to 30 patients who were transported locally, a mortality rate of 2.9%. This was statistically significant with a  $p = 0.023$ .

Motor vehicle collisions were the most common reason for transport across the Northern Québec population, with falls being the predominant



mechanism in the local group. Transfer times across all Northern Québec communities averaged 18.5 hours, highest for penetrating injuries at 20.6 hours and lowest in MVC patients at 15.6 hours. The overall operative profile was similar between both groups, with a higher thoracotomy rate in the Northern Québec cohort.

Table 2. Characteristics and mortality of patients transported from Northern Québec and locally

Variable	Northern transport (n=254)	Local transport (n=1027)	p-value
Age, mean (SD)*	32.3 (18.6)	46.5 (21.3)	0.0001
Male, n (%)	158 (62.3%)	575 (56.2%)	0.130
ISS**, median (range)	36 (17-41)	24 (13-28)	0.017
Number of regions with AIS*** $\geq 3$ , median (range)	1.87 (1.47-1.99)	1.32 (1.17-1.52)	0.001
Mechanism of injury, %			
MVC	47.3%	36.7%	0.033
Fall	18.4%	48.0%	0.017
Penetrating	21.7%	12.5%	0.001
Other Blunt	12.6%	2.8%	0.016
Type of Surgery, %			
Laparotomy	24.1%	22.6%	0.432
Thoracotomy	13.6%	8.3%	0.077
Laparotomy and Thoracotomy	11.1%	2.1%	0.021
Neurosurgery	36.5%	32.4%	0.066
Transport time, mean (SD) (hours)			
MVC	15.6 (4.6)	6.2 (3.4)	0.0001
Fall	17.4 (6.7)	3.5 (2.4)	0.0001
Penetrating	20.6 (7.2)	0.8 (0.3)	0.0001
Other Blunt	12.6 (5.4)	2.3 (1.2)	0.0001
Mortality, n (%)	23 (9%)	30 (2.9%)	

\*SD: standard deviation \*\*AIS: abbreviated injury scale \*\*\*ISS: injury severity score

Results of the model are shown in Table 3. For the same injury severity score, age, and comorbidity status, a patient from the North is 24% more likely to die when compared to a patient who was transferred from a local suburban hospital (OR 1.24, 95% CI 1.13-1.35,  $p=0.008$ ).

Table 3. Multivariate logistic regression model to assess trauma origin with mortality outcome.

Parameter	Adjusted Odds Ratio (95% CI)	p-value
Age (years)		
18-40 (reference)	1.00	
40-60	1.08 (0.94, 1.21)	0.912
above 60	1.23 (1.03, 1.41)	0.034
ISS (per point increase)	1.25 (1.05, 1.43)	0.023
CCI (per point increase)	1.15 (0.97-1.31)	0.971
Geographic origin		
local transport (reference)	1.00	
Northern Québec	1.24 (1.13, 1.35)	0.008

Table 4 compares the comorbidity and number of complications for each of the two populations. The population from the North had a higher CCI average of 5.3 compared to 4.3 for local patients ( $p=0.036$ ). The Northern transport population had a higher complication rate with 46% of patients having at least one complication postoperatively, whereas 22.4% of patients transported locally went on to develop at least one complication ( $p=0.026$ ). Noting that pulmonary includes disease processes such as pneumonia and pulmonary embolus, in the Northern transport group the most common single complication was blood transfusion, whereas in the locally transported group it was need for a ventilator.

The median length of stay for patients transported from Northern Québec was 67 days (4 – 219) whereas for patients transported locally it was 43 days (1 – 112).

Table 4. Comorbidity and complications for patients transported from Northern Québec compared to patients transported from local, suburban hospitals

Variable	Northern transport (n=254)	Local transport (n=1027)	p-value
Charlson Comorbidity Index, mean (SD)	5.6 (3.6)	4.3 (3.3)	0.036
Any complication, n (%)	117 (46%)	231 (22.4%)	0.026
Number of complications, n (%)			
0	137 (53.9%)	796 (77.5%)	0.031
1	54 (21.2%)	89 (8.6%)	0.014
2	33 (12.9%)	100 (9.7%)	0.132
≥3	30 (11.8%)	42 (4.1%)	0.041
Type of complication, n (%)			
Wound	87 (34.2%)	120 (47.2%)	0.029
Pulmonary	219 (86.2%)	934 (90.9%)	0.770
Intubation	96 (37.7%)	412 (40.1%)	0.344
Ventilator	114 (44.8%)	506 (49.2%)	0.624
Urinary	98 (38.5%)	188 (18.3%)	0.021
Cardiac	9 (3.5%)	16 (1.5%)	0.061
Bleeding (transfusion)	154 (60.6%)	344 (33.4%)	0.014
Septic Shock	43 (16.9%)	62 (6.0%)	0.027

#### 3.4.4 Applying ARIA+ criteria to Northern Québec

Applying ARIA+ criteria to Northern Québec revealed that the most remote regions (Kangiqsujuak, Kangirsuk, Salluit, and Ivujivik) were the most remote with a score of 13.61 on the ARIA+ scale. The remaining communities had a range of ARIA+ from 6.62 to 11.24. Puvirnituq in James Bay scored 6.6 and Kuujuaq in Nunavik scored 7.25.<sup>49</sup>

### 3.5 Manuscript Discussion

We undertook the task of compiling a comprehensive blueprint of available trauma care services in each of Northern Québec's major areas, as well as outlining in detail the complicated decision-making tree that is utilized when transport of a patient becomes necessary. Patients injured in Northern Québec who require transport to the MGH undertake a complicated journey that often requires stops at two airports before landing in Montreal. (Figure 2) In Nunavik, the main airport hub lies at Kuujuaq, whereas in James Baie and Eeyou Istchee it's in Chisasibi. This is where the final journey to Montreal originates. To arrive to either Kuujuaq or Chisasibi the patient often needs to take another journey using a propeller plane from one of a few towns in the North that has an airstrip. In some of the Northernmost fishing villages, to access a town that has an airstrip often involves a journey of many hours using boats, sleds, and motorized snowmobiles when available.

The difficulty we describe in accessing essential trauma care services in Northern Québec mirrors results from other studies. Fatovich and Jacobs quantified a direct relationship between remoteness and trauma deaths in Western Australia. Using ARIA+, a geographic measure of remoteness that reflects the ease/difficulty to access services when in non-metropolitan areas of Australia, they described 5 areas of remoteness based on distance by road from service centres. Using the ARIA+ model, Fatovich and Jacobs concluded that death rates from trauma in very remote areas is four times higher than that in major cities. This increase in mortality is caused in part by delay in discovery and delay in accessing trauma system.<sup>49</sup>

Furthermore, in a study by Gomez et al. that looked at the relationship between rurality and the setting in which patient death from injury is most likely to occur, a significant amount of trauma deaths in rural areas occurred in the emergency departments. In fact, Gomez et al.

found a threefold increase in the risk of death in the emergency department in areas with limited access to trauma centres. This further emphasizes the importance of improving the delivery of trauma care in rural environments.<sup>58</sup>

