

# A Population-Based Analysis of Injury-Related Deaths and Access to Trauma Care in Rural-Remote Northwest British Columbia

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**Background:** Injury rates and injury mortality rates are generally higher in rural and remote communities compared with urban jurisdictions as has been shown to be the case in the rural-remote area of Northwest (NW) British Columbia (BC). The purpose of study was to identify: (1) the place and timing of death following injury in NW BC, (2) access to and quality of local trauma services, and (3) opportunities to improve trauma outcomes.

**Methods:** Quantitative data from demographic and geographic databases, the BC Trauma Registry, Hospital discharge abstract database, and the BC Coroner's Office, along with qualitative data from chart reviews of selected major trauma cases, and interviews with front-line trauma care providers were collated and analyzed for patients sustaining injury in NW BC from April 2001 to March 2006.

**Results:** The majority of trauma deaths (82%) in NW BC occur prehospital. Patients arriving alive to NW hospitals have low hospital mortality (1.0%), and patients transferring from NW BC to tertiary centers have better outcomes than matched patients achieving direct entry into the tertiary center by way of geographic proximity. Access to local trauma services was compromised by: incident discovery, limited phone service (land lines/cell), incomplete 911 emergency medical services system access, geographical and climate challenges compounded by limited transportation options, airport capabilities and paramedic training level, dysfunctional hospital no-refusal policies, lack of a hospital destination policies, and lack of system leadership and coordination.

**Conclusion:** Improving trauma outcomes in this rural-remote jurisdiction requires a systems approach to address root causes of delays in access to care, focusing on improved access to emergency medical services, hospital bypass and destination protocols, improved transportation options, advanced life support transfer capability, and designated, coordinated local trauma services.

**Key Words:** Rural-remote trauma, Trauma systems, Preventable trauma death, EMS systems.

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Multiple North American and international studies have reported higher injury and injury mortality rates in rural and remote communities when compared with urban jurisdictions.<sup>1–8</sup> Health Canada statistics indicate similar increased injury and injury death rates in rural versus urban communities in Canada, including Northern areas of British Columbia (BC), a large, sparsely populated region of Canada.<sup>9</sup> Higher injury rates in rural-remote communities are often attributed to higher motor vehicle crash rates<sup>1,2,4,5,7</sup> (in part, because of road conditions and behavior differences such as seat belt use and speed limit observation), higher suicide rates,<sup>1</sup> and higher occupational injury rates<sup>4,8</sup> (secondary to prevailing industries, e.g., fishing, mining, forestry, and agriculture).

Higher injury mortality rates have been attributed simply to higher injury rates, particularly motor vehicle crashes where rural death rates caused by motor vehicle collisions (MVC) are often reported as twice as those for urban jurisdictions.<sup>1,5,7</sup> However, with the exception of poisonings, injury death rates from all causes tend to be higher in rural communities, suggesting access to care or quality of health care may also be factors.<sup>1,3,5,10–15</sup> Prolonged discovery times,<sup>10</sup> delays in accessing emergency medical services (EMS),<sup>5,11,14</sup> training level of available EMS,<sup>3</sup> delays in accessing hospital care,<sup>3</sup> level or performance of available local trauma services,<sup>12,15,16</sup> and delays in accessing definitive or tertiary trauma services<sup>6</sup> have all been cited as potential causes of higher rural injury death rates. However, data on rural hospital trauma outcomes are conflicting with several studies showing equivalent survival compared with urban centers.<sup>2,10,13,17</sup>

Northwest (NW) BC is a vast area of nearly 200,000 km<sup>2</sup> with a population of ~80,000 (<1 person/square mile) distributed in widely separated communities with populations ranging in size from 600 to 18,500. There are no designated trauma centers, although acute care services are available in larger communities with variable access to general and orthopedic surgeons. All centers function as Level V trauma centers as defined by the Accreditation Guidelines of the

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Trauma Association of Canada,<sup>18</sup> providing resuscitative care for major trauma victims with some communities providing definitive care for single system minor and moderate acuity trauma. General and orthopedic surgeries are the only specialist surgical services that are routinely available in the region, i.e., no neurosurgeons or plastic surgeons, and only one center offers critical care services with extended ventilator support. The nearest designated trauma center is 4 hours to 10 hours drive away in Prince George (Level III).<sup>18</sup> Prehospital EMS is provided in all communities by the BC Ambulance Service (BCAS) with ground transport and basic life support (BLS) capabilities only. In smaller communities, this service depends on volunteers with limited training and delayed response. There are no hospital bypass protocols in place with patients being taken to the nearest acute care facility irrespective of capability. A single BLS helicopter is available in Prince Rupert for interfacility transfers and transfers to and from the local airport, but its location precludes coverage of the entire region, and lack of a local destination trauma center precludes its use in scene response. Access to EMS is through 911 central dispatch in the larger communities or local phone numbers in smaller communities. Cell phone coverage is patchy and generally absent outside the larger population centers. All major and multisystem traumas require secondary transfer by fixed-wing advanced life support (ALS) aeromedical transport provided by BCAS out of Vancouver with transport to trauma centers outside the region, usually in Prince George or Vancouver. Some communities have airports with daylight operations only, and inclement weather can, and regularly, interrupt air transport during winter months. In short, NW BC faces many barriers and challenges in providing effective and timely trauma care.

