Access to Neurosurgical Care for Traumatic Brain Injury in Ontario

by

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A thesis submitted in conformity with the requirements for the degree of Masters of Science

Institute of Medical Science
University of Toronto

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Abstract

Introduction: Trauma centers (TC) are the only institutions with resources to manage patients with severe traumatic brain injury (TBI). We chose to examine potential barriers to access to TC care for TBI patients.

Methods: Administrative datasets were used to evaluate access to TC among patients with severe TBI. We examined triage practices of EMS in TBI. Finally, we analyzed surveys to capture the beliefs, perceptions and knowledge of ED physicians with respect to TBI.

Results: 57% of patients in Ontario had any access to a TC following TBI. Of patients who had potential access to a TC from the scene of injury as defined by pre-hospital triage guidelines, 60% of patients were undertriaged. Challenges that ED physicians faced with managing TBI, included lack of beds at TC and difficulty attaining transport resources.

Conclusion: Access to TC care for patients with TBI is impeded by patient and system level factors.
Acknowledgments

First and foremost, I would like to thank my family- my parents and brother. Their constant love and support allows me to fulfill my dreams, and for that I will forever be in their debt.

I would like to thank Drs. Rutka, Spears, Mainprize and Wallace for helping me develop as a surgeon, researcher and person and encouraging my interest in trauma.

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<td>AIS</td>
<td>Abbreviated Injury Scale</td>
</tr>
<tr>
<td>AANS</td>
<td>American Association of Neurological Surgeons</td>
</tr>
<tr>
<td>ATLS</td>
<td>Advanced Trauma Life Support</td>
</tr>
<tr>
<td>BTF</td>
<td>Brain Trauma Foundation</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control</td>
</tr>
<tr>
<td>CT</td>
<td>Computed Tomography</td>
</tr>
<tr>
<td>CIHI</td>
<td>Canadian Institute for Health Information</td>
</tr>
<tr>
<td>CAEP</td>
<td>Canadian Association of Emergency Physicians</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>CCFP</td>
<td>Canadian College of Family Physicians</td>
</tr>
<tr>
<td>DAD</td>
<td>Discharge Abstract Database</td>
</tr>
<tr>
<td>EMS</td>
<td>Emergency Medical Services</td>
</tr>
<tr>
<td>ED</td>
<td>Emergency Department</td>
</tr>
<tr>
<td>EDH</td>
<td>Epidural Hematoma</td>
</tr>
<tr>
<td>FRCP</td>
<td>Fellow of Royal College of Physicians</td>
</tr>
<tr>
<td>FTC</td>
<td>Field Triage Criteria</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Scale</td>
</tr>
<tr>
<td>ICD</td>
<td>International Classification of Diseases</td>
</tr>
<tr>
<td>ICP</td>
<td>Intracranial Pressure</td>
</tr>
<tr>
<td>ISS</td>
<td>Injury Severity Score</td>
</tr>
<tr>
<td>ICES</td>
<td>Institute for Clinical and Evaluative Sciences</td>
</tr>
<tr>
<td>IKN</td>
<td>ICES Key Number</td>
</tr>
<tr>
<td>LHIN</td>
<td>Local Integrated Health Network</td>
</tr>
<tr>
<td>mGCS</td>
<td>Motor GCS</td>
</tr>
<tr>
<td>MVC</td>
<td>Motor Vehicle Collision</td>
</tr>
<tr>
<td>NACRS</td>
<td>National Ambulatory Care Reporting System</td>
</tr>
<tr>
<td>NTC</td>
<td>Non Trauma Center</td>
</tr>
<tr>
<td>OHIP</td>
<td>Ontario Health Insurance Plan</td>
</tr>
<tr>
<td>OR</td>
<td>Odds Ratio</td>
</tr>
<tr>
<td>ROC</td>
<td>Resuscitation Outcomes Consortium</td>
</tr>
<tr>
<td>SDH</td>
<td>Subdural Hematoma</td>
</tr>
<tr>
<td>SAH</td>
<td>Subarachnoid Hemorrhage</td>
</tr>
<tr>
<td>TC</td>
<td>Trauma Center</td>
</tr>
<tr>
<td>TBI</td>
<td>Traumatic Brain Injury</td>
</tr>
<tr>
<td>TTL</td>
<td>Trauma Team Leader</td>
</tr>
</tbody>
</table>
Chapter 1 Background

1.1 Introduction

Traumatic brain injury (TBI) is defined as craniocerebral trauma associated with neurological or neuropsychological abnormalities, skull fracture, intracranial lesions or death. TBI remains a significant public health challenge as TBI can lead to life altering disability or death, both of which have significant economic and social implications. Management of head injuries often involves complex supportive care and surgical intervention. These interventions and treatment strategies are implemented optimally at trauma centers (TC) with multidisciplinary teams. Improving the care of TBI patients may improve their quality of life, and the impact of this condition on society.

1.1.1 Epidemiology of Traumatic Brain Injury

Injury is among the leading causes of death worldwide, and affects people of all ages and income groups. Worldwide, injury is estimated to be the cause of 5 million deaths per year and accounts for 1 of every 10 deaths globally. TBI plays a significant role in the burden of injury related disease as it is a contributing factor to a third of all injury related deaths in the United States.

TBI affects patients of all ages, often with injury mechanisms that show a predilection for a specific age group. In the young, most TBI is a result of motor vehicle collisions (MVC) and risk taking behavior while in the elderly, TBI is more often a result of falls. Falls represent a major cause of injury at both extremes of age, both the very young (<4 years of age) and elderly (>75 years of age) and account for approximately 30% of all brain injuries in these populations. Motor vehicle collisions, by contrast, account for approximately 20% of all TBI in young adults (ages 15-19). Regardless of the mechanism, these patient populations sustain an insult to the brain resulting in neurological sequelae. In North America, TBI disproportionately affects patients under the age of 45, and is the leading cause of death and disability in this population.

Absolute incidence rates for TBI are difficult to ascertain through review of the literature, as inclusion criteria and categorization of hospital admission and outcome in these studies are subject to significant variability. In Canada, TBI accounts for a significant burden of disease with
approximately 18,000 admissions to hospital per year. A recent study done in Alberta extrapolated the annual incidence of TBI in Canada to 11.4/100,000 adult individuals, using the population in the Calgary health region as the sample. To gain perspective on the dramatic incidence of TBI, it should be noted that the number of people hospitalized for TBI each year exceeds those diagnosed with multiple sclerosis, spinal cord injury and breast cancer combined.

In the United States, the annual incidence of TBI is estimated to be as high as 19/100,000 adult individuals. Incidence estimates vary widely, again, due to differences in study design and analysis however the CDC estimates that approximately 1.5 million Americans sustain a TBI per year. Of this number, the CDC predicts that 235,000 will require long-term hospitalization and a further 50,000 will die. Outside of North America, TBI has a similar impact. The effects and increasing incidence of TBI is so significant that the World Health Organization (WHO) has estimated that it will be the third leading cause of death and disability globally by 2020.

Hospital admission rates, like injury mechanisms, have also been shown to vary by age. Studies suggest that while ED utilization is greatest in TBI for young children and adolescents, the rate of hospital admissions and death is highest in those over 75. Regardless of age, males are more than twice as likely to sustain a TBI than females, potentially due to risk taking behavior and participation in high-risk activities.

The impact of TBI can be seen across all ages. The high incidence of this injury along with its devastating impact remains one of the reasons that TBI is a global public health epidemic.

1.1.2 Cost

Economic costs associated with TBI are driven by the devastating outcomes of the injury and the high incidence and the expensive nature of medical care for this disease. Cost related to TBI can be categorized as direct and indirect. Direct costs are those expenditures directly related to acute medical care required by the TBI patient, while indirect costs encompass economic expense not directly related to medical care. Examples of indirect costs would include lost wages, removal from the workforce and other costs resulting from the injury that are not related to treatment.

In the United States, direct and indirect costs for TBI totaled an estimated $76.5 billion in 2000. Total costs of TBI are heavily skewed towards those patients that survive their injury,
regardless of outcome. Survivors of TBI account for 65% of costs, while only 35% of the costs are related to TBI deaths. The skewed cost towards survivors of TBI highlights the importance of functional outcome in this injury. In Canada, direct and indirect costs totaled approximately $7 billion in 2009 alone.

Not reflected in the figures are the economic costs borne by family as measured by lost productivity of caregivers. Patients left with significant disability resulting from TBI have emotional and financial impact on family members caring for them. These impacts have significant economic effects, that are not captured in the current estimation of costs associated with TBI.