In this study, we identified the trauma epidemiology in Northern Québec, focusing on patients whom require transfer to Montreal. We compared the outcomes of these patients to another population of trauma patients transferred from a local Montreal network of hospitals. Despite being younger with an average age of 32.3, the Northern Québec population had a CCI of 5.6 compared to the local population's 4.3. The Northern Québec population is known to have higher rates of diabetes, acute and chronic respiratory conditions such as asthma and tuberculosis, and poorer access to primary and preventative health care, which is likely the result of this population's poorer health.<sup>34</sup> (Table 2 and 4)

The nature of trauma injuries were also worst from Northern Québec, with a median ISS of 36 compared to the local population's 24. Poor road conditions, more difficult winters, short daylight hours and lower visibility, and the use of riskier motorized snowmobiles for travel all contribute to more severe injuries. The proportion of patients with penetrating injuries was also significantly higher in the Northern population, with 20.6% of all transports having penetrating wounds, compared to 12.5% locally. Higher rates of alcoholism, suicide, and substance abuse lead to more violent means of injury. Interestingly, Table 2 transport times were highest for penetrating injuries in the Northern Québec group at 20.5 hours whereas it was the lowest for the local transport group at 0.8 hours. Reexamining the data we discovered that most penetrating injuries in Northern Québec occurred in the most remote regions, requiring the longest travel times.

We used a multivariate logistic regression model to predict mortality based on origin of transport, and as expected mortality outcomes were worst for the Northern Québec group with an OR of 1.24 (1.13-1.35) when

compared to patients who were transported from a local suburban hospital. Our model controlled for ISS, age, and comorbidity between both groups. These results are similar to findings of other studies that assessed mortality outcomes in rural trauma. Gomez et al. found that the RR for death in the rural populations they examined was 2.0, or two times as high as their urban counterparts.<sup>58</sup> They also attributed their findings to several factors, including high-risk behaviors such as speeding and inappropriate use of protective devices;<sup>5,6,58</sup> higher prevalence of alcohol use while driving;<sup>7,58</sup> higher prevalence of loaded unlocked firearms at home;<sup>58,67</sup> environmental factors such as exposure to agricultural machinery<sup>3,58</sup> and prolonged discovery times.<sup>8,58</sup> Their last point is true for the Northern Québec population as reflected in the longer transport times for most injuries.

In the single ecologic study of trauma, which controlled for injury severity, Goldberg et al. examined outcome after trauma as a function of hospital size (by extension, rurality).<sup>68</sup> Surprisingly, the authors found that small hospitals performed as well as large hospitals. Because rural hospitals are typically smaller than urban hospitals, Goldberg concluded that rural care for trauma victims was no worse than urban care.<sup>68</sup> Our data suggest that this is not the situation for trauma victims, especially those in very remote areas.

Beyond mortality, the Northern Québec patients experience more complications than locally transported patients, with 46% of all patients experiencing at least one complication compared to 22.4% of the local transport group. We predict that the more severe injuries, longer travel times, and poorer access to early definitive care lead to more complex injuries and thus the higher rate of complications and longer length of stays. Interestingly, use of ventilator was the most common complication amongst the local transport group, with 576 of the most severely injured patients requiring one, whereas it was lower in the Northern Québec group, perhaps as a result of the higher mortality rate precluding use of intensive

care services.

This study has several limitations. There is a strong selection bias if this data is used to make conclusions about the state of trauma injury in Northern Québec. Ultimately we are analyzing patients who have survived long enough to make it to the MGH, and thus there are many cases we have missed by nature of the study design and limitations in data acquisition. Exclusion of pre-hospital death from the analysis takes away important insights about burden of injury, excess pre-hospital mortality, and opportunities for injury prevention and optimization of trauma systems. This can be addressed by introducing a trauma registry into the local health centres operating in Northern Québec, and initial steps have been taken to accomplish this.

Furthermore, vital physiologic data wasn't always available for the Northern Québec population, thus limiting our ability to develop a clear picture of the state these patients are arriving to the ED in. Scores such as ISS, AIS, and complications are static measures that predict prognosis, but they don't address the specific physiologic challenges that complex trauma cases present with after long delays. As such, conclusions about adequate resuscitation at any of the stops that these patients encounter on their long journeys are not possible. A discovery project that involves groundwork in Northern Québec locales would tackle this issue, and help identify areas where further training and support can be provided.

Another limitation is that the transport time data is just an overview of a complicated journey. Questions arise about where the patient is spending most of this time (i.e. waiting for an evacuation flight?). Without a clear description of the flow of patients it is also difficult to conclude where capacity building is needed.

Despite these limitations, our effort presents the first demographic and trauma outcomes analysis for this rural region, and serves as an introduction to this complex region. Further studies that incorporate the Northern perspective are needed in order to improve care delivery.

## CHAPTER 4

### DISCUSSION

#### 4.1 Describing the Northern Québec trauma model

This study introduces the important issue of rural trauma health in Northern Québec. A lot of the information presented is crude and descriptive in nature and only scratches the surface of a complex system of trauma care that lies at the intersection point of many issues: social and political vulnerability, underdeveloped infrastructure, poorer population health, dependence on a central hospital (MGH) thousands of kilometers away, and a spatially large and rugged geography. Our goal was to put together a study that begins to organize our knowledge of this important region. In this regard, we have outlined a fragmented health care infrastructure that depends on a few community health centres that struggle daily with difficult pathology, low resources, and isolation.

Chronic medical diseases and widespread infections in Northern Québec have stretched an already fragile health system without the added burden of having to deal with trauma injury. Trauma is a resource intensive and invasive disease process that needs a well-developed network of hospitals, personnel, and technology to be effective. Despite this, the local communities and health professionals active in Northern Québec have managed to respond with available resources and are dependent on transport to the MGH for complex injuries.

When compared to other rural areas both nationally and internationally, Northern Québec emerges as the most difficult geographic region to deal with extraction. The Northern Québec region as a whole has a very rugged and varied geographic terrain, with 121,000 squared kilometers of the geographic landmass being covered by water. There is a limited network of roads in the Jamésie region reaching most of the few, small communities, and there are no roads to connect the south to the



Nunavik region. Within Nunavik itself there are only a few isolated roads in and around villages, and access to this region is limited to air travel, sea travel, or hiking long distances in tumultuous weather and terrain conditions. Most villages do have access to local airstrips, with the regional hub at Kuujuaq, the largest community in Nunavik. Air travel continues to be the main lifeline of the region.

Definitive trauma care for this population remains the MGH, and this brings up an important issue with regards to the current trauma model in Northern Québec that goes beyond just access, and begins to tackle a theme that is beginning to emerge in the rural trauma literature. The model described in this study is an extension of urban trauma care into the Northern Québec rural community. In the U.S. work by Hsia et al. predicts that over 30 million people are more than 1 hour away from trauma care.<sup>1</sup> This study has shown that this will vary from area to area, even within a single country (e.g. British Columbia vs. Northern Québec experience).<sup>69</sup> Many of the patients injured in rural areas will have less severe injuries that do not require transport. Such patients can be managed effectively in their local communities without the need for travel. Having access to surgical care is crucial in this regard, as some studies have shown that the presence of a general or orthopedic surgeon in a regional centre will cover up to 80% of traumatic injuries, with the remaining 20% being transferred after initial resuscitative and life-saving measures have been taken.<sup>69</sup>

This introduces a unique challenge for Northern Québec not shared by many other areas we assessed, namely that there is no surgical capacity beyond Val d'Or, which means that Nunavik and James Bay have no access to surgeons on most days of the year. The solution becomes better training for emergency medical personnel and health professionals currently working in Northern Québec.