The purpose of this study was to examine injury-related death and trauma service capabilities in a rural-remote jurisdiction, with specific focus on the place and timing of deaths because of injury and the accessibility and quality of available trauma services in NW BC using a combination of quantitative and qualitative methods. The goal was to assist health care planners identify cost-effective interventions that would most likely result in improved patient outcomes. The primary study hypothesis was that prehospital delays preventing timely access to acute medical services and not the level of available in-community trauma services account for most of the excess trauma-related deaths in NW BC. The secondary hypothesis was that the lack of designated trauma centers and a systemic approach to trauma care in NW BC likely result in further delays in care with the potential for adverse events.

## METHODS

This study was approved by the Clinical Research Ethics Board, University of British Columbia, and the Hospital/Health Authority Ethics Boards of Vancouver Coastal and Northern Health Authorities. The study period was from April 2001 to March 2006 and involved a quantitative analysis of demographic, geographic, and multiple medical administrative databases along with a qualitative analysis including hospital chart reviews and structured focus-group sessions with mul-

tidisciplinary health care providers in all acute care facilities in NW BC. All data management was consistent with provincial Freedom of Information and Privacy Act. Privacy impact analyses of each contributing database and information sharing agreements (ISA) between database stewards and the research group were completed.

## Quantitative Analysis

### Population Demographics and Adjusted Injury Mortality Rates

BC is divided into five geographical Health Authorities, each subdivided into Health Service Delivery Areas (HSDAs) and further subdivided into community level local health areas. The jurisdiction of the Northern Health Authority (NHA) is a vast area (500,000 km<sup>2</sup>), bigger than California, covering more than half the landmass of BC, but has a population of only 291,160 (mean population for years 2003–2006) or 7% of the total population of BC. The NW is one of the three HSDAs within the NHA with a population of 78,816 (mean, 2003–2006); its largest community has 18,500 people and a population density of <1 per square mile (rural remote/frontier). Statistics of BC publish census data for each of these jurisdictions providing health care researchers with common denominators for population-based research. Demographic data permit injury rates to be adjusted for age and sex.

### BC Coroner's Office

The BC Coroner's office provided data on all trauma deaths occurring in BC for the last 3 years of the study period, April 2003 to March 2006. The following data points were abstracted for analysis (the frequency of missing data are indicated in parentheses): age (0.1%), sex (0.2%), cause and class of death (5%), date of death (3%), time of death (36%), date of injury (39%), time of injury (62%), place of death (0.02%), and place of residence (4.3%). Age- and sex-adjusted standardized mortality rates were calculated for residents of NW BC and compared with those for residents of other BC jurisdictions and provincial level data.

### Discharge Abstract Database

All hospitals in Canada collect, code, and store data on all hospital admissions. Data from BC hospitals are provided to the Regional Health Authorities, the BC Ministry of Health, and the Canadian Institute of Health Information (CIHI) and are available with identifiers under ISAs for research purposes. Discharge Abstract Database (DAD) data were collected for all trauma-related admissions from April 2001 to March 2006, as identified by MCC22 (burns) and MCC25 (significant injury) codes, for hospitals in NW BC (study group) and Vancouver Coastal Health Authority (VCHA; comparison group). The following data points were abstracted: age, date of admission, date of discharge, and injury diagnoses (International Classification of Diseases); surgeries performed (International Classification of Diseases); and disposition (e.g., death, discharge home, and transfer to acute care facility). A recent report by CIHI determined that nonclinical data (age, admission and dis-

charge date, and discharge disposition) are reported with high reliability (>99% confirmed on chart review). The quality of fields relating to diagnosis and procedures is much lower (~75%).<sup>19</sup> To our knowledge, no study has investigated the quality of DAD records relating specifically to trauma.

DAD data on all trauma admissions during the study period to NW BC hospitals were screened by one of the authors (R.K.S.) for the evidence of trauma-related deaths, major or multisystem trauma, transfers to other centers, and delays in operative care for fractures or solid organ injury. These cases were then flagged for subsequent peer chart review. Regional in-hospital trauma mortality rates were calculated and compared with those in urban jurisdictions.