1.1.3 Pathophysiology

TBI results from the application of an external force, dissipating energy into the cranial vault and subsequently the cerebral cortex. Phases of TBI are dichotomized to primary and secondary injury. Primary injury occurs immediately after sustaining an insult. Following the transfer of energy, the final step of the injury pathway is tissue injury secondary to deformation. This deformation leads to disruption of synaptic connections as well as gross destruction of neuronal and supportive structures. Other than prevention, little can be done to modify this initial primary injury.

Secondary injury occurs following the primary tissue injury and is a result of structural or metabolic derangements subsequent to the insult. Secondary injury is the focus of medical treatment, as it is the only phase of TBI that is modifiable by medical intervention. Because secondary injury is the only part of TBI that can be manipulated, the mainstay of TBI treatment rests on the prevention and modification of secondary injury.

Secondary injury can be a result either of structural changes (e.g. hematoma or edema) or physiological changes leading to oxygen deprivation and global cerebral ischemia resulting in stroke. Structural changes cause injury to the brain in keeping with the Monroe-Kellie hypothesis. This doctrine is based on the fixed volume of the skull. Under normal circumstances, there is a fixed, consistent amount of blood, cerebrospinal fluid and brain tissue in the cranial vault. The brain is able to compensate for minor variations in these volumes through auto regulation of blood flow. If any of these components increases significantly in volume, the pressure in the
cranial vault, known as the intracranial pressure (ICP) increases. Increases in ICP lead to compression of arterial structures, ultimately leading to decreased blood flow and stroke. Additionally, expansion of the cerebral volume may lead to shearing injuries of brain matter due to the interaction between brain and the bony ridges of the skull. These types of secondary injury are often only amenable to surgical treatments that either reduce the volume inside the skull (i.e. removal of hematoma, lobectomy) or expand the volume of the skull (i.e. craniectomy).

Physiological causes of secondary injury are the components of the insult that respond to non-surgical interventions. This is done by rapid and specialized care provided to TBI patients by neurosurgeons, trauma surgeons and critical care physicians. Management strategies include correction of physiological aberrations often guided by invasive monitoring of ICP and brain tissue oxygen monitoring. Upon sustaining a TBI, the patient may undergo a variety of metabolic derangements including coagulopathy, anemia, respiratory failure, hypoglycemia or other systemic changes that can lead to hemorrhage or stroke. Locally, around the site of injury, edema, hypoperfusion and increased metabolic demand can further effect the expansion and severity of injury through oxygen deprivation ultimately resulting in tissue oxygen starvation and neuronal damage. Treatment of these pathologies requires normalization of physiological parameters. This is often done acutely in the trauma bay and continues for the duration of the patient’s admission in the intensive care unit and acute care hospitalization.

Physiologic and surgical strategies to reduce secondary injuries are the focus of the Brain Trauma Foundation (BTF) guidelines published by the American Association of Neurological Surgeons (AANS). Because reduction of secondary injury is time sensitive, prompt access to neurosurgical and neurocritical care is imperative in reducing the impact of TBI on the patient thereby maximizing functional outcome.

1.2 Injury Severity

1.2.1 TBI Severity

Treatment and prognosis in TBI is dependent on the severity of a patient’s injury. To characterize injuries effectively and accurately, appropriate measures of grading injury severity are required. A variety of scales and scores exist, however the highest utility comes from those scores that are widely used and validated in the literature.
The severity of TBI is usually described by the Glasgow Coma Scale (GCS). This is a score that reflects the level of consciousness of a patient taking into account their motor responses to stimuli, how aware they are of their outside surroundings by the degree of eye opening demonstrated, and their ability to verbally communicate. In order to calculate a GCS score the component scores are combined to derive a single number. The highest possible score is 15 while the lowest possible is 3. The GCS was initially developed in 1974 by Graham Teasdale and was (and currently remains) the only widely used score to help prognosticate outcome following TBI. While the GCS was intended as a score to be used only for TBI patients, in contemporary use, it is often misused to describe the level of consciousness of any patient, even when the clinical status is due to a non-TBI mechanism or a physiologic/metabolic phenomenon (i.e. Diabetic Ketoacidosis).
**Figure 1- Calculation of Glasgow Coma Scale Score**

<table>
<thead>
<tr>
<th></th>
<th>Eye</th>
<th>Motor</th>
<th>Verbal*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No eye opening</td>
<td>No motor response</td>
<td>No verbal response</td>
</tr>
<tr>
<td>2</td>
<td>Opens eyes to painful stimuli</td>
<td>Decerebrate posturing to painful stimuli</td>
<td>Incoherent speech</td>
</tr>
<tr>
<td>3</td>
<td>Opens eyes to command</td>
<td>Decorticate posturing to painful stimuli</td>
<td>Inappropriate words</td>
</tr>
<tr>
<td>4</td>
<td>Opens eyes spontaneously</td>
<td>Flexion to painful stimuli</td>
<td>Confused</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Localizes to painful stimuli</td>
<td>Oriented</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Obeys commands</td>
<td></td>
</tr>
</tbody>
</table>

This table demonstrates components of the Glasgow Come Score (GCS) in adults. To determine the GCS the patients best response in each category is added to come up with a final score. The maximum score is 15 while the minimum score is 3.
Despite common use of the GCS to describe head injury severity, it has significant limitations in accurately categorizing the neurological insult of a TBI patient. Evidence suggests that the interrater variability in assessing GCS is high. This can be due to a variety of reasons including methods used to apply stimulus to elicit a response, and discrepancies in assessing response. For instance, injuries to the face can complicate calculation of the eye score, while paralysis or language barriers can complicate calculation of the motor and verbal scores respectively.

Building on the GCS, a method of categorizing patients with TBI into broad categories based on the total GCS score has been used increasingly in the literature. Under this paradigm, based on GCS, TBI is stratified into mild, moderate and severe.

Mild head injuries are those in which the patient has a GCS of 13 or more, irrespective of if there has been a loss of consciousness or not. Mild head injuries are the most common type of head injury seen in the ED, and are often managed by emergency physicians without the need for specialist care. While these are typically low energy injuries, recent evidence suggests that even mild head injuries may have significant implications for the patient with respect to mood, cognitive ability and return to pre-morbid status.

Patients with a GCS of 9-12 on arrival to the ED are characterized as having moderate TBI. Often these patients have had a significant head injury and require specialized monitoring and care. Patients with moderate head injuries typically require evaluation by a neurosurgeon, and often will have identifiable lesions on CT scan.

Those patients presenting to hospital with a GCS of 3-8 are thought to have sustained a severe TBI. These patients have undergone significant trauma with large amounts of energy transfer. Patients with severe head injuries will often have other associated injuries and require intubation due to the low level of consciousness. CT scan of these patients almost always demonstrates an identifiable traumatic lesion. Severe head injuries require specialized critical care, and often operative procedures by a neurosurgeon to measure intra-cranial pressure within the skull, or more extensive procedures to evacuate traumatic lesions.

While methods to assess severity of brain injury exist, GCS remains the only tool to allow rapid, real-time prognostication and quantification of a patient’s head injury. Additionally, the GCS requires no clinical criteria, and no information on the specific type of injury. This is both an
advantage and disadvantage. It is advantageous to employ a tool that uses only clinical response, as it can be applied in the field and in situations where accurate discrimination of the type of injury is not possible. However, the disadvantage of not incorporating injury characteristics is the non-specificity of GCS as a measure of brain dysfunction and injury.

Many studies have looked at GCS as a predictor of in-hospital mortality\textsuperscript{29-33}. The results in the literature identify GCS as an independent predictor of morality. With decreasing GCS scores, mortality significantly increases. At least one of these studies has shown that the motor component of the GCS taken in isolation is a more robust predictor of mortality than the overall score\textsuperscript{29}. The improved ability of the motor GCS score to predict mortality is likely a function of reduced confounding by factors that can complicate the overall score as discussed previously.

1.2.2 Abbreviated Injury Scale

While the GCS uses patient response to assess the severity of a patient’s brain injury, other scales exist that are widely used to categorize injuries once the exact insults are known. The most commonly used are the injury severity score (ISS) and abbreviated injury scale (AIS) score. These measures are related and are used to describe injury characteristics in the multiply injured patient\textsuperscript{34}.

The AIS is an anatomical scoring system that was introduced in 1969 by Copes et al. in conjunction with the Association for the Advancement of Automotive Medicine (AAAM)\textsuperscript{35}. Since its introduction the AIS has been revised to ensure its validity in gauging survival. AIS scores are widely accepted as being a relatively accurate characterization of the threat a specific injury has to the patient’s life. The last revision of the AIS score was in 2008, and it is continually reviewed and updated by the AAAM\textsuperscript{36}.