A means of accomplishing this objective is to introduce training modules to health professionals in Northern Québec. The Rural Trauma Team Development Course (RTTDC©), Pre-Hospital Trauma Life Support

(PHTLS), Advanced Trauma Life Support (ATLS®), Trauma Nursing Critical Care (TNCC), Advanced Trauma Operative Management (ATOM®) and Advanced Surgical Skills for Exposure in Trauma (ASSET) can fill the knowledge gaps, noting that Surgeons would need to be recruited to the region to provide such courses. Kappel and colleagues demonstrated that RTTDC significantly reduced delays in the transfer process.

One difficulty that emerges in the unique Northern Québec context is course delivery options over such a large geographic area. We propose that use of videoconferencing technology to deliver the course materials is a viable option. Although we have yet to assess the impact of such courses, a pilot RTTDC® course delivered to nurses who were over 250 kilometers away from where the course was being taught found that it increased their knowledge (Razek, personal communication). This will be formally assessed in upcoming studies at the MUHC.

The concept of triage, or determining the priority of a patient's treatment based on their presentation has emerged as an important skill that needs to be reinforced in Northern Québec. This will help providers identify which hospital or centre is correct for the patient. Training to improve emergency medical personnel's skills in triage and life-saving resuscitative measures can improve local capacity. As an adjunct, the use of tele-trauma and tele-ultrasound may potentially enlarge the capabilities of the current trauma system in Northern Québec.<sup>71</sup>

## 4.2 Injury Prevention and Post-Injury Reintegration

Despite the common belief that trauma is a random event, several studies have shown that trauma is actually a predictable event with certain groups being at a higher risk for its occurrence.<sup>72,73,74,75</sup> Rogers et al. recently studied the concept of “recidivism” in their hospital, a term that refers to high-risk trauma patients who have multiple visits to the ED for subsequent injuries.<sup>78</sup> One factor that is considered high-risk for violent trauma is urban residential origin, as rural areas are seen as less risky for

violent injuries<sup>77,78,79</sup>, such as penetrating trauma or assault. We have found the opposite to be true for the Northern Québec population. Furthermore, patients with self-afflicted injuries were three times more likely than other injured patients to have had previous ED visits for injuries. Many of the penetrating injuries from Northern Québec population were self-inflicted, but it was difficult to quantify this because their identification is not easy through the registry (most cases were identified during chart reviews).

Northern Québec can be thought of as high-risk zone for trauma injuries, especially in the context of high socioeconomic vulnerability, high substance abuse rates, violent injuries, and high rates of mental illness. It becomes imperative that these issues be tackled in order to prevent injury, lower the trauma burden, and support community-based approaches to reintegration of trauma patients once injury has occurred.

These are bold statements but the literature does support the role injury prevention programs can play in rural areas, regardless of socio-demographic and cultural risk factors. Scott et al. reduced violent injuries and recidivism in their community through an injury prevention program that consisted of tours, videos, discussions groups, and group psychotherapy.<sup>80</sup> Gomez et al. created a program to help social reintegration after violent injury, which decreased readmission rates at both 1-year and 5-years.<sup>81</sup> If key stakeholders can be brought together such programs could potentially play an important role in Northern Québec's rural communities.

#### 4.3 Limitations

Beyond the limitations discussed in Chapter 3, there are important confounding issues with our study that need to be discussed. The statistical methods we employed do not take into account factors at the scene of injury that might influence both the decision regarding directness

of transport and risk of adverse outcomes.

The use of pre-hospital triage and transport guidelines introduce a type of confounding by indication such that the factors that are indications for direct transport to a Level-I trauma centre and those that dictate stopping at an intermediate facility may also be strongly related to risk of adverse health outcomes including complications and mortality. If this confounding is unaccounted for, such as in our study, estimates of the “transport” effect will be biased. Because the patient’s clinical status is likely to change as medical interventions are provided during different phases of their transport, risk adjustment limited to variables measured at hospital may be inadequate. Furthermore, evaluation of short-term mortality outcomes may be limited by not taking into account the timing of death or discharge in relation to injury. By definition, transferred patients have survived initial stabilization and transportation, whereas all patients transported directly to a Level-I trauma centre do not go through this selection process.

Furthermore, the comparison group from centers in the Montreal area with transport times of less than 1 hour to the Montreal General Hospital maybe fundamentally different from the Northern group. These patients come from different socioeconomic backgrounds and maybe have thresholds for transfer. They are likely not directly comparable to Northern patients who come from isolated communities over great and challenging distances. Despite this, attempts to control for various confounders were made through use of logistic regression modeling.

These reasons mean that we are only to make descriptive conclusions about the current state of trauma transport outcomes from Northern Québec. Despite this, this study presents an initial overview of patient flow through our trauma network, opening the door to future studies and interventions, discussed in the following section.

#### 4.4 Future Directions

The most important next step is to perform an assessment on the ground in Northern Québec. This will take the form of a simplified trauma registry, which can make use of electronic platforms. Several groups have now begun to introduce such electronic application-based registries in South Africa and Tanzania (Razek, personal communication). A simplified registry that collects information on mechanism as well as vital physiologic information can provide a more comprehensive picture of trauma injuries in Northern Québec.

Trauma registries are a method of actively assessing injury epidemiology of trauma with the goal of ameliorating effective prevention and acute care strategies. Trauma registries have sprung from the ideology of Quality Assurance, which is based on the philosophy that the majority of defects in care results from failure of the system rather than the individuals themselves.<sup>82</sup>

As reviewed in this study, there is a role for geographic mapping systems and tools such as PIVA in the quantification of remoteness. This has yet to be applied to Northern Québec, but is an important next step we will be undertaking to better characterize where resources and training are needed the most. Through maps we hope to identify communities with the most difficult access to care, the longest extraction process, and where the greatest sites of trauma influx are.

Lastly, we will offer the RTTDC© to health professionals working in the North. The first pilot course and study will be held in 2014, and will include a pre- and post-test as well as a global assessment scale for procedures.

## CHAPTER 5

### CONCLUSION

The region of Nord-du-Québec (Northern Québec) is the largest of the seventeen administrative regions of Québec, covering 55% of the geographic landmass of the province. It is divided into the Jamésie region in the South and the Nunavik region in the North, with a shared total population of almost 40,000 inhabitants.<sup>61</sup>

The Northern Québec region has a very rugged and varied geographic terrain, most of the landmass covered by water. There is a limited network of roads in the Jamésie region and there are no roads to connect the south to the Nunavik region in the North. Air travel continues to be the main lifeline of the region.<sup>61</sup>

Few studies have outlined the health care infrastructure of this isolated area, which is heavily dependent on health care professionals cycling through the few clinics, community health centers, and small hospitals that are distributed throughout. These factors often place the communities in this region at an increased risk of morbidity and mortality. Trauma, a major public health burden in this region, represents a unique challenge and strain on the available health care infrastructure, with all moderate-to-major trauma injuries requiring transfer to the Montreal General Hospital, a regional level-1 trauma centre. Extraction of the injured through air travel remains the only option in the management of life-threatening injuries.