### BC Trauma Registry

All designated trauma centers in BC (Levels I-III) contribute to a standardized hospital-based trauma registry and contribute their data to the provincial database, the BC Trauma Registry (BCTR). None of the hospitals in NW BC are designated trauma centers and, therefore, do not contribute to the BCTR. Patients from NW BC seeking tertiary trauma care are referred to one of the designated trauma centers in BC, and the BCTR captures details of their incident, prehospital, local hospital, tertiary care, and outcome data. The BCTR was used to examine times from injury to definitive tertiary care and whether any excess mortality could be observed in trauma patients transferred out of NW BC hospitals to trauma centers. We chose severe head injury (defined as Glasgow Coma Scale score of 8 or less, a time-dependent injury, associated with significant mortality, and often requiring specialist interventions unavailable in NW BC) to evaluate this question. BCTR data are routinely screened for accuracy by using standardized data checks performed by provincial BCTR analysts and again after submission to CIHI before inclusion in the National Trauma Registry.

### Geographical Database

Access to trauma services in NW BC and for the larger NHA were assessed using a geographic information system and based on verified road driving times to designated trauma centers, adjusted for road and weather conditions. Figures for population outside health services catchments were obtained by linking rural postal codes along the roads to Canada census data. This methodology was developed by one of the authors (N.S.) and has successfully been used to determine health service catchments in rural areas.<sup>20</sup>

### Qualitative Study

#### Chart Review

Hospital charts on 127 trauma patients admitted to five NW BC hospitals were formally reviewed by a multidisciplinary team comprising a trauma surgeon and two or more of the following: a community general surgeon (from outside of NW BC), a trauma program manager from Vancouver, or trauma research nurse. Charts on all injury-related deaths and other trauma cases of interest as identified during the prereview of the DAD dataset were

audited by at least one member, with deaths and problematic cases reviewed by all three members of the multidisciplinary team. A standardized data sheet was used for chart review at all sites (Fig. 1). In-hospital deaths were determined to be nonpreventable, potentially preventable, or preventable based on the identification of avoidable errors or delays in care contributing to mortality during the in-hospital phase of care and in the context of available local resources. This determination of preventability was based on team consensus and was unanimous in all cases. Prehospital times, times to operating room, and times to transfer were noted and documented to determine treatment delays. Delays were further classified as being system related or provider related where possible. Screening for evidence of care errors was also performed. Errors and delays (problematic cases) were determined based on consensus. This entire chart review process was limited to the research teams and performed in confidentiality with no attempt being made to “close the loop” and to provide quality assurance feedback to local providers. Inclusion of local physicians in this process was considered but rejected on the basis of the potential to compromise objectivity.

### Focus Groups

To obtain a clearer understanding of the barriers to effective trauma care in NW BC, focus group sessions were held at each of the six larger acute care facilities in the NW. The visiting multidisciplinary research team provided 11 standardized questions (Fig. 2) to the front-line doctors and nurses in a structured focus group environment. The questionnaire tool was specifically developed for this study and not previously used or validated. Care was taken to ensure whether all the participants were given an opportunity to address each of the standardized questions and the opportunity for providing additional comment. This allowed for information gathering on their perspectives and impressions of trauma care in the NW in support of the quantitative data. All front-line staffs who interviewed volunteered through an open invitation process, which was sent out before the site visit. All who volunteered participated in the group sessions without further selection. At all sites, these sessions were well attended by emergency room doctors and nurses, nursing leaders, and (in sites with them) general and orthopedic surgeons. This qualitative component to the study was used to gain a clearer understanding and further evidence of the issues that the health care providers face in delivering effective trauma care. Answers to these standardized questions and other volunteered observations were collated and trended for common themes across sites.

## RESULTS

### Class of Traumatic Death and Adjusted Injury Death Rates

The class of death in NW BC because of injury as determined by the BC Coroner's Office is very similar to other BC jurisdictions with unintentional injury and suicide accounting for the majority of deaths (Table 1). Adjusted injury mortality rates, however, are higher in NW BC when