The AIS breaks the body down into individual components, these being: head, face, neck, thorax, abdomen, upper extremity, lower extremity and other (including pelvis). The AAAM has coded specific injuries that occur in each body region comprehensively. The severity of each injury is scaled as score from 1-6. A score of 1 represents a relatively minor injury with minimal threat to life, while 6 represents an injury that is not compatible with survival\textsuperscript{36}. The AIS score does not represent injury severity, but rather represents the threat to life of each injury. For instance, if a
patient has multiple injuries in a particular body region, the AIS for that region will be dictated by the injury with the most lethality.

The predictive value of head AIS scores in isolated TBI has been examined. Increasing head AIS score has been shown to be an independent predictor of in-hospital mortality. In one study, a head AIS of 4 or greater was used as a cutoff beyond which mortality increased significantly. However, given the independent predictive value of both GCS and head AIS scores, there is no correlation seen between the two in their ability to predict mortality.

1.2.3 Injury Severity Score

In order to grasp the severity of a patient’s clinical condition following trauma, a scale that takes all injured body regions into consideration is necessary. The most common way of measuring injury severity is the ISS. Baker et al developed the ISS score in 1974. The ISS is a derivation of the AIS.

ISS score calculation is done through multiple steps. First, body regions in ISS are divided into 6 parts: head and neck, face, chest, abdomen and pelvis, extremities and external. In order to calculate ISS, the three body regions with the greatest maximum AIS are isolated. The AIS values for each of these three regions are then squared. Finally, the sum of the squared values is calculated- this final number is the ISS. The maximum possible ISS score is 75 ($5^2*5^2*5^2$). If a patient has an AIS score of 6 in any body region, the ISS is automatically 75. A major trauma is defined as when a patient has an ISS of more than 15. The ISS functions as an aggregate measure of injury severity taking into account all the patients injuries and allows comparison of polytrauma patients across total injury severity, without focusing on the specific body regions injured.

Being able to accurately characterize a patient’s brain and associated injuries is an important part of identifying severely injured isolated TBI patients. The aforementioned schemes allow quantification and examination of a brain injured patient’s process of care as well as their outcome. These measures are imperative in quality assurance and improvement practices.
1.3 Management Guidelines

1.3.1 Introduction

To adequately care for TBI patients, processes that standardize care have been developed which have been shown to improve outcome\textsuperscript{42}. Potential mortality and morbidity reductions may be achieved with protocol driven care as these formulas may not only reduce missed injuries, but also provide a framework through which a consistent approach to care delivery can be undertaken.

1.3.2 Advanced Trauma Life Support (ATLS)

In North America, and globally, trauma patients are initially managed using the Advanced Trauma Life Support algorithm (ATLS) developed by the American College of Surgeons (ACS)\textsuperscript{43}. These guidelines are universally applied to all trauma patients to standardize care delivery. The ATLS guidelines address the different components of a patient’s injuries in a stepwise fashion. The order of priorities in this paradigm begins with airway moving on to breathing, and moves on to circulation. [Figure 2] These 3 priorities are commonly known as the ABC’s of trauma care. In TBI the ATLS guidelines have limitations as they are largely focused on initial management of injuries of the abdomen and thorax, and do not comprehensively address initial management and intervention strategies geared to reducing secondary injury in the brain.
**Figure 2- Advanced Trauma Life Support Algorithm**

**A-** Airway. The patient’s airway is to be assessed. Obstructions, injuries or depressed level of consciousness that lead to airway obstruction of the airway are assessed at this stage. If the patient is suffering from airway compromise, intervention in the form of intubation of tracheostomy is performed at this stage. At this stage, cervical spine precautions are also employed.

**B-** Breathing. Injuries that prevent adequate oxygenation and ventilation are assessed at this stage. If injuries are identified that prevent breathing, intervention is undertaken (e.g. thoracostomy).

**C-** Circulation. This node in the algorithm pertains to the evaluation of any injuries that compromise, or may compromise, the patient's circulatory volume and blood pressure. It is at this stage that shock is identified and treated. Part of the circulation component of the ATLS algorithm includes identifying intra-abdominal injuries that may compromise the patient's circulation with the focused abdominal sonogram for trauma (FAST). Intervention such as volume resuscitation, blood products, central line and Foley catheter insertion occur at this stage.

**D-** Disability. The disability component of ATLS pertains to the neurological condition of the patient. The GCS is calculated at this stage as well as any evidence of spinal injury. A focused neurological exam is undertaken in order to identify any clinical neurological injuries including a digital rectal exam for spinal cord injury.

**E-** Exposure. The patient is completely exposed and examined to look for any external signs of trauma.

ATLS guidelines as created by the American College of Surgeons. The algorithm flows sequentially, and is to be repeated multiple times during the same trauma in order to assess for changes in the patient’s clinical status. Often, multiple components of the pathway are assessed at the same time in the setting of a trauma team.
1.3.3 Brain Trauma Foundation Guidelines

Recognizing the need to protocolize care and provide guidelines for management of head injuries, in 2001 the AANS in conjunction with the BTF developed guidelines for the management of patients with severe TBI\textsuperscript{21}. These guidelines were largely developed through expert consensus with consultation of the existing literature. The BTF guidelines represented the first time accepted treatment protocols were established for head injury. Although initial application of these guidelines varied, a developing body of literature has demonstrated that application of the BTF guidelines not only improve outcome, but also in conjunction, reduce costs at the hospital level in caring for patients with TBI\textsuperscript{44,45}.

A small portion of the recommendations published by the BTF can be applied in non trauma centers- this includes criteria such as keeping systolic blood pressure above 90, intubating the patient if the GCS is 8 or less, and providing basic hemodynamic support. However, full application of the BTF guidelines requires specialized trauma care consisting of trauma surgeons, neurosurgeons, critical care physicians and appropriately trained nurses. Because trauma center care is required to apply BTF guidelines, and BTF guidelines have been shown to improve outcome through reduction of secondary injury, optimal care for TBI patients is likely only achieved at a trauma center. Prior studies\textsuperscript{46-48} have addressed this fact by demonstrating the improved outcomes for patients with TBI treated at trauma centers compared to non-trauma centers, supporting the argument that patients sustaining severe TBI should be transported to a trauma center as expeditiously as possible to deliver optimal care in the timeliest manner.

1.4 Trauma Systems

1.4.1 Introduction

Organized trauma systems have been shown to improve outcome for all injured patients, including those with TBI\textsuperscript{49}. A trauma system is composed of both transport mechanisms as well as accredited centers meeting specified criteria. In the United States the accreditation body is the American College of Surgeons (ACS) while in Canada, trauma centers are accredited by the Trauma Association of Canada (TAC).
1.4.2 Pre-Hospital Care

Within North America patients are transported to accredited trauma centers by either air and land transport. These modalities aim to deliver patients with traumatic injuries to trauma centers as rapidly as possible. The Ministry of Health and Long Term Care in Ontario coordinate emergency medical services (EMS) in Ontario. Land ambulance services are administered at the municipal level. In Ontario, 50 municipalities or districts coordinate 70 EMS services.

EMS providers have varying levels of certification, which allow them to deliver different levels of intervention. However, overall, two general philosophies of EMS behavior exist. These philosophies are described as “scoop and run” or “stay and play”. The “scoop and run” philosophy is based on the hypothesis that the value of an organized EMS system is in rapid access to definitive care. Under this philosophy, very little intervention is performed in the field and only those procedures required to stabilize the patient enough for transport are undertaken. In contrast, under the “stay and play” philosophy, significant intervention is delivered in the field, in an effort to stabilize the patient medically, beyond what is required for transport. In some cases, EMS services that use this “stay and play” philosophy have physicians on board their vehicles. In North America, the “scoop and run” philosophy dominates to ensure patients are transported to definitive care as quickly as possible.

EMS use guidelines to identify patients that should be transported to a trauma center (in some cases bypassing closer hospitals) in an effort to maximize the benefit achieved through a philosophy centered on patient access to definitive care in as timely a manner as possible. These guidelines, known as field triage criteria (FTC), are only of relevance in geographic areas that encompass a trauma center, as in rural areas the distance to a trauma center is prohibitive given long transport times. Generally, if a patient can reach a trauma center by EMS within a specified time, usually 30 minutes, FTC identifies those patients who will benefit from immediate access to trauma center care. FTC are developed and implemented by EMS through the same network structure used to organize services administratively. In Ontario, for instance, because EMS services are regionalized municipally these criteria are developed and implemented municipally, whereas in Alberta, where EMS is administered by health region, the health region is responsible for guideline implementation. In the United States, FTC are developed by the Centers for Disease Control (CDC) and are evidence based. While this may not necessarily impact
adherence to FTC, unlike Canadian guidelines, there is literature supporting the structure of FTC in the United States\(^5\).