Preliminary work conducted in this study has provided a better perspective of the trauma model in the North, a demographic assessment of the available trauma care services, and a characterization of the complicated transport algorithm used to extract critically injured patients. Future work will expand the characterization of this region's trauma system by the following strategies:

- 1) measurement of trauma system access using geographic mapping software and trauma outcomes data;
- 2) introduce a local trauma registry to capture the level of injury, patient characteristics, and local health provider expertise;
- 3) introducing unique methods of capacity-building and education of local health care workers by utilizing tele-conferencing technology

Epidemiological data, whether collected at health facilities or on the basis of surveys are essential for properly quantifying the magnitude of a public health problem.<sup>34</sup> This is a crucial first step in a public health approach to the issue of rural trauma in Northern Québec. The results of such studies facilitate the planning of interventions, the allocation of resources and aid in evaluating the impact of interventions. Information can then be accessible for the key players to mount an inter-sectoral response.

In conclusion, this work demonstrates the long transport times faced by injured patients in Northern Québec who require definitive trauma care in Montreal. A disproportionate number of these patients are victims of violence. These patients experience high complication rates, lengthy hospitalizations, and high mortality rates. A multivariate logistic regression was used to control for confounders such as age, injury severity, and comorbidity on the association between geography and injury mortality. This study relied on analysis of the McGill trauma database and is such to be viewed as hypothesis generating. It needs to be followed up by more comprehensive analysis of provincial, and particularly Northern, data when it becomes available.

## LIST OF REFERENCES

- 1) Statistics Canada. Statistical area classification: highlight tables, 2001 counts, for Canada, provinces and territories. Available at:  
[http://www12.statcan.ca/english/census01/products/highlight/SAC/Page.cfm?Lang\\_E&Geo\\_PR&Code\\_01&Table\\_1a&StartRec\\_1&Sort\\_2&B1\\_Age&B2\\_Counts](http://www12.statcan.ca/english/census01/products/highlight/SAC/Page.cfm?Lang_E&Geo_PR&Code_01&Table_1a&StartRec_1&Sort_2&B1_Age&B2_Counts).  
 Accessed March 12, 2013.
- 2) United States Department of Agriculture. Rural population and migration. Economic Research Service. Available at:  
<http://www.ers.usda.gov/Briefing/Population/>. Accessed March 12, 2013.
- 3) Peek-Asa C, Zwierling C, Stallones L. Acute traumatic injuries in rural populations. *Am J Public Health*. 2004;94:1689 -1693.
- 4) Eberhardt MS, Ingram DD, Makuc DM, et al. Urban and Rural Health Chartbook. Hyattsville, MD: National Center for Health Statistics; 2001.
- 5) Harlos S, Warda L, Buchan N, Klassen TP, Koop VL, Moffatt ME. Urban and rural patterns of bicycle helmet use: factors predicting usage. *Inj Prev*. 1999;5:183-188.
- 6) Zwierling C, Merchant JA, Nordstrom DL, et al. Risk factors for injury in rural Iowa: round one of the Keokuk County Rural Health Study. *Am J Prev Med*. 2001;20:230 -233.
- 7) Muelleman RL, Mueller K. Fatal motor vehicle crashes: variations of crash characteristics within rural regions of different population densities. *J Trauma*. 1996;41:315-320.
- 8) Gonzalez RP, Cummings G, Mulekar M, Rodning CB. Increased mortality in rural vehicular trauma: identifying contributing factors through data linkage. *J Trauma*. 2006;61:404-409.
- 9) Committee on Trauma. Resources for Optimal Care of the Injured Patient. Chicago: American College of Surgeons, 1999.
- 10) Baker SP. The Injury Fact Book. New York: Oxford University Press; 1992.
- 11) Nathens AB, Brunet FP, and Maier RV. Development of trauma systems and effect on outcomes after injury. *Lancet* 2004; 363: 1794-801.
- 12) Bazzoli GJ, Madura KJ, Cooper GF, MacKenzie EJ, Maier RV. Progress in the development of trauma systems in the United States: results of a national survey. *JAMA* 1995; 273: 395-401.
- 13) West JG, Williams MJ, Trunkey DD, Wolferth CC. Trauma systems: current status-future challenges. *JAMA* 1988; 259: 3597-600.
- 14) Sancton TA, Macleod S. Death of a princess: the investigation. New York: St Martin's Press, 1998.



- 15) Nathens AB, Jurkovich GJ, Rivara FP, Maier RV. Effectiveness of state trauma systems in reducing injury-related mortality: a national evaluation. *J Trauma* 2000; 48: 25-30.
- 16) Nathens AB, Jurkovich GJ, Cummings P, Rivara FP, Maier RV. The effect of organized systems of trauma care on motor vehicle crash mortality. *JAMA* 2000; 283: 1990-94.
- 17) O'Keefe GE, Jurkovich GJ, Copass MK, Maier RV. Ten-year trend in survival and resource utilization at a Level I trauma center. *Ann Surg* 1999; 229: 409-15.
- 18) Peitzman AB, Courcoulas AP, Stinson C, Udekwu AO, Billiar TR, Harbrecht BG. Trauma center maturation: quantification of process and outcome. *Ann Surg*. 1999; 230: 87-94.
- 19) Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. *J Trauma*. 1999; 47(3 suppl):S25-S33.
- 20) Trauma care. In: Bonnie RJ, Fulco CE, Liverman CT. *Reducing the Burden of Injury: Advancing Prevention and Treatment*. Washington, DC: National Academies Press; 1999:chap 6.
- 21) Thomas SH, Harrison TH, Buras WR, Ahmed W, Cheema F, Wedel SK. Helicopter transport and blunt trauma mortality: a multicenter trial. *J Trauma*. 2002;52:136-145.
- 22) Bass RR, Gainer PS, Carlini AR. Update on trauma system development in the United States. *J Trauma*. 1999;47(3 suppl):S15-S21.
- 23) Branas CC, MacKenzie EJ, ReVelle CS. A trauma resource allocation model for ambulances and hospitals. *Health Serv Res*. 2000;35:489-507.
- 24) Goldfarb MG, Bazzoli GJ, Coffey RM. Trauma systems and the costs of trauma care. *Health Serv Res*. 1996;31:71-95.
- 25) MacKenzie EJ, Hoyt DB, Sacra JC, et al. National inventory of hospital trauma centers. *JAMA*. 2003;289: 1515-1522.
- 26) Nathens AB, Maier RV. The relationship between trauma center volume and outcome. *Adv Surg*. 2001;35:61-75.
- 27) Hameed SM, Schuurman N, Razek T, et al. Access to Trauma Systems in Canada. *J Trauma*. 2010;69: 1350-1361.
- 28) Government of Québec Website on Northern Québec  
<http://www.nord.gouv.qc.ca/english/overview/index.asp>.  
 Accessed on February 3, 2013.