<b>North West Health Region</b>		Name 2 <sup>nd</sup> NW Hospital	_____
<b>Data Collection Sheet</b>		Interventions (2 <sup>nd</sup> Site)	_____
Hospital:	_____	Hours at 2nd NW Hospital:	_____
Home address:	_____	Leave 2nd Hospital/clinic	Date/Time
Mechanism of Injury:	_____	Arrive 3rd NW Hospital	Date/Time
Injury place/Post code:	_____	Reason for transfer	_____
	<b>Date/Time</b>	Reason for transfer delay	_____
Injury:	_____	Name 3 <sup>rd</sup> (or final) NW Hospital	_____
EHS called	_____	Mode of transfer to 3 <sup>rd</sup> or final NW Hospital:	
EHS on-scene	_____	MRP Service (3 <sup>rd</sup> Hosp)	_____
EHS leave scene	_____	Admitting MD Service	_____
EHS arrive at 1 <sup>st</sup> hospital	_____	Outcome: Lived/died/transferred	
Total prehospital time (h)	_____	<b>Transfer to tertiary care</b>	
Transport mode scene to 1 <sup>st</sup> hospital/clinic:		Hours at final NW Hospital:	_____
1 <sup>st</sup> NW Hospital/Clinic name:	_____	Leave NW Hospital/clinic	Date/Time
Interventions (1 <sup>st</sup> Site)	_____	Arrive Tertiary Hospital	Date/Time
Leave 1 <sup>st</sup> Hospital/clinic	Date/Time	Reason for transfer	_____
Arrive 2 <sup>nd</sup> NW Hospital	Date/Time	Reason for transfer delay	_____
Hours at 1 <sup>st</sup> NW Hospital/clinic	_____	Name Tertiary Hospital	_____
Hours in transport	_____	Mode of transfer to tertiary Hospital:	
Reason for transfer	_____		
Reason for transfer delay	_____		
Mode of transfer 1 <sup>st</sup> to 2 <sup>nd</sup> NW Hospital:			

**Figure 1.** Standardized form used to collect chart review data from trauma admissions to NW BC hospitals.

compared with other more urban BC jurisdictions (BC Coroner’s Office). This is evident for most categories of injury death including all injuries, MVC, suicide, and accidental death (Fig. 3).

**Hospitalization Rates for Injury**

DAD and BC census data were used to determine adjusted hospitalization rates for injury. Rates (per 10,000) for the NW BC are higher (62.9) than those for each of the three most rural HSDAs within the predominantly urban jurisdiction of VCHA (30.4, 32.2, and 46.3, respectively).

**Place of Death**

Majority of the injury-related deaths occur prehospital for all classes of injury in all jurisdictions in BC. However, there are significant differences depending on the class of injury death and jurisdiction (Table 2). Prehospital deaths are

significantly more frequent in NW BC (82%) when compared with more urban jurisdictions of BC (67–73%) for all classes of injury death. This is particularly evident for MVC where 77% of deaths are occurring at scene in NW BC when compared with 48% in the more urban jurisdiction of VCHA with its advanced prehospital capabilities and four designated trauma centers.

**Time of Death**

During the study period, the recording of injury and death times were not mandatory at the BC Coroner’s Office; thus, times to death could be calculated for only 35% of cases. However, among individuals who did not die at the scene, there were large differences in the median times to death after injury in NW BC compared with other BC jurisdictions. Fifty percent of deaths occurred within 1



1. What are the challenges you face when caring for a severely injured patient?
2. What resources are available to you in caring for this patient population?
3. What issues do you face regarding transfers and transport? Who do you call?  
How well does it work?
4. What patients are easy or difficult to place?
5. What communication strategies are utilized when caring for these patients?  
Who supports you medically for advice, is there a direct line to call (1 800) and is it a streamlined process?
6. If you had more resources or they were distributed differently, are there patients you could care for that you cannot care for now? If so, what kind of patients?
7. What support would help you care for this population?
8. How do you see tertiary trauma centres supporting you in caring for these patients?
9. How good is after transfer communication
10. How does the repatriation process work? What priority is given to patients returning to their communities?"
11. What else can you tell us about trauma care in your community, specific issues you face, and barriers preventing patients obtaining optimal care?

**Figure 2.** Structured 11-point questionnaire provided to local front-line trauma care staff in focus group setting as an aid to elucidate underlying barriers to effective and timely trauma care in NW BC.

**TABLE 1.** Percentage of Deaths After Injury From Different Classes in Various Jurisdictions of BC (BC Coroner’s Office)

Jurisdiction	Class of Death (%)		
	Unintentional	Suicide	Homicide
NW BC (rural remote)	67.5	28.3	3.3
Fraser Health Authority (urban)	64.2	27.2	6.7
Vancouver Coastal Health (urban)	61.8	28.7	5.5
Vancouver Island Health (urban-rural mix)	65.9	28.5	2.4
Interior Health Authority (rural)	69.3	23.7	4.0

Percentage of deaths from major classes of injury as defined by BC Coroner’s office for NW BC (rural remote) and other rural and urban jurisdictions in BC.

hour in NW BC when compared with 6 hours in VCHA (Table 3).