In cases where injuries are deemed to be severe or rapid access to a trauma center is required from the scene or non-trauma center, air transport mechanisms exist in most provinces.

Air transport in Ontario is provided through one, semi-private service. ORNGE is a transport medicine network with 11 helicopters and a newly developed land ambulance program. The program was established in 1977 as Ontario Air Ambulance and subsequently transitioned to ORNGE (a public private partnership) in 2005. These resources are all staffed by trained pilots and critical care paramedics. ORNGE remains the largest air medical system in North America with bases currently located in Thunder Bay, Kenora, Moosonee, Sudbury, London, Hamilton, Toronto and Ottawa.

These EMS assets are the gateway to trauma center care and provide timely access to ensure the definitive management of injury. Further, these EMS resources are able to engage in basic intervention to ensure all injured patients (including those with TBI) survive to reach medical intervention at a trauma center.

1.4.3 Acute Care Hospitals

Ontario has over 190 acute care hospitals, however only 9 of these centers are verified as adult level I and II trauma centers by the Ontario Ministry of Health and Long Term Care.[Figure 3]
Figure 3- Location of Trauma Centers in Ontario

Location of the nine trauma centers in Ontario
1.4.4 Trauma Centers

Trauma centers in the United States and Canada are accredited through their respective bodies and must meet stringent criteria in order to be referred to as a level I or II trauma center.

The accreditation process to gain trauma center designation in Canada requires fulfillment of the same criteria required for level I designation in the United States. There are both clinical and non-clinical criteria\(^{52}\). Clinically, to pass the accreditation process in Canada a hospital must have a dedicated trauma team composed of: general surgery, orthopedic surgery, anesthesia, and a trauma team leader (TTL). In addition there must be immediate access to surgical subspecialties such as neurosurgery, cardiothoracic surgery and vascular surgery. There must be well-established hospital infrastructure such as a 24 hour emergency department (ED), comprehensive medical imaging facilities, a 24-hour operating room and appropriately staffed intensive care unit. From a non-clinical perspective, quality improvement, research and educational endeavors are required\(^{52,52}\).

The above criteria coalesce to create the optimal environment for care of the injured patient. By immediate access to critical resources, injuries can be diagnosed and treated in an expeditious manner obtaining the best possible outcome for the patient.

The resource intensive nature of trauma centers often leads to their regionalization. For instance, Ontario- with a population of 13 million people- has 9 adult trauma centres. These hospitals are located in large, urban centers, which have patient volumes that can ensure critical mass to maintain quality and serve the greatest population.

In Canada, neurosurgical centers and trauma centers tend to be co-regionalized due to the resource demands required to deliver care in both specialties. Given the complexity of treating patients with TBI, access to a trauma center is critical in attaining access to neurosurgical resources for definitive care of head injuries. The literature demonstrates the importance of trauma center care for comprehensive management of TBI in an effort to reduce secondary injury and improve outcome through invasive monitoring as well as operative intervention as described by the BTF guidelines\(^{53,54}\).
Access to Trauma Centers

Access to the trauma system, and subsequently a trauma center, for all trauma patients (including those with TBI) is realized through a cascade of events [Figure 4]. First, a patient must be identified as requiring trauma center care. If the patient is severely injured at the scene and the patient meets established field triage criteria, EMS can transport the patient to a trauma center directly. However, often, patients may be injured in scenarios where, for a variety of reasons, they are transported to a non-trauma center from the scene. Non-trauma centers in Canada are diverse, and can range from large, regional community hospitals to small, rural hospitals. When patients arrive at a non-trauma center after TBI, they must achieve trauma center access through transfer mechanisms. This process is made up of multiple steps and involves: i) identification of the patient as requiring trauma center care, ii) acquiring a bed at an accepting trauma center and iii) organization of transport for the patient from the non-trauma center to trauma center. Delays in any of these steps can result in the patient succumbing to their injuries at the non-trauma center.
Figure 4- Pathway to Realized Care at Trauma Center for Patients with TBI

This figure represents the method of access to a trauma center (TC). Patients are either transported directly from the scene, or are first taken to a non-trauma center (NTC). At the NTC, the patient must be identified as requiring trauma center care before the transfer cascade is activated. Spaces between each node represent areas where significant delay can occur.

*CRT* = *CritiCall Ontario*
1.4.5.1 Access following Transport to a Non Trauma Center

When TBI patients arrive at a non trauma center, they are initially cared for by ED physicians and nursing staff. Depending on clinical expertise and the resources available at the particular institution, the patient will receive varying levels of initial care. Standard management of the trauma patient is driven by the ATLS guidelines and therefore attention is paid to this algorithm. It is not commonplace, however, for non-neurosurgeons to have knowledge of the BTF guidelines, and therefore, often TBI patients do not receive targeted care for their head injuries to reduce secondary injury. If a non-trauma center physician decides that a patient requires transfer to a trauma center, they make contact with a trauma center, either directly through established hospital agreements, or through a centralized network (i.e. CritiCall in Ontario). The ED physician conveys the clinical situation of a patient to a trauma team leader or neurosurgeon, and a decision for transfer is made. This decision is largely based on the patient’s clinical status, but may involve other factors such as resource availability at the trauma center. Once the decision to transport a patient to a trauma center from a non-trauma center has been made, transportation resources are required as the final portion of the pathway. TBI patients often require the highest level of paramedic care, and the ability to manage clinical changes in the patient during the transfer process. Upon arrival of transport at the non-trauma center, the patient is then flown or transported by land ambulance to a trauma center where they will receive definitive care.

Trauma networks help ensure that patients with TBI reach definitive care in the most efficient manner possible. Access to resources that allow modification of secondary injury help improve the outcome of patients who have sustained a severe head injury.

1.4.6 Non Trauma Centers

1.4.6.1 Physician Beliefs and Perceptions at Non Trauma Centers

Many traumatic injuries occur in settings where transport to a trauma center from the scene of injury is not possible (i.e. geographic location of injury). As described previously, the evaluation and initial medical management of these patients occurs at non-trauma centers by ED physicians. While trauma centers must meet standard criteria to be certified, there is considerable variability in resources at NTC. Additionally, it is plausible that physicians with varying backgrounds and
dissimilar levels of experience managing head injuries staff non-trauma center ED’s and may provide variable care to patients with TBI.

The differences in resources and staff experience at non-trauma centers may create unique beliefs and perceptions in ED physicians that could ultimately influence care delivered to TBI patients. Literature on the management of TBI is relatively recent and ever changing, and while algorithms such as ATLS have been disseminated for decades, the BTF guidelines are scarcely a decade old, and may not yet be disseminated to non-trauma centers. The potential lack of awareness of BTF guidelines at non-trauma centers, along with variations in resource availability at these institutions may play a role in limiting goal directed therapy administered to patients with TBI, which might impact outcome. Additionally, physician beliefs regarding outcome after TBI at a non-trauma center may be nihilistic, as these physicians do not participate in long term follow-up or quality improvement exercises, and may impact the intensity with which care is delivered.

The availability of resources, methods used to contact neurosurgeons and satisfaction with interactions with neurosurgeons may also vary among ED physicians and influence the way they perceive and treat TBI patients. Confidence managing neurosurgical patients, the ability to identify patients requiring transfer and other measures of comfort with neurosurgical emergencies may be influenced by practice location and experience. These perceptions and beliefs may impact a variety of factors such as the ability to identify subtle, but potentially devastating injuries, the promptness with which the physician contacts a TC, and the initial stabilization of the patient, all contributing to the efficiency by which a TBI patients is treated and transferred

1.4.7 Examination of the Transport Network

1.4.7.1 Goals

TBI is a complex, and devastating injury that affects the most productive members of society. While care of TBI patients continues to evolve, the literature demonstrates that patients are best served when they are cared for at trauma center. Trauma center care in TBI is essential for a
variety of factors, including but not limited to, guideline driven care, and availability of all required resources to definitively manage a patient’s injury.

Treatment of patients with TBI remains a complex and time sensitive issue. Due to this, the transfer of TBI patients to trauma centers from non-trauma centers and the transport of TBI patients from the scene to a trauma center, remains a priority.

A framework exists through which to provide trauma center access to TBI patients either from the scene of injury, or after transport to a non-trauma center. These established mechanisms rely on various elements of the transport and transfer network to function efficiently.

As described previously, a variety of steps are involved in achieving definitive care for the TBI patient. Factors that result in delays or inefficiency in any of these mechanisms can lead to increased time to definitive care, and in some cases, can prevent transfer completely. [Figure 5] This comes with significant implications for the overall outcome of the patient, which is also associated with increased costs for society as a whole. The importance of expeditious access to TC care for patients with TBI warrants examination of the transfer process and variables leading to delay- if any.
Figure 5- Factors Impeding Transfer of Patient from Non Trauma Center to Trauma Center

Not sure how sex of patient influences transfer?