- 29) MINISTÈRE DES AFFAIRES MUNICIPALES ET DES RÉGIONS (2008). Aménagement et gestion du territoire, la Conférence régionale des élus, [http://www.mamr.gouv.qc.ca/amenagement/outils/amen\\_outi\\_acte\\_conf.asp](http://www.mamr.gouv.qc.ca/amenagement/outils/amen_outi_acte_conf.asp) Accessed on: March 22, 2013.
- 30) COMMISSION DE PROTECTION DU TERRITOIRE AGRICOLE DU QUÉBEC (2007). Rapport annuel 2006-2007, tableau synthèse de la zone agricole par MRC, [http://www.cptaq.gouv.qc.ca/fileadmin/fr/publications/publications/rannuel/rap\\_annuel2006-2007/contenu/pdf/14\\_tableau\\_MRC.pdf](http://www.cptaq.gouv.qc.ca/fileadmin/fr/publications/publications/rannuel/rap_annuel2006-2007/contenu/pdf/14_tableau_MRC.pdf) Accessed on: March 22, 2013
- 31) EMPLOI QUÉBEC (2007). Profil socio-économique Nord-du-Québec, <http://emploiquebec.net/francais/regions/nordquebec/publications.asp?categorie=1016103> Accessed on: March 24, 2013
- 32) MINISTÈRE DES RÉGIONS (2001). Politique de développement du Nord-du-Québec, 2001, [http://www.mdeie.gouv.qc.ca/fileadmin/sites/internet/documents/publications/pdf/developpement\\_regional/fr/general/polnqc.pdf](http://www.mdeie.gouv.qc.ca/fileadmin/sites/internet/documents/publications/pdf/developpement_regional/fr/general/polnqc.pdf) Accessed: May 12, 2013
- 33) Adelson, N., 2005. The embodiment of inequity—health disparities in Aboriginal Canada. *Canadian Journal of Public Health-Revue Canadienne De Sante Pub-lique* 96, S45-S61.
- 34) PHAC, 2008. The Chief Public Health Officer's Report on the State of Public Health in Canada 2008. Public Health Agency of Canada, Ottawa, p. 122.
- 35) Eastman AB, Lewis FR Jr, Champion HR, Mattox KL. Regional trauma system design: critical concepts. *Am J Surg.* 1987;154:79-87.
- 36) Mullins RJ, Veum-Stone J, Helfand M, et al. Outcome of hospitalized injured patients after institution of a trauma system in an urban area. *JAMA.* 1994;271:1919 -1924.
- 37) Mullins RJ, Veum-Stone J, Hedges JR, et al. Influence of a statewide trauma system on location of hospitalization and outcome of injured patients. *J Trauma.* 1996;40:536 -545.
- 38) McConnell KJ, Newgard CD, Mullins RJ, Arthur M, Hedges JR. Mortality benefit of transfer to level I versus level II trauma centers for head-injured patients. *Health Serv Res.* 2005;40:435- 457.
- 39) Newgard CD, McConnell KJ, Hedges JR, Mullins RJ. The benefit of higher level of care transfer of injured patients from nontertiary hospital emergency departments. *J Trauma.* 2007;63:965-971.
- 40) Nathens AB, Maier RV, Brundage SI, Jurkovich GJ, Grossman DC. The effect of

interfacility transfer on outcome in an urban trauma system. *J Trauma*. 2003;55:444-449.

41) Rogers FB, Osler TM, Shackford SR, Cohen M, Camp L, Lesage M. Study of the outcome of patients transferred to a level I hospital after stabilization at an outlying hospital in a rural setting. *J Trauma*. 1999;46:328-333.

42) Obremskey W, Henley MB. A comparison of transferred versus direct admission orthopedic trauma patients. *J Trauma*. 1994;36:373-376.

43) Rivara FP, Koepsell TD, Wang J, Nathens A, Jurkovich GA, Mackenzie EJ. Outcomes of trauma patients after transfer to a level I trauma center. *J Trauma*. 2008;64:1594 -1599.

44) Sampalis JS, Denis R, Frechette P, Brown R, Fleischer D, Mulder D. Direct transport to tertiary trauma centers versus transfer from lower level facilities: impact on mortality and morbidity among patients with major trauma. *J Trauma*. 1997;43:288 -295.

45) Hartl R, Gerber LM, Iacono L, Ni Q, Lyons K, Ghajar J. Direct transport within an organized state trauma system reduces mortality in patients with severe traumatic brain injury. *J Trauma*. 2006;60:1250 -1256.

46) Young JS, Bassam D, Cephas GA, Brady WJ, Butler K, Pomphrey M. Interhospital versus direct scene transfer of major trauma patients in a rural trauma system. *Am Surg*. 1998;64:88 -91.

47) Garwe T, Cowan LD, Neas BR, et al. Directness of Transport of Major Trauma Patients to a Level I Trauma Center: A Propensity-Adjusted Survival Analysis of the Impact on Short-Term Mortality. *J Trauma*. 2011;70: 1118-1127

48) Danne PD. Trauma management in Australia and the tyranny of distance. *World J Surg*. 2003;27:385-389.

49) Fatovich DM and Jacobs IG. The Relationship Between Remoteness and Trauma Deaths in Western Australia. *J Trauma*. 2009;67: 910-914.

50) Australian Bureau of Statistics. National Regional Profile: Western Australia. Canberra: Australian Bureau of Statistics; 2006.

51) Gupta R, Rao S. Major trauma transfer in Western Australia. *ANZ J Surg*. 2003;73:372-375.

52) Croser JL. Trauma care systems in Australia. *Injury*. 2003;34:649-651.

53) "Population Estimates, British Columbia and Sub-Provincial". BC Stats. December, 2012. Retrieved June 28, 2013.

54) Schuurman N, Bell N, Hameed MS, Simons R. A model for identifying and ranking need for trauma service in nonmetropolitan regions based on injury risk and access to services. *J Trauma*. 2008;65:54-62.