### Access to Designated Trauma Services

The nearest trauma center to the communities of NW BC is the Prince George Regional Hospital, a designated Level III trauma center serving the whole northern half of the province and within the jurisdiction of the NHA. Only a few of the NW BC communities are within 4 hours drive of this trauma center, and most of the population is at 6 hours to 8 hours driving time. Level I trauma services and neurosurgery services are in Vancouver (adult and pediatric) and require ALS aeromedical secondary transport. The initial hospital care for all trauma patients in NW BC (major and moderate trauma) is, therefore, provided in local, nontrauma designated, acute care facilities.

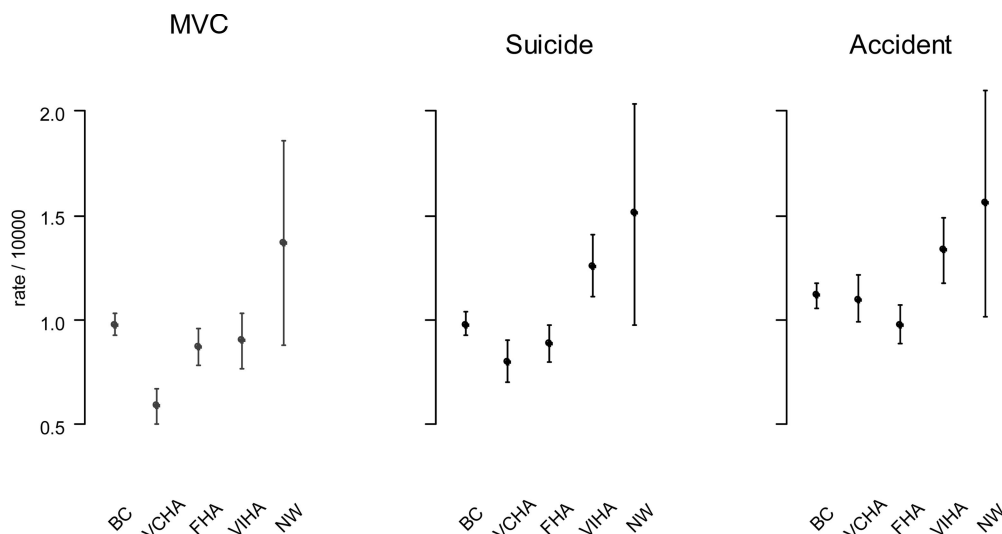
### In-Community Trauma Care

Single system, moderate acuity trauma care is provided by acute care hospitals within the community of NW BC, and as stated, all major and multisystem traumas are initially cared for in local facilities while secondary transfer is arranged. Prehospital times could be determined in 61 of the 127 charts reviewed with mean time of 85 minutes, 48% had times >1 hour, 21% had times >2 hours, and 13% had times >3 hours. These times underestimate the problem because the first-documented time is dispatch time, which does not account for the often-prolonged incident discovery and system access times.

Secondary transfer for definitive care was common with 725 of 2,318 (31%) NW trauma admissions requiring transfer to another acute care facility, 356 within the NW region, and 369 out of the region, primarily to the NHA Level III trauma center in Prince George (151) or the provincial adult (106) and pediatric (22) Level I centers in Vancouver. Mean time delay to transfer for secondary and tertiary referrals, based on hospital chart review, were 42 hours from admission to time of departure from the primary center. Access time to tertiary care (incident time to time of arrival at a major trauma center) were a mean, 24.2 hours; median, 13.1 hours; and range, 4.9 hours to 178.8 hours based on BCTR data. Secondary transfer within region occurred in 223 (12.9%) patients, 196 (11.2%) requiring one transfer, 23 (1.3%) requiring two transfers, and 7 (0.4%) requiring three or more transfers. In part, this seemed to be because of the lack of bypass and destination protocols and specialty services in the region being distributed across several sites with general surgery, orthopedics, and critical care typically available at different centers on any given day with collocation of all three never occurring.

Outcomes for trauma patients, managed within their NW community facilities, were assessed primarily by a multidisciplinary peer review process. Nineteen in-hospital deaths occurred in NW BC hospitals during the study period. Thirteen of the deaths occurred in elderly (mean age, 85 years; range, 69–99 years), with nonmajor injuries but significant comorbidities and/or complications. None of these deaths were considered preventable or potentially preventable. Of the remaining six deaths (mean age, 42 years; range, 17–62 years), three had nonsurvivable injuries or complications and had care that was considered appropriate. The remaining three deaths had associated system-/provider-related issues resulting in significant, potentially avoidable delays in critical interventions and were considered potentially preventable for a 15.7% potentially preventable hospital mortality rate. Crude hospital trauma mortality rates in NW BC (overall 0.82%; range, 0.0–1.44%) were equivalent to crude hospital mortality rate for the moderate trauma population (Injury Severity Score < 16) treated in the Level I trauma centre (1.4%). There were an insufficient number of in-hospital deaths to calculate diagnosis-specific injury survival probabilities and make any meaningful comparisons with provincial or national survival probability data.<sup>21</sup>