Factors affecting efficient patient transport from non trauma center (NTC) to a trauma center (TC). A multitude of patient, institutional and environmental factors can modify the speed at which a patient is transferred, or if a patient is transferred at all. If the NTC does not identify the patient as requiring transfer, the other factors are extraneous, as the process will not initiate.
By reviewing transfer and transport patterns, adherence to established guidelines and barriers to transfer from non-trauma centers, we aim to identify factors that may delay or prevent prompt access to definitive care.

If barriers to access are identified, delineation of their place in the transfer paradigm can be determined. Once these impediments to access are acknowledged, they can be addressed through behavior change, education or policy modification. Identifying and correcting potential deficiencies in the overall path of care for TBI patients might allow delivery of patient care in a more efficient manner. Efficient access to trauma center care for patients with TBI may lead to improved outcomes for patients and ultimately reduce the burden of disease on the system and society as a whole.
Chapter 2
Hypothesis and Study Design

2.1 Study Setting

We chose to use Ontario as the ideal study site for a variety of factors. First, Ontario has the capability of capturing and recording all patient interactions with acute care hospitals through centralized administrative databases. This allows for an accurate characterization of injuries sustained by patients, as well as resources used. Secondly, Ontario has a centralized air ambulance program, which provides comprehensive coverage to the entire province. Further, because Ontario has no lower level trauma centers, patients can be dichotomized to being treated at a trauma center or a non trauma center. The ability to dichotomize the point of care helps clarify the distinction between where patients were cared for and what resources they had access to. Finally, the tenants of the Canada Health Act (CHA), namely accessibility and universality, facilitate the expectation of comprehensive care for patients regardless of location of injury or socioeconomic status, as all patients are fully insured through a single payer.

2.2 Conceptual Framework

When examining access to care, patients might be characterized as having potential access and/or realized access.

Potential access has been defined as the presence of enabling resources\(^5^6\). In the setting of trauma, potential access can be thought of as access to care based solely on the presence of available resources. Potential access largely incorporates infrastructure into measurement, as it is the potential utilization of healthcare resources by patients.

Realized access differs from potential access, in that is the actual usage of healthcare resources by a patient. Realized access, unlike potential access, can be measured by patient outcome as well efficiency. Realized access is a reflection of actual healthcare utilization and it therefore can provide information on process.
The gap between potential access and realized access can be thought of as inefficiency in the system. Theoretically, in a perfect system, realized and potential access should be equivalent. However, due to a variety of factors, a gap between potential and realized access can exist. In this case, the system is inefficient and can result not only in poorer outcomes for the patient, but higher costs for the system. It is through examination of this gap that problem areas can be identified and solutions can be proposed to improve access to care.

Figure 5 demonstrates variables that may lend to a gap between potential and realized access. These include patient level factors (i.e. age, sex, co morbidities), resource availability and geography (i.e. time of day, season, distance). Patient level factors may negatively influence triage decisions by EMS or non trauma center physicians, thereby reducing access. Resource availability largely encompasses bed availability and transport availability. Availability of appropriate transport mechanisms in a timely manner may serve to reduce access to a trauma center in a timely fashion, or at all if the patient succumbs to their injury awaiting transport. Similarly, access may be reduced due to lack of available beds at the trauma center thereby delaying or preventing transfer. Finally, geographic factors such as weather, distance and time of day may play a role in reducing access. These variables represent factors that may prevent access to trauma center care from being realized by patients with severe TBI.

2.3 Hypothesis

The overarching hypothesis of this thesis as that through evaluation of trauma center access in TBI, modifiable factors that impede optimal care may be identified, prompting improvements in access to definitive care.

2.4 Research Aims

**Research Aim 1**- To explore whether a difference exists between potential and realized access in the setting of TBI at the provincial level.

**Research Aim 2**- To evaluate adherence to FTC by emergency medical services in triaging patients with potential access to a trauma center in the setting of TBI in an urban setting.
Research Aim 3: To explore the beliefs, perceptions and challenges of emergency physicians in non trauma centers in context of treating patients with TBI.

2.5 Data Sources

2.5.1 Introduction

Data sources used for this thesis were derived from population based databases and a provincial survey potentially distributed to all emergency physicians in the province of Ontario.

Population based administrative datasets include the Canadian Institute for Health Information (CIHI) National Ambulatory Care Reporting System (NACRS) and the CIHI Discharge Abstract Database (DAD). Both of these databases are held at the Institute for Clinical and Evaluative Sciences (ICES) at Sunnybrook Health Sciences Centre. The population based datasets not held at ICES that were used in this thesis were the Resuscitation Outcomes Consortium (ROC) Epistry database held at the Rescu research group at Sunnybrook Hospital in Toronto, and the CanMap RouteLogistics database.

The provincial survey was disseminated through the Emergency Medicine Local Health Integration Network (LHIN) leads of the Ontario Ministry of Health and Long Term Care (MOHLTC) and the Canadian Association of Emergency Physicians (CAEP).

2.5.2 National Ambulatory Care Reporting System (NACRS)

NACRS was developed by CIHI in 1997 and was subsequently adopted by Ontario in 2000.

The goal of NACRS is to capture all emergency department and ambulatory care (including day-surgery) department visits in an effort to provide data on these services. Data elements captured by NACRS on these visits include demographic data (e.g. age, sex, postal code of residence), clinical parameters (e.g. ICD-10 diagnoses and procedures, co morbidity, discharge disposition) and administrative parameters (e.g. time to discharge).

2.5.3 Discharge Abstract Database (DAD)

CIHI developed the DAD in 1963, initially in Quebec and Ontario, to capture all in-patient
hospital admissions. By 2010, the DAD had the ability to capture 75% of all in-patient admissions across Canada.

Similar to NACRS, the DAD contains demographic, clinical, administrative and financial information; however it collects these data upon discharge of patients from acute care hospitals (e.g. death, discharge, transfer, etc.). As such, the DAD is limited to patients who were admitted to hospital.

2.5.4 Resuscitation Outcomes Consortium (ROC)

ROC is a multicenter, international group conducting research on a variety of issues related to the outcome of patients following events necessitating resuscitation. The United States Federal Government, US Department of Defense, National Institutes of Health, Canadian Institutes of Health Research (CIHR), Heart and Stroke Foundation and Canadian Defense Research and Development sponsor the ROC. The Epistry dataset is the database maintained by ROC, which compiles data from ROC centers. The data used for this thesis was the RESUeNET subset of Epistry, which includes only the Hamilton and Toronto submission centers. To meet inclusion criteria for the trauma component of the Epistry database, patients must be identified as meeting one of the following criteria following a traumatic event: i) systolic blood pressure < 90mmHg ii) respiratory rate <10 or >29, iii) intubated iv) GCS <12 or v) died in field. The Epistry dataset includes demographic, clinical and administrative information about the patient, including geospatial co-ordinates of injury.

2.5.5 CanMap RouteLogistics

CanMap RouteLogistics is a software package developed by DMTI for GPS data. This database provides geospatial information (longitude and latitude) on roads, motorways, waterways, and points of interest among other information. The package used was specific to Ontario. CanMap RouteLogistics contains an enhanced point of interest file that identifies geospatial co-ordinates for over 1.6 million points of interest. This data was used to calculate the location (latitude and longitude) of all hospitals in the province as well as locations of injury for individual patients.
2.6 Cohort Definitions and Descriptions

2.6.1 NACRS and DAD

2.6.1.1 Data Linkage (NACRS and DAD)

While NACRS and the DAD are both components of ICES, patients are not linked between the two databases. In order to follow patients along the course of their presentation to hospital and hospital stay, linking the same patient between both databases is necessary. Patient records at ICES are assigned an OHIP number known as the ICES key number (IKN).

2.6.1.2 Patient Identification

To identify those patients injured through a traumatic mechanism patient records were queried in NACRS between 2002 and 2010 limited to those patients with traumatic injury diagnoses as defined by the ICD-10. The emergency department visit in NACRS was labeled as the injury event and was deterministically linked to the DAD using each patients unique IKN.

2.6.1.3 Mechanism of Injury

The mechanism leading to the patient’s injury was identified using ICD-10 external cause of injury codes. Using a pre-existing matrix developed by the American Public Health Association, the International Collaborative Effort on Injury Statistics and the National Center for Health Statistic, the ICD-10 codes were categorized into broad categories of injury mechanisms. The mechanism categories included: i) motor vehicle collision ii) motor vehicle collision- pedestrian iii) fall from same level iv) fall from height v) penetrating vi) other blunt. Those patients who were injured by burns, poisoning, foreign bodies, suffocation, drowning, asphyxiation and toxic effects were excluded.