- 55) Wisborg T, Hoylo T, and Siem G. Death after injury in rural Norway: high rate of mortality and prehospital death. *Acta Anaesthesiologica Scandinavica* 2003;47:153-156
- 56) Laflamme L and Engstrom K. Socioeconomic differences in Swedish children and adolescents in road traffic accidents: cross-sectional study. *BMJ* 2002;324:396-397
- 57) Sollid S, Munch-Ellingsen J, Gilbert M, et al. Pre- and Inter-Hospital Transport of Severely Head-Injured Patients in Rural Northern Norway. *Journal of Neurotrauma* 2003;20:309-314.
- 58) Gomez D, Berube M, Xiong W, et al. Identifying targets for potential interventions to reduce rural trauma deaths: a population-based analysis. *J Trauma*. 2010;69: 633-639.
- 59) Baker SP, Whitfield RA, O'Neill B. Geographic variations in mortality from motor vehicle crashes. *N Engl J Med*. 1987;316:1384-1387.
- 60) GISCA The National Centre for Social Applications of GIS. ARIA\_ Accessibility/Remoteness Index of Australia Plus Version 2.0. Adelaide: University of Adelaide; 2004.
- 61) Nord-du-Québec Territorial Profile. Published by Direction générale du Nord-du-Québec. [www.mrnf.gouv.qc.ca/territoire/planification/planification-portraits.jsp](http://www.mrnf.gouv.qc.ca/territoire/planification/planification-portraits.jsp). Accessed July 2012.
- 62) Charlson ME, Charlson RE, Peterson JC, et al. The Charlson comorbidity index is adapted to predict costs of chronic disease in primary care patients. *J Clin Epi* 2008;61:1234-1240.
- 63) Baker, S.P.; B. O'Neill, W. Haddon Jr., W.B. Long (1974). "The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care". *The Journal of Trauma* (Lippincott Williams & Wilkins) 14 (3): 187-196.
- 64) Stata Statistical Software: Release 12. College Station, TX: StataCorp LP)
- 65) Schwarz, Gideon E. (1978). "Estimating the dimension of a model". *Annals of Statistics* 6 (2): 461-464.
- 66) Anderson, D. R. (2008), *Model Based Inference in the Life Sciences*, Springer.
- 67) Nordstrom DL, Zwerling C, Stromquist AM, Burmeister LF, Merchant JA. Rural population survey of behavioral and demographic risk factors for loaded firearms. *Inj Prev*. 2001;7:112-116.
- 68) Goldberg J, Levy PS, Morkovin V, Goldberg JB. Mortality from traumatic injuries. A case-control study using data from the National Hospital Discharge Survey. *Med Care*. 1983;21:692-704.

- 69) Hsia R, Shen YC. Possible geographical barriers to trauma center access for vulnerable patients in the United States: an analysis of urban and rural communities. *Arch Surg* 2011;146: 46-52.
- 70) Kappel DA, Rossi DC, Polack EP, Avtgis TA, Martin MM. Does the rural trauma team development course shorten the interval from trauma patient arrival to decision to transfer? *J Trauma* 2011; 70: 315-319.
- 71) Hussain P, Melville D, Mannings R et al. Evaluation of a training and diagnostic ultrasound service for general practitioners using narrowband ISDN. *Journal of telemedicine and telecare*. 1999;5:95-99.
- 72) Reiner DS, Pastena JA, Swan KG, Lindenthal JJ, Tischler CD. Trauma recidivism. *Am Surg*. 1990;56(9):556-60.
- 73) Poole GV, Griswold JA, Thaggard VK, Rhodes RS. Trauma is a recurrent disease. *Surgery*. 1993;113(6):608-11.
- 74) Wan JJ, Morabito DJ, Khaw L, Knudson MM, Dicker RA. Mental illness as an independent risk factor for unintentional injury and injury recidivism. *J Trauma*. 2006;61(6):1299-304.
- 75) Smith RS, Fry WR, Morabito DJ, Organ CH Jr. Recidivism in an urban trauma center. *Arch Surg*. 1992;127(6):668-70.
- 76) Rogers A, Horst M, Rittenhouse K, et al. Urban versus rural trauma recidivism: is there a difference? *Eur J Trauma Emerg Surg*. 2013. Accessed online ahead of print: DOI 10.1007/s00068-013-0355-6
- 77) Williams JM, Furbee PM, Hungerford DW, Prescott JE. Injury recidivism in a rural ED. *Ann Emerg Med*. 1997;30(2):176-80.
- 78) Sayfan J, Berlin Y. Previous trauma as a risk factor for recurrent trauma in rural Northern Israel. *J Trauma*. 1997;43(1):123-5.
- 79) Kaufmann CR, Branas CC, Brawley ML. A population-based study of trauma recidivism. *J Trauma*. 1998;45(2):325-32.
- 80) Scott KK, Tepas JJ 3rd, Frykberg E, Taylor PM, Plotkin AJ. Turning point: rethinking violence-evaluation of program efficacy in reducing adolescent violent crime recidivism. *J Trauma*. 2002;53(1):21-7.
- 81) Gomez G, Simons C, St John W, Creasser D, Hackworth J, Gupta P, Joy T, Kemp H. Project Prescription for Hope (RxH): trauma surgeons and community aligned to reduce injury recidivism caused by violence. *Am Surg*. 2012;78(9):1000-4.
- 82) Cameron, Peter A., et al. "The trauma registry as a statewide quality improvement tool." *The Journal of Trauma and Acute Care Surgery* 59.6 (2005): 1469-1476

## APPENDIX A

### Description of trauma centre levels

In North America trauma centres are designated as level-I to level-V by the American College of Surgeons.

Level-I: a trauma centre capable of delivering the full spectrum of trauma care, including all surgical subspecialties (in addition to neurosurgery). It is required to have a certain number of surgeons, emergency physicians, nurses, and anesthesiologists on duty 24 hours a day, 7 days a week. Furthermore, it is required to have a continuing education program (i.e. residency) and an injury prevention program for the community it serves in order to maintain its designation.

Level-II: a centre that works in conjunction with a level-I centre and has to provide all essential services 24 hours a day, 7 days a week. It is not required to have a residency or injury prevention program.

Level-III: a level-III trauma center does not have the full availability of specialists, but does have resources for emergency resuscitation, surgery, and intensive care of most trauma patients. A level-III center has transfer agreements with level-I or level-II trauma centers that provide back-up resources for the care of exceptionally severe injuries.

Level-IV: a centre that provides initial evaluation, stabilization, diagnostic capabilities, and transfer to a higher level of care.

Level-V: same as a level-IV but the emergency department is not open 24 hours a day.

Reference: American College of Surgeons (2006). Consultation/Verification Program, Reference Guide of Suggested Classification. American College of Surgeons. p. 3. ISBN 0-7817-2641-7.

## Appendix B

### Injury Severity Score

The Injury Severity Score (ISS) is an established medical score to assess trauma severity. It correlates with mortality, morbidity and hospitalization time after trauma. It is used to define the term major trauma. A major trauma (or polytrauma) is defined as the Injury Severity Score being greater than 15. The AIS Committee of the Association for the Advancement of Automotive Medicine (AAAM) designed and improves upon the scale.

The Abbreviated Injury Scale (AIS) is an anatomically based consensus-derived global severity scoring system that classifies each injury in every body region according to its relative severity on a six point ordinal scale:

1. Minor
2. Moderate
3. Serious
4. Severe
5. Critical
6. Maximal (currently untreatable).

There are nine AIS chapters corresponding to nine body regions:

1. Head
2. Face
3. Neck
4. Thorax
5. Abdomen
6. Spine
7. Upper Extremity
8. Lower Extremity
9. External and other.

Calculating an ISS score:

The ISS is based upon the Abbreviated Injury Scale (AIS). To calculate an ISS for an injured person, the body is divided into six ISS body regions. These body regions are:

- Head or neck - including cervical spine
- Face - including the facial skeleton, nose, mouth, eyes and ears
- Chest - thoracic spine and diaphragm
- Abdomen or pelvic contents - abdominal organs and lumbar spine
- Extremities or pelvic girdle - pelvic skeleton
- External

To calculate an ISS, take the highest AIS severity code in each of the three most severely injured ISS body regions, square each AIS code and add the three squared numbers for an ISS ( $ISS = A^2 + B^2 + C^2$  where A, B, C are the AIS scores of the three most injured ISS body regions). The ISS scores ranges from 1 to 75 (i.e. AIS scores of 5 for each category). If any of the three scores is a 6, the score is automatically set at 75. Since a score of 6 ("unsurvivable") indicates the futility of further medical care in preserving life, this may mean a cessation of further care in triage for a patient with a score of 6 in any category.