Outcomes for patients injured in NW BC and who were subsequently transferred to tertiary trauma facilities in Van-



**Figure 3.** Age- and sex-adjusted, standardized mortality rates for MVC, suicide, and accidental injury in different jurisdictions with in BC, April 2004 to March 2007. Adjusted injury mortality rates for the rural-remote jurisdiction of NW BC are higher for most injury classes when compared with other BC jurisdictions. NW, Northwest British Columbia; BC, data for entire province; VCHA, Vancouver Coastal Health Authority (urban); FHA, Fraser Health Authority (urban); VIHA, Vancouver Island Health Authority (urban and rural).

**TABLE 2.** Percentage of Deaths that Occur in Hospital, After Common Classes of Injury Death, in Various Jurisdictions in BC (BC Coroner’s Office)

Jurisdiction	All			
	Injuries (%)	MVC (%)	Accidental (%)	Suicide (%)
NW BC (rural remote)	17.6	20.0	17.7	9.4
Fraser health (urban)	32.4	40.5	25.1	14.6
VCH (urban)	27.9	46.0	17.8	10.2
Vancouver Island Health (urban rural)	29.0	35.8	21.5	7.5
Interior Health (rural urban)	26.3	27.9	22.7	8.8

Percentage of deaths after injury occurring in hospital are lower in the NW when compared with other BC jurisdictions. This is particularly evident for deaths after MVC.

**TABLE 3.** Time at Which 25%, 50%, and 75% of Deaths After Injury Have Occurred in Different BC Jurisdictions

Health Authority	Time (h)		
	P25	P50	P75
NW	0.2	1	6.7
FHA	0.9	4.4	66.8
VCH	0.9	6	41.7
VIHA	1.1	7.7	78.6

NW, Northwest British Columbia; BC, data for entire province; FHA, Fraser Health Authority (urban); VIHA, Vancouver Island Health Authority (urban and rural).

Times to death after injury measured as the time at which 25%, 50%, and 75% of deaths have occurred in the NW and other jurisdictions in BC.

couver were assessed using the BCTR. Patients transferred to Vancouver General Hospital from the NHA with a diagnosis of severe head injury (Glasgow Coma Scale score 3–8) had a mortality of 23.5% compared with a mortality of 43.9% for

similar patients with severe head injury admitted directly from scene to Vancouver General Hospital. Even after allowing for patients with severe head injury who were not transferred and died in NHA facilities, mortality for severe head injury in patients presenting to NW BC hospitals is lower than that for patients gaining direct and rapid access to trauma centers within Vancouver. This incongruity is most likely a result of more patients in the NW dying at the scene or on route to the hospital and, thus, is not included in the patient cohort creating a survival bias in the data.

**Focus Group Findings**

The focus group findings were collated and grouped into two consistent recurring themes that covered both the prehospital and in-hospital phases of care. These themes included incident scene discovery, primary transport, stabilization, hospital access, intraregional and tertiary referral processes, and continuing trauma education. All themes and issues were identified as barriers in providing adequate access to trauma care. Results of these interviews were correlated with findings from the quantitative analyses. The data were trended for common, region-wide issues and specific site-related issues (Table 4).

**Limitations**

Standardized death rates were calculated based on the location of the individual’s residence and not on the location where the injury actually occurred. Thus, there is some misclassification of “exposure” (geographic region). However, in >90% of the cases, the individual’s residence and location of injury were coincident, which would suggest that any effect of misclassification would be small. This study has used data from administrative databases and recognizes the inherent data quality limitations of this methodology. Rates for missing data have been indicated and are particularly

**TABLE 4.** Barriers to Effective Trauma Care in NW BC as Cited by Front-Line Health Care Providers

Phase	Component	Barrier
Prehospital	Discovery	Limited 911 coverage
		Limited cell phone coverage
		Remote highways (light traffic)
Prehospital	Primary transport	EHS-delayed response (distance, volunteer)
		Ground option only
		Long distances
Prehospital	Stabilization	Road conditions (road type and weather)
		BLS capability only
		No hospital bypass protocols
Hospital	Access	Disparate, inconsistent services
		No designated trauma centre
		No systems approach to trauma
Hospital	Intraregional referral	Ineffective no-refusal policies
		No ALS transfer capability
		Limited BLS helicopter transfer capability
Hospital	Tertiary referral	Inconsistent and disparate surgical services
		No “go to” centre (trauma centre)
		No “go to” trauma service or care coordination
Hospital	Trauma education	Long aeromedical response times (fixed wing)
		Limited local airport capabilities (night/weather)
		Long transport distances/times
		In-community trauma CPD lacking