2.6.1.4 Injury Severity

To identify those patients in the NACRS/DAD who had only a severe head injury the AIS score was used in conjunction with the ISS score. To identify severely injured patients, the cohort was limited to those patients with an ISS > 15. Patients with ISS > 15 are widely accepted to be
severely injured. Because the ISS does not provide injury information about specific body regions, in order to identify those patients with only severe head injuries we limited the cohort to patients with an AIS of 3 or more in the head. Further, to ensure there was no contamination by patients with severe injuries in other body regions the cohort was limited to patients with an AIS score of no more than 2 in any other body region but the head. Because NACRS and DAD do not record AIS scores, a previously validated ICD-10 to AIS score crosswalk was used. Patients who died at the scene, as well as those who died within 30 minutes of arrival to the ED were excluded. Excluding patients who died within 30 minutes of arrival was done to exclude patients presenting dead on arrival as well as those patients that died in the field and were transported to the hospital for declaration.

2.6.1.5 Patient Level Variables

Patient variables collected for the cohort included sex, age, number of comorbidities, mechanism of injury, ISS, AIS scores for all body regions, ICD-10 diagnoses codes, discharge disposition, 30-day mortality, transfer status.

Co morbidities were established using the DAD over 2 prior years. The number of diagnosis were evaluated in previous records and recorded for each patient.

2.6.1.6 Hospital Level Variables

Trauma center status was identified for each institution, identifying it as either a trauma center or non-trauma center.

2.6.2 ROC- Epistry

2.6.2.1 Injury Event

Patients were identified based on their inclusion criteria into the Epistry dataset. All patients, by definition, were injured as a result of a traumatic mechanism. However, patients can meet Epistry inclusion criteria based on a variety of physiological derangements (i.e. heart rate, respiratory rate etc). For the purpose of this thesis, the Toronto EMS field triage criteria were used to identify patients. Patients were limited to those who would meet FTC solely through the
TBI component of the FTG. Within the Epistry dataset, this would be operationalized to those patients with a GCS of 10 or less and no other physiologic derangements.

2.6.2.2 Injury Severity

Within the patients with a GCS $\leq 10$ the group was dichotomized into those with severe and less severe injuries. Patients with a motor GCS (mGCS) score of 4 or less were operationalized to be severely injured, while those with a mGCS $>4$ were deemed to be less severely injured. It is salient to note, by the very nature of FTC, all patients would have had a high likelihood of requiring an operation.

2.6.2.3 Patient Variables

Patient variables collected from this dataset included: age (yrs.), sex, and mechanism of injury, GCS, mGCS, intubation status.

2.6.2.4 Hospital Level Variables

Hospital-level variables collected included: trauma center status, distance to the closest trauma center from the scene of injury and distance to the closest hospital from the scene of injury.
Chapter 3
Access to Trauma Center Care following Severe Traumatic Brain Injury

3.1 Abstract

**Background:** Traumatic brain injury (TBI) is one of the most common causes of injury-related morbidity and mortality. Access to neurosurgical services is critical to optimal outcomes through reduction of secondary injury. We sought to evaluate variations in access to neurosurgical care across a regional trauma system.

**Methods:** This is a population-based retrospective cohort study of patients who sustained isolated severe TBI from 2005-2009. Administrative datasets capturing all ED visits and hospitalizations were linked deterministically. Differences between access to a trauma center (TC) defined as direct transport from scene or transfer from a non trauma center (NTC) as opposed to no access were evaluated; this included patient level determinants of access to TC and delineation of mortality differences between TC and NTC care. Transfer patterns from NTC to TC were also evaluated.

**Results:** We identified 9,448 patients with isolated severe TBI. Almost two thirds (60%, n=5701) received initial care at a NTC. Of these patients, 30% (n=1737) were subsequently transferred to a TC. 30-day mortality of patients treated at TC vs. NTC was 19% vs. 18% respectively (p=0.19). 67% of patients < 65 received TC care while only 41% of patients > 65 were treated at a TC (P<.01). Mechanism, age, brain hemorrhage and injury severity were associated with TC care.

**Conclusions:** Considerable variation in delivery of initial care to TBI patients was identified. Factors such as age and injury characteristics were associated with TC access. Because early TC care in TBI confers survival benefits, the demonstrated variability necessitates improvements in access to care for patients with severe head injuries.
3.2 Introduction

Severe traumatic brain injury (TBI) is a significant public health concern. The annual incidence of severe TBI in the United States is 11.4 per 100,000 people\textsuperscript{10} and severe TBI accounts for a third of all trauma related deaths\textsuperscript{58}. The effects of TBI extend beyond the injured, as caregivers for these patients require significant economic and social support once the patient is discharged from hospital\textsuperscript{59}. Patients with severe TBI also represent a considerable economic burden as the direct and indirect costs associated with TBI in the US amount to approximately $60 billion per year\textsuperscript{60}.

Protocol driven care can reduce mortality and cost in severe TBI through application of the Brain Trauma Foundation (BTF) guidelines\textsuperscript{61}. Application of these guidelines requires specialized surgical and medical care that can only be delivered at a trauma center. Effects of this specialized care are realized through the prevention of secondary injury, which is the modifiable phase of the acutely head injured patient. Adherence to the BTF guidelines has been shown to reduce cost and improve outcome in TBI\textsuperscript{44}.

Due, in part, to the resource intensive nature of neurosurgery and neuro-critical care, these centers are highly regionalized in Canada. In Ontario, 9 of the 11 adult neurosurgical centers are also level 1 trauma centers. Access to these trauma centers, and ultimately definitive neurosurgical care, is realized either: i) through direct transport of the head injured patient from the scene of injury to a trauma center or ii) indirectly through transfer of the patient to a trauma center following initial triage and transport to a center without neurosurgical resources (a non-trauma center).

Given the regionalization of trauma center and neurosurgical centers along with the importance of prompt neurosurgical care in TBI, we sought to evaluate access to trauma center care for patients with severe TBI. Specifically, we evaluated if patients had access to a trauma center within the first 24 hours of injury either directly from the scene or through transfer from another institution. Of the patients who were first taken to a non-trauma center, we aimed to identify the proportion that were subsequently transferred to a trauma center. We further attempted to understand patient level factors associated with transport and transfer.
3.3 Methods

3.3.1 Design

A population-based retrospective cohort study design was undertaken to evaluate access to neurosurgical care for patients with TBI. The outcomes of interest were overall access (direct and indirect) to a trauma center as well as transfer to a trauma center for those patients who were initially triaged to a non-trauma center.

3.3.2 Study Setting

There are approximately 13 million persons in Ontario spread out over a geographic area of 1 million square miles. While the majority of the population lives in major metropolitan areas, approximately 20% of Ontarians live over 60 minutes from any specialty medical care. There are over 190 hospitals, eleven of which provide adult neurosurgical care. In Ontario, seven of these nine neurosurgical centers are located at designated trauma centers in an attempt to regionalize care.

3.3.3 Data Sources

There are two administrative databases in Ontario relevant to this work. The National Ambulatory Care Reporting System (NACRS) includes every visit to an emergency department in the province. The Discharge Abstract Database contains information on all patients admitted to acute care hospitals in Ontario. Each of these databases contains patient demographic information and ICD-10 diagnostic and procedure codes. Records in NACRS can be deterministically linked by means of a unique patient identifier to the Discharge Abstract Database. This linkage provides the unique opportunity to follow patients from first ED presentation through to same facility admission or through interfacility transfer to admission at another hospital.
3.3.4 Study Subjects

Adult patients (≥18 years) presenting to the ED between 2002 and 2010 with an Injury Severity Score (ISS) > 15 were identified. Since our goal was to understand triage and transfer practices related to a need for neurosurgical evaluation and management, we limited this analysis to patients with isolated severe brain injury defined as an Abbreviated Injury Severity (AIS) Score >=3 in the head region and an AIS <=2 in all other body regions. AIS scores were derived using a previously validated ICD-10 to AIS crosswalk algorithm. Patients who presented dead on arrival or those who died within 30 minutes of ED arrival were excluded from analysis as these outcomes are typically not modifiable through improved access to neurosurgical care.

3.3.5 Outcomes

We considered two outcomes. The first was any trauma center access, defined as trauma center access either directly from the scene or indirectly as a transfer from a non-trauma center. In those patients who were transported to a non-trauma center, the second outcome was trauma center access via transfer within 24 hours.