Reference: Baker, S.P.; B. O'Neill, W. Haddon Jr., W.B. Long (1974). "The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care". The Journal of Trauma (Lippincott Williams & Wilkins) 14 (3): 187-196.

# APPENDIX C Detailed health service infrastructure for James Bay and Nunavik

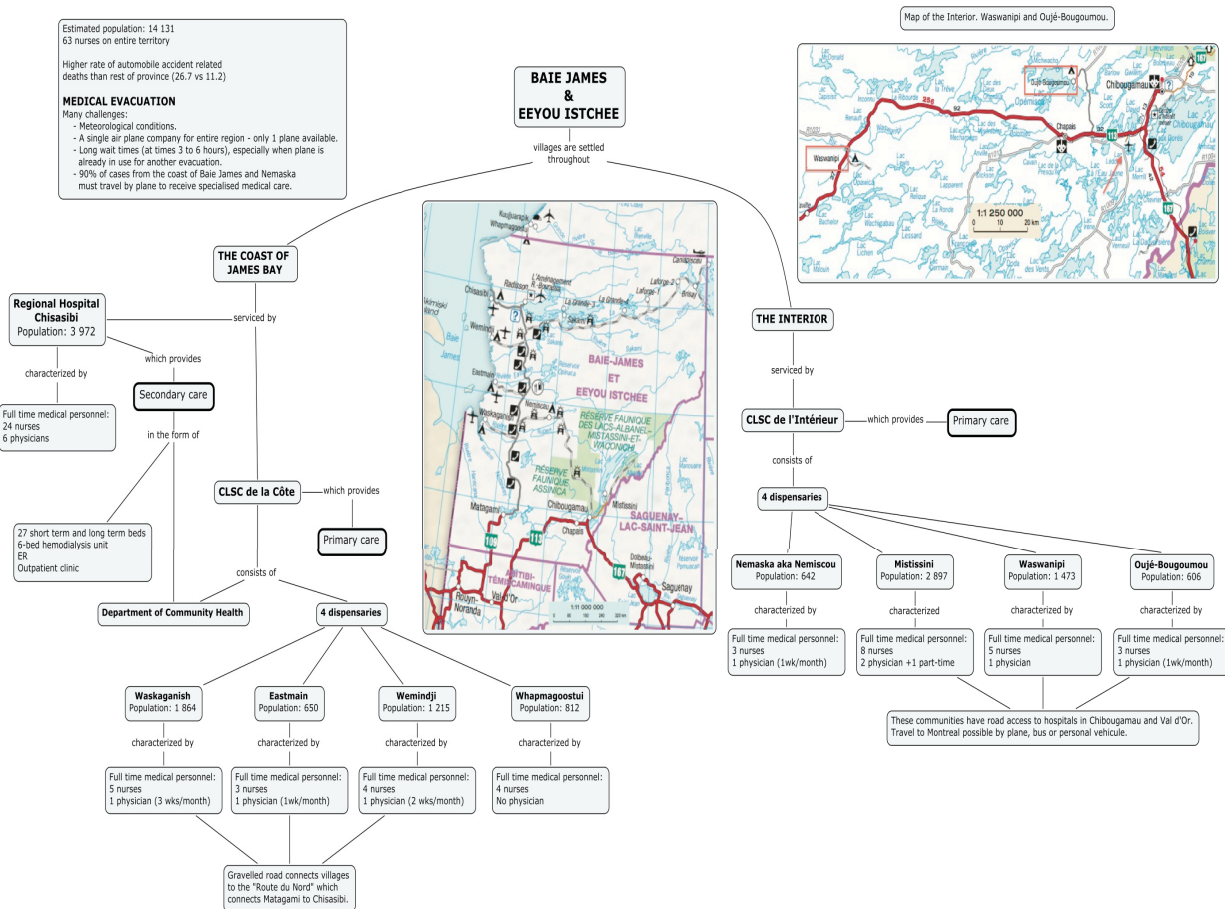


Figure 3. Detailed visual map of available health and trauma services in James Bay.



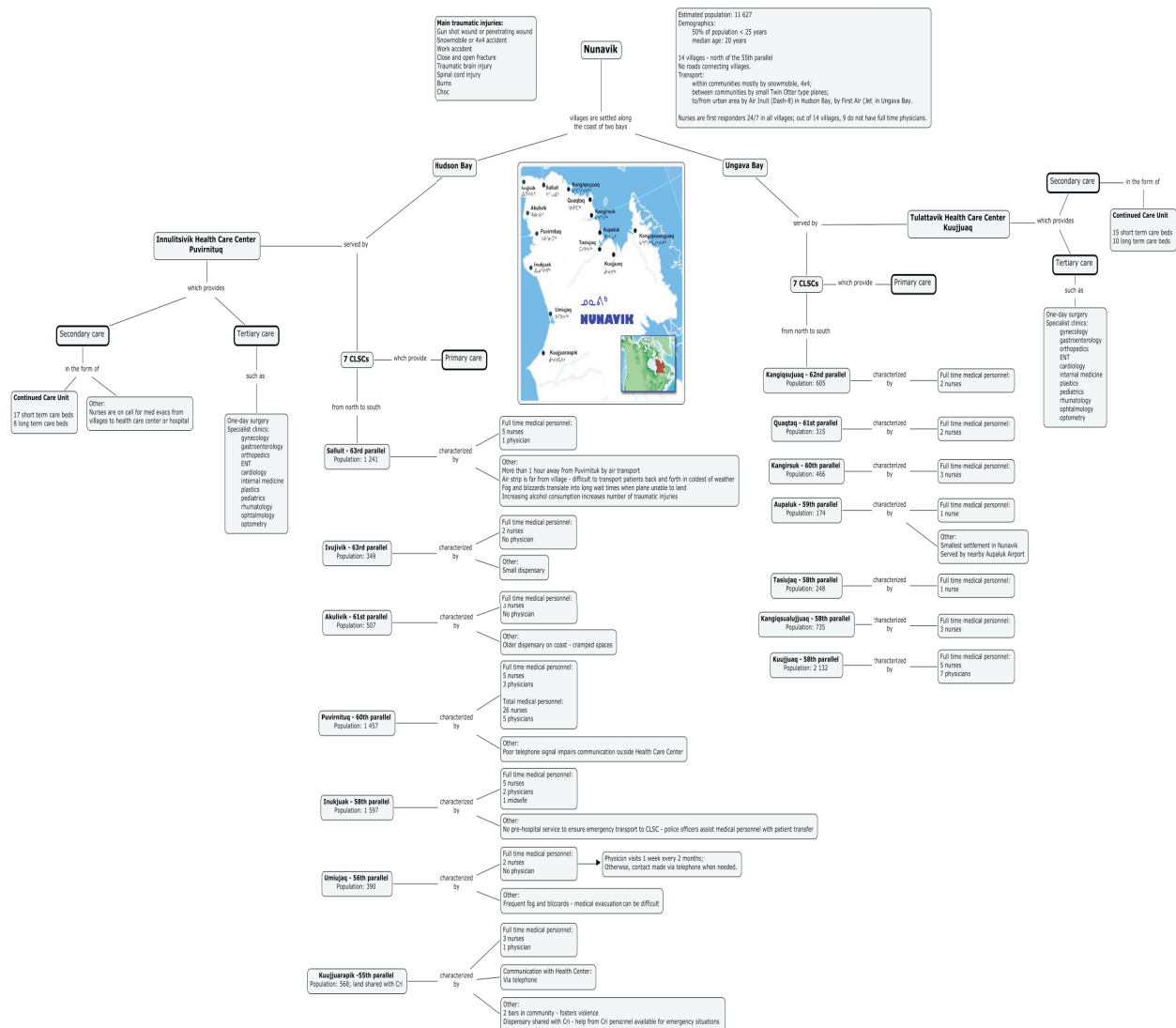


Figure 4. Detailed visual map of available health and trauma services in Nunavik.