CPD, continued professional development.  
 Barriers to effective trauma care as cited by front-line health care providers in NW BC.

relevant for the time-to-death data presented. Even though we were unable to determine any resultant bias, neither accuracy nor completeness (65% indeterminate) can be claimed. The data are included for presentation because of the dramatic differences between jurisdictions and especially between rural-remote versus urban settings and the questions that this observation raises. At the time of this study, data on EMS activities in BC and, particularly, the NW were lacking and/or inaccessible to study personnel. This was considered as an important though unavoidable deficiency in the study and one which is now being rectified by BCAS. Much of the study’s quantitative data represent a census of injury and injury death for the study time period; deaths were infrequent events and sample sizes small, resulting in wide confidence intervals particularly for data from NW BC. The differences, although seem to be self-evident and large, cannot be completely ruled out as being because of sampling variability.

**DISCUSSION**

Life in rural-remote communities has its rewards and its challenges. Among the latter are the well-recognized high injury rates and high injury mortality rates when compared

with more urban jurisdictions.<sup>1-8</sup> Causes for the increased injury risk have been variously attributed to higher motor vehicle crash rates, particularly affecting younger age groups, in turn attributed to bad road conditions and behavior differences including alcohol use, speed limit violation, and lack of seat belt use, which have all been cited as more common in rural-remote communities.<sup>1,2,4,5,7</sup> Prevailing industries in rural communities such as fishing, mining, agriculture, and forestry have also been associated, at least historically, with high injury rates. Demographic mix, especially if there is a large proportion of recognized “at-risk” populations such as aboriginals,<sup>22</sup> may also contribute to higher injury rates.

Increased injury mortality in these communities may simply be a result of the increased injury risk and rate of injury from all causes but particularly motor vehicle-related trauma and suicide. In addition, it has been suggested that injury discovery delays, the ability to access EMS and hospital care and the quality of medical services play a role in the increased death rate from injury.<sup>1,3,5,10-15</sup>

This study has focused on death after injury and on the barriers in HSD that adversely impact trauma care in a rural-remote area of BC, Canada. NW BC is a large, sparsely populated area of Northern Canada without designated trauma facilities and many hours away from any organized trauma system or major trauma center. This study has developed a comprehensive picture of trauma and trauma care in this jurisdiction by accessing demographic-, geographic-, and multiple administrative health care-related databases, augmented by qualitative data from onsite multidisciplinary case reviews and structured focus groups with front-line care providers, achieving a number of objectives.

First, we have been able to confirm that NW BC does indeed have higher injury hospitalization and injury death rates than most other parts of the province. A higher rate of motor vehicle-related trauma is clearly a significant contributor to these statistics, though rates from all causes of injury death are higher in this jurisdiction. This specific study has not attempted to further characterize this increased injury risk in NW BC nor the underlying causes, although the research group is actively engaged in answering these questions.<sup>22</sup>

Second, we have been able to show that the majority of trauma death in NW BC occurs before hospital admission. The proportion of prehospital deaths in the NW, however, is much higher than that found in more urban jurisdictions in BC, with a disconcerting 77% of all MVC-related death occurring at the roadside, when compared with ~50% in other BC jurisdictions, consistent with findings from previous studies.<sup>5,10,12</sup> The large proportion of prehospital deaths in NW BC is further underlined by the large disparities in time-to-death data when compared with other jurisdictions in BC that do have rapid access to ALS paramedical response (±helicopter scene response), short prehospital times, and direct access to tertiary trauma centers (Level I or II). Although the data related to time-to-death is inconsistently reported, the differences between jurisdictions are dramatic, with the majority of trauma death occurring within a short time span in the NW. These times to death currently preclude any realistic ability for severely injured patients to survive



long enough to access any level of hospital care before death, given current prehospital times. These data are consistent with Grossman et al.<sup>14</sup> study that demonstrated a sevenfold increase in death for rural trauma patients compared with urban counterparts if response time was >30 minutes. Whether these foreshortened times to death in the NW reflect a higher injury severity in rural trauma patients or to delayed access to appropriate care cannot be determined by this study, in part, because of missing EMS data.