3.3.6 Statistical Analysis

3.3.6.1 Univariate Analysis

First, we compared characteristics of patients who had any access to a trauma center (direct and indirect) with those who never attained trauma center care using univariate analysis. We then used similar univariate analysis to compare differences between patients at non-trauma center who were transferred to a trauma center and those that were not.

3.3.6.2 Logistic Regression Analysis

Second, two separate multivariable logistic regression models were generated.

The outcome of interest in the first model was any access to a trauma center (direct or indirect). Covariates used in this model included: age, gender, comorbidity count, mechanism of injury and ISS.
The outcome of interest in the second model was the transfer of patients from a non-trauma center to a trauma center. Covariates used in this model were similar to those used in model 1, however we considered the possibility that transferring centers had additional information upon which to base decisions as a result of CT imaging. Thus we added three covariates to the model: epidural hematoma, subdural hematoma and subarachnoid hemorrhage. All data were analyzed using SAS version 9.2 (Carey, NC). A 2-sided p-value <0.05 was considered significant. Research ethics approval was obtained from Sunnybrook Health Sciences Center.

3.4 Results

3.4.1 Overall Results

9,448 patients meeting criteria for isolated severe head injury over the interval of study were identified. Overall thirty-day mortality was 19% (n=1774). Overall access to trauma center was realized in 57.8% (n=5466) of patients sustaining severe TBI. 40% of patients (n=3,747) were transported directly from the scene of injury to a trauma center. Of the 5,701 patients who were transported to non-trauma center, approximately a third (n = 1,719, 30%) were ultimately transferred to a trauma center within the first 24 hours. (Figure 6)

3.4.2 Access to a Trauma Center

There were significant differences between patients who realized access to a trauma center and those who did not. (Table 1) Patients who realized access to a trauma center were younger, more often male, and had fewer comorbidities. Furthermore, patients who realized access were more often injured as a result of a motor vehicle collision (MVC) or penetrating mechanism and more often severely injured (ISS>25) as well as more likely to have an epidural, subdural, or subarachnoid hemorrhage. Although no difference was seen in 30-day mortality between patients with trauma center access as opposed to patients with no access, 19% (n=772) of patients died at a non-trauma center without ever being evaluated by a neurosurgeon.
### Table 1 - Patient characteristics as a function of TC access

<table>
<thead>
<tr>
<th></th>
<th>Access to a TC (direct and indirect)</th>
<th>No Access to TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=3747</td>
<td></td>
<td>N=5701</td>
</tr>
<tr>
<td>Mean Age* - mean±SD</td>
<td>55±22</td>
<td>65 ±21</td>
</tr>
<tr>
<td>Male* - N(%)</td>
<td>3837 (69)</td>
<td>2419 (60)</td>
</tr>
<tr>
<td>Comorbidity* - N(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>4767 (87)</td>
<td>3189 (80)</td>
</tr>
<tr>
<td>1</td>
<td>395(7)</td>
<td>436 (11)</td>
</tr>
<tr>
<td>&gt;1</td>
<td>304 (6)</td>
<td>357(9)</td>
</tr>
<tr>
<td>ISS &gt; 25* - N(%)</td>
<td>3461 (63)</td>
<td>2169 (54)</td>
</tr>
<tr>
<td>Mechanism* - N(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVC Occupant</td>
<td>832 (15)</td>
<td>257 (6)</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>703 (13)</td>
<td>238 (6)</td>
</tr>
<tr>
<td>Fall- Same Level</td>
<td>1671 (31)</td>
<td>2027 (51)</td>
</tr>
<tr>
<td>Fall- Height</td>
<td>1280 (23)</td>
<td>878 (22)</td>
</tr>
<tr>
<td>Penetrating</td>
<td>83(2)</td>
<td>20 (0.5)</td>
</tr>
<tr>
<td>Other Blunt Mechanism</td>
<td>897(16)</td>
<td>562 (14)</td>
</tr>
<tr>
<td>Brain Hemorrhage* - N(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDH</td>
<td>559 (10)</td>
<td>182 (5)</td>
</tr>
<tr>
<td>SDH</td>
<td>2909 (53)</td>
<td>1968 (50)</td>
</tr>
<tr>
<td>SAH</td>
<td>5458 (58)</td>
<td>3973 (42)</td>
</tr>
</tbody>
</table>

*Figure 6* - TBI Patient access to Trauma Center and Non Trauma Center from Scene of Injury
Division of the overall cohort into three distinct populations. The first population encompasses patients that were taken directly to a TC following injury. The second population is comprised of those patients that were taken from the scene of injury to a NTC. A subset of the second population consists of those patients transferred from NTC to TC.
3.4.3 Transfer from a Non Trauma Center to a Trauma Center

Among patients first evaluated at a non-trauma center, there were significant differences among those who ultimately were transferred to a trauma center for further evaluation and management and those who remained at the non-trauma center (Table 2). The former were younger, more severely injured and more frequently injured by means of a MVC or penetrating mechanism, compared to those that were not transferred for trauma center care. There was a significant difference in the distribution of specific head injuries among those transferred compared to those who remained at a non-trauma center.

3.4.4 Brain Hemorrhage

More EDH and SAH were seen in those transferred but the proportion of SDH was the same. Among all patients with an EDH first evaluated in a non-trauma center, only half (n=202, 53%) were transferred for care within 24 hours. Similarly, only half of those with a traumatic SAH (n=499, 50%) were transferred for care. The majority of patients with a SDH (n=855, 70%) were not transferred for neurosurgical care in the first 24 hours.

3.4.5 Predictors of Access To Any Trauma Care

We used a logistic model to identify factors associated with realizing trauma center access (direct or indirect). Younger patients and those with greater injury severity were more likely to realize access to a trauma center compared to those who did not. Mechanism was also an important factor, with falls associated with a lower likelihood of access compared to MVC. (Figure 7) Model fit was confirmed as discrimination measured by the ‘c’ statistic was 0.84.
Table 2- Patient characteristics as a function of transfer from NTC

<table>
<thead>
<tr>
<th></th>
<th>Transfer to TC</th>
<th>Stay at NTC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=1719</td>
<td>n=3982</td>
</tr>
<tr>
<td>Mean Age* - mean ± SD</td>
<td>52 (21)</td>
<td>65 (21)</td>
</tr>
<tr>
<td>Male* - N(%)</td>
<td>1254 (73)</td>
<td>2429 (61)</td>
</tr>
<tr>
<td>Comorbidity* - N(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1564 (91)</td>
<td>3185 (80)</td>
</tr>
<tr>
<td>1</td>
<td>103 (6)</td>
<td>438 (11)</td>
</tr>
<tr>
<td>&gt;1</td>
<td>51 (3)</td>
<td>358 (9)</td>
</tr>
<tr>
<td>ISS &gt; 25* - N(%)</td>
<td>1083 (63)</td>
<td>2150 (54)</td>
</tr>
<tr>
<td>Mechanism* - N(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVC Occupant</td>
<td>326 (19)</td>
<td>238 (6)</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>258 (15)</td>
<td>238 (6)</td>
</tr>
<tr>
<td>Fall- Same Level</td>
<td>378 (22)</td>
<td>2030 (51)</td>
</tr>
<tr>
<td>Fall- Height</td>
<td>464 (27)</td>
<td>876 (22)</td>
</tr>
<tr>
<td>Blunt</td>
<td>206 (12)</td>
<td>358 (9)</td>
</tr>
<tr>
<td>Penetrating</td>
<td>34 (2)</td>
<td>39 (1)</td>
</tr>
<tr>
<td>Other Mechanism</td>
<td>68 (4)</td>
<td>199 (5)</td>
</tr>
<tr>
<td>Brain Hemorrhage* - N(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDH</td>
<td>202 (12)</td>
<td>182 (5)</td>
</tr>
<tr>
<td>SDH</td>
<td>855 (50)</td>
<td>1968 (50)</td>
</tr>
<tr>
<td>SAH</td>
<td>499 (29)</td>
<td>504 (13)</td>
</tr>
</tbody>
</table>

* p<.05
Forrest plot demonstrating results of logistic regression modeling with outcome being any access to a TC. The plot demonstrates the stepwise reduction in access with increasing age and changes in access patterns based on injury severity and mechanism.
3.4.6 Predictors of Interfacility Transfer

As age increased, the adjusted odds of transfer from a non-trauma center to a trauma center were lower. For example, patients over the age of 75 were half as likely to be transferred to a trauma center compared to patients under age 25. Patients injured as a result of a fall were less likely to be transferred to a trauma center compared to those injured through a MVC. There was a strong association between the specific intracranial lesion and transfer status, with EDH and SAH associated with an increased odds of transfer. No such relationship was observed in patients with SDH (Figure 8).
Figure 8- Predictors of Transfer from Non Trauma Center to Trauma Center

Forrest plot demonstrating results of logistic regression modeling results for the outcome of transfer to a TC from a NTC. This plot demonstrates the stepwise reduction in access with increasing age and the influence of severity, mechanism and type of head injury on access.
3.5 Discussion

Access to trauma care for patients with severe TBI is important to prevent secondary injury and improve outcome. Two major modes of realizing access exist. Direct access occurs in those patients who are taken from the scene of injury directly to a trauma center. Indirect access occurs in those patients who are first taken to a non-trauma center and are subsequently transferred to a trauma center.