APPENDIX D  
Statistical process for choosing best model

Variable	Description
age.cat	Categorized age groups. age.1= patient between 40 and 60 age.2= patient between 60 and 80 age.3= women that are 80 or older
iss	The injury severity score is an established medical score to assess trauma severity. All patients had ISS > 15 to be considered in the analysis. Coded as a continuous variable with increments of 1 point, i.e. 16, 17, 18, etc.
er.visit	The number of visits to an emergency room for injury or acute surgery in the year prior to the first transport for trauma (based on the trauma registry type code in medical service claims)
adm	Whether or not the patient was hospitalized in the year prior to the first transport for trauma. Options are: "0 - Never", "1 - One admission", "2 - 2 admissions", "3 - more than 2 admissions"
rur.access	1 - Yes, 0 - No. Rural was determined by the patient's origin being from Northern Québec.
cci	Charlson comorbidity index value. Range from 0 (no comorbidities) to 5 and above (many comorbidities). This modified to a dichotomous outcome where 0 = no comorbidities and 1 = one or more comorbiditeis.
intub.stat	Dichotomous variable on whether the patient arrived intubated or not. 1 - Yes, 0 - No.

Analysis Plan:

The primary outcome of our study is whether the patient died within the same admission after transport to the MGH for a traumatic injury. Given the binary outcome, a logistic regression model was chosen for the analysis of the data and estimation of the adjusted odds ratios for each predictor.

Furthermore, we have utilized the Bayesian Information Criterion (BIC)<sup>65</sup> in order select the most appropriate logistic model that fits our data. For comparison purposes, we also conducted the frequentist model selection process using the Akaikies Information Criterion (AIC) method.<sup>66</sup>

#### Summary of the inferential Results:

Comparing univariate to multivariate logistic regression analysis:

	Intercepts, Univariate OR and 95% CI	Multivariate OR and CI	Confounding ? Yes/No	Comments.
age.cat	Intercept 0.54 (0.21, 1.22) age.cat2: 1.12 (1.02, 1.36) age.cat3: 1.23 (1.13, 1.56)	age.cat2: 1.08 (0.94, 1.21) age.cat3: 1.22 (1.03, 1.41)	No	Though there is a change in the estimates, but movements are w/n CI range.
iss	Intercept 0.74 (0.35, 0.96) iss: 1.08 (1.03, 1.43)	iss: 1.26 (1.05, 1.43)	No	Though there is a change in the estimate, movements are w/n CI range.
er.visit	Intercept 0.84 (0.31, 1.4) er.visit: 0.91 (0.81, 1.01)	er.visit: 0.96 (0.69, 1.21)	No	Change in estimate w/n CI range.
adm	Intercept 0.76 (0.45, 1.4) 1 admission: 0.77 (0.31, 0.91) 2 admissions: 1.06 (0.22, 12.56) More than 2: 0.51 (0.33, 0.8)	1 admission: 0.55 (0.3, 0.97) 2 admissions: 1.95 (0.23, 16.8) More than 2: 0.56 (0.33, 0.95)	Probably.	Though some parameters were significant on univariate analysis, on multivariate analysis, the upper limit of their CI approaches 1.
rur.access	Intercept 0.96 (0.76, 1.7) rur.access: 1.36 (1.09, 1.82)	rur.access: 1.24 (1.13, 1.35)	No	Little change in estimate, still narrow significant CI
cci	Intercept 0.56 (0.20, 0.87) cci: 1.07 (0.96, 1.91)	cci: 1.15 (0.97, 1.31)	No	
intub.stat	Intercept 1.02 (0.65, 2.3) intub.stat: 1.05 (0.7, 1.6)	intub.stat: 1.08 (0.68, 1.22)	No	Not significant as crosses 1 in both univariate and multivariate analysis. Dropped.

--Chosen variables based on univariate vs. multivariate logistic regression analysis: age.cat, iss, er.visit, rur.access, and cci

--Dropped variables: adm, intub.stat

After executing the BIC and AIC method, er.visit was not included in the selected models. The results are demonstrated below.

Call:

```
bic.glm.formula (f = mort ~ age.cat + iss + er.visit + rur.access + cci, data =  
project.dat, glm.family = "binomial", prior.param = c(0.5, 0.5, 0.5, 0.5, 0.5,  
0.5, 1, 0.5))
```

1 model was selected

Best model (cumulative posterior probability = 1):

	p!=0	EV	SD	model 1
Intercept	100.0	0.39102	0.1987	2e-16
age.cat	100.0			
.2		1.06784	0.1395	0.908651
.3		1.21703	0.1950	0.038321
iss	100.0	1.23845	0.1890	0.229134
er.visit	79.6	0.94956	0.2529	0.419865
rur.access	100.0			
.1		1.22933	0.1188	0.007967
cci	100.0			
.1		1.13916	0.1681	0.958180
nVar		4		
BIC		-2.224e+04		
post prob		0.796		

```
> bic.model$BestModel
```

```
[1]"age.cat,iss,rur.access,cci"
```

### AIC Method:

Following is the output from the AIC method.

Call:

```
glm(formula = mort ~ age.cat + iss + er.visit + rur.access + cci, family =  
"binomial", data = project.dat)
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-2.8648	0.2737	0.3510	0.4482	1.5409

Coefficients:

	Estimate	Std. Error	z value	Pr(> z )
(Intercept)	3.050026	0.232087	13.142	< 2e-16 ***
age.cat2	1.076356	0.148083	-0.110	0.912052
age.cat3	1.226032	0.196898	-11.305	0.03452 *
iss	1.248432	0.190396	4.522	0.02316 *
er.visit	0.958920	0.263466	1.212	0.425684
rur.access	1.238653	0.118647	-2.649	0.008062 **
cci	1.149540	0.170751	-0.037	0.970180

---

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 1950.5 on 2999 degrees of freedom

Residual deviance: 1689.0 on 2982 degrees of freedom

AIC: 172.5

Number of Fisher Scoring iterations: 6

Final Model Selection:

Both model selection methods include age category (age.cat), injury severity (iss), transport origin (rur.access), and comorbidity status (cci) as predictors in the best fitting model.