Third, we have been able to demonstrate that in-hospital mortality contributes minimally to excess death after injury in this rural-remote community of BC. Of the deaths occurring within the local facilities, we were only able to demonstrate a 15.7% potentially preventable death rate. These data are consistent with previous studies on in-hospital preventable death in rural communities.<sup>13,15,23</sup> Crude hospital mortality rates in the NW were no different to those in urban Level I center (Injury Severity Score <16 population). This low, local in-hospital mortality may simply reflect selection and survival biases caused by prolonged prehospital times rather than adequacy of local hospital services, an observation that may change if prehospital times could be shortened. Patients with head injuries transferred out of community for tertiary trauma care also had better survival rates than those with similar injuries admitted directly to trauma centers. Again this is thought to be because of selection and survival biases produced by long prehospital times leading to a higher percentage of prehospital deaths for these severely injured patients in the NW.

Fourth, we have gained insight into the challenges and barriers to providing optimal trauma care in this rural-remote community. The qualitative component of this project provided several common themes and suggestions for improvement. There was clear recognition that prehospital delays were primarily responsible for excess mortality in this jurisdiction with specific barriers identified. Delays in discovery, EMS response, and transport inevitably lead to a disproportionate number of on-scene deaths and short times to death.

Although the hospital staff felt supported by the recognition that there was minimal in-hospital preventable death, they were far from reticent about identifying their limitations and the need for more organized trauma services in the region. Common themes expressed by all sites visited were the need for functional local no-refusal policies, centralized and coordinated trauma capabilities in-region with or without a designated trauma center, and access to in-region trauma-related continued professional development. There was a palpable level of frustration with the current in-region services that result in inappropriate primary transfers because of lack of hospital bypass protocols or inconsistent service availability, frequent and often multiple secondary transfers to obtain needed care, and transfer delays because of non-functional, no-refusal policies, and lack of coordination or system leadership. These comments underline our previous work on access to trauma services in BC and a modeling proposal to identify where new trauma services should be located.<sup>24</sup> More remote sites reported that lack of local ALS transfer capability seriously challenged their community medical services because trauma transfers often require med-

ical or nursing staff to accompany patients, leaving the community short handed, often for prolonged periods. This became a major issue with multiple casualty incidents.

The goal of this study has been to establish an evidence base to inform health care policy makers (local, regional, and provincial) on the underlying issues related to excess injury mortality in their constituencies and to identify appropriate areas for remediation. To that end, these data have been or will be presented to the respective HSDA, Regional Health Authority, and Provincial Health Ministry.

Primary and secondary prevention must remain the corner stones to reducing injury and injury death rates in rural-remote communities, particularly in addressing the demonstrated excess MVC-related death. In terms of tertiary prevention, this study has emphasized the need to focus on EMS access and response as the most pressing need to improve trauma outcomes. A coordinated systems response including destination and hospital bypass protocols, enhanced transport capabilities including ALS interfacility transfer, and access to rotary transport would greatly assist in primary and secondary transfer. More elaborate proposals would include expansion of the BCAS aeromedical Autolaunch scene response program to NW BC by using local BLS rotary transport and provincial fixed-wing aircraft for patients meeting scene response criteria. Destination local trauma centers, in addition to the provincial centers, are a prerequisite to implementing this type of initiative. Greater use of automatic crash response technology such as the GM OnStar system would assist in earlier discovery of MVC occurring on remote highways.

Our data would suggest that improvements in the local hospital trauma services may have only modest impact on preventable death after injury, at least initially. However, if improved prehospital care results in more critically injured patients surviving to hospital admission, then optimal care will require a coordinated systems response with performance improvement programs, system leadership, designated services, and formalized, audited policies covering hospital destination, no-refusal, repatriation, and hospital/physician response expectations. These interventions have relatively modest price tags and can be achieved without prohibitively expensive service augmentation in the region. Opportunities to provide relevant trauma-related multidisciplinary educational programs in-community need to be explored in addition to the standard ATLS, TNCC, and DSTC offered out of Vancouver. Just-in-time telemedical support from regional and/or provincial trauma centers has been piloted in NW BC with proof of feasibility<sup>25</sup> and may offer front-line providers support in stabilizing major trauma patients in these communities and expedite transfer as has been demonstrated in other jurisdictions.<sup>1,26,27</sup> Operational barriers currently preclude wide use of this technology.

In summary, trauma services in NW BC face many challenges and barriers to optimal care. To move forward, these services need to be fully integrated into both the NHA regional and the provincial trauma system plans with particular focus on improving prehospital response but with an opportunity to improve hospital trauma services with only



modest cost increment. This system requires the support of ministry, the regional health authority (NHA), adjacent regional trauma systems, particularly the VCHA system (with its designated provincial adult and pediatric Level I trauma centers), and provincial ambulance services. To achieve optimal functionality, the trauma system as a whole (local, regional, and provincial) should meet national trauma system guidelines as defined by the Trauma Association of Canada.<sup>18</sup>

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