Our results demonstrate considerable opportunities to improve access to trauma center care after incurring a severe TBI. All patients in our cohort should have had some form of access to a trauma center given the severity of their injuries. However, only two thirds of patients ever reach a trauma center for definitive care. Further, although mortality between patients who attained trauma center access and those who didn’t was similar (19%), patients who died following a severe TBI without neurosurgical evaluation may have had injuries in which intervention by a neurosurgeon could have prevented death or improved outcome. With such a substantial number of patients at non-trauma center not having access to comprehensive neurosurgical and trauma resources- quality of care in these patients is likely compromised.

Access to a trauma center across all modalities and specifically through transfer was associated with several patient level factors. Across both modes of access increasing age was associated with a step-wise reduction in access to a trauma center. Age-dependent limitations to access might be a function of beliefs and perceptions of the provider – either EMS or physician. Alterations in the level of consciousness in elderly patients may be attributed to medical problems rather than traumatic injury, which could delay or complicate the diagnosis and management of TBI in this patient population.

Compared to MVC, all other mechanisms of injury were associated with lesser access to care. This finding was most pronounced in patients with same level falls, as patients injured as a result of this mechanism were the least likely to have any trauma center access or be transferred. Compared to other forms of injury, same-level falls are often deemed to be low energy by both providers and family members. Additionally this mechanism of injury is likely most predominant in elderly patients. Conversely, patients sustaining injury through MVC’s were the most likely to realize trauma center access. This is likely because MVC’s are usually high-energy events which often result in severe systemic injuries thereby making emergency
personnel more vigilant to traumatic injuries in these patients. The beliefs and perceptions surrounding both falls and MVC’s, such as the perceived low likelihood of injury with falls and perceived very high likelihood of injury with MVC’s, may account for their association with trauma center access. While attempts were made to ensure variables used in the logistic regression model were measured accurately, there is undoubtedly imperfect measurement of the confounding variables thereby introducing the potential of residual confounding. Residual confounding may have impacted the results of our logistic regression by preventing full removal of the effect of confounding variables and thereby impacting the associations seen in the model.

Hemorrhagic lesions in patients following injury were associated with increased the likelihood of access to a trauma center through all potential modes of access compared to those without lesions. Specifically, EDH and SAH are associated with significantly better access to care. There are several potential explanations as to why there was no association between SDH and access to care. It is plausible that some of the patients with a SDH were those with chronic SDH, leading to elective or semi-elective transfer. Alternatively SDH are often seen in elderly patients on anticoagulation as a result of falls. In these patients decisions may have been made at the non-trauma center to not escalate care given the patients poor perceived outcome or, alternatively, that they were unlikely to benefit from treatment.

Although hemorrhagic lesions are only diagnosed at non-trauma center through appropriate imaging, the association between these injuries and access to care was strong, irrespective of whether imaging was performed (i.e. transferred patients) or not (direct transport patients). It is likely that those with hemorrhagic lesions were more likely to have a significantly decreased level of consciousness, influencing the field triage by EMS providers.

While our study demonstrates opportunities for improving access to definitive care for patients with severe TBI, limitations of this study exist. Primarily, there are no physiologic data. Specifically, we do not have GCS scores, or pupillary responses, both of which might influence provider decision-making. However, it is likely that greater anatomic severity of injury as determined by ISS, for which we adjusted for in our models, is highly correlated with physiologic abnormalities. Secondly, no data exists on provider knowledge, or perceptions, which might greatly influence decision making. Lastly, without information on the decision making process, it is difficult to gain a clear understanding of non-medical factors (such as do
not resuscitate orders) that mitigate access. Additionally, as data about location of injury was not present in our database, we were unable to identify those patients for whom direct transport was possible or impossible due to proximity of the trauma center. Patients who do not realize direct access to a trauma center, even though it may be geographically feasible may be different than those patients who do not realize access directly from the scene due to geographic impracticality. Finally, without data on resources at non-trauma center, it is not possible to explore how resource limitations may affect transfer practices.

Our results demonstrate variability in access to trauma center care for patients with severe head injury. Furthermore, significant patient and injury level factors exist that mitigate access to appropriate definitive care. These results prompt further investigation into hospital factors and non-medical decision making components that influence decisions regarding access. Further, this research can be used to inform policy changes that may improve the identification and appropriate transport of patients from the scene or from other hospitals to trauma center. Improving the efficiency through which patients with severe head injuries attain definitive trauma care, will ultimately improve outcome in these patients and reduce cost to the individual and society.
Chapter 4 Adherence to Field Triage Criteria by Emergency Medical Personnel

4.1 Abstract

**Background:** Traumatic brain injury (TBI) is best managed at trauma centers (TC) to reduce secondary injury and improve outcome. Access to TC care from the scene of injury through emergency medical services (EMS) is guided by field triage criteria (FTC). We sought to evaluate the predictors of adherence to FTC in the setting of TBI.

**Methods:** Study data were derived from the Resuscitation Outcomes Consortium database and were limited to patients in the city of Toronto, Canada. Adults who met TBI FTC for direct transport to a TC (GCS<10 and traumatic mechanism) were identified. Patients who would have met FTC by non-TBI criteria were excluded. TC access, defined as transport to TC from the scene, was the outcome of interest. Logistic regression was used to identify independent predictors of TC access.

**Results:** We identified 493 patients who met TBI FTC. 40% (N=199) were appropriately transported from the scene to a TC. Compared to those not brought directly to a TC, these 199 patients were younger (48 vs. 62, p<0.001), predominantly male (74% vs. 50%, p<0.001) and more often had a motor GCS score ≤4 (62% vs. 51%, p=0.01). On multivariable analysis, male sex, MVC mechanism increased the adjusted odds of direct transport to a TC in accordance with FTC. Age under 65 was associated with a reduced odds of direct TC access.

**Conclusions:** Adherence to FTC in TBI is not uniform. Patient level factors other than injury severity may influence transport to a TC. Further study is required to understand decision-making by EMS in the setting of TBI.
4.2 Introduction

Injury related hospitalization is a significant cause of morbidity and mortality in North America. A substantial proportion of injured patients present to hospital with an associated traumatic brain injury (TBI) and approximately one third of all trauma-related deaths occur as a result of TBI. The World Health Organization estimates that TBI will be the third leading cause of death and disability by 2020. Furthermore, there are significant societal and economic costs resulting from TBI. In the United States alone, in 2001, the direct and indirect costs of TBI were estimated to amount to as high as 60 billion dollars.

Treatment of TBI is focused on reduction of secondary injury which requires complex and resource intensive treatment. Optimal management of the head injured patient is guided by protocols set forth by the Brain Trauma Foundation (BTF) and the American Association of Neurological Surgeons (AANS). These guidelines help direct intervention and monitoring with the goal of reducing secondary injury thereby enhancing outcome after TBI. Recent evidence suggests that application of the BTF guidelines improves patient outcome and reduces cost.

Application of the BTF guidelines is best done at trauma centers. These hospitals are designated to care for the most severely injured patients and have the resources and personnel to apply the BTF guidelines in the timeliest manner. Further, trauma centers are capable of treating any other associated injuries the patient may have complicating clinical outcome. These institutions are usually located in large, heavily populated, urban settings.

Triage decisions surrounding access to a trauma center from the location of injury depend on both the transport time from the scene of injury to a trauma center and identification of a patient requiring trauma center care by emergency medical services (EMS). In urban settings, a trauma center is typically accessible by EMS in an acceptable timeframe (usually <30 minutes), and therefore distance and time required to reach a trauma center should not factor into triage decisions.

In the setting of trauma, EMS systems rely on field triage criteria that help identify patients who would benefit the most from direct transport to a trauma center potentially bypassing other hospitals. These criteria select for patients who are the most severely injured, and who are at highest risk of requiring immediate surgical intervention using physiologic and mechanic
criteria. Application of field triage criteria in TBI allows for rapid access to neurosurgical care in an effort to minimize the degree of secondary injury sustained by the patient. Patients who should be transported to a trauma center but are transported to the closest hospital should be considered undertriaged.

We sought to evaluate compliance to established field triage criteria in TBI patients in the setting of a large urban city served by two level I adult trauma centers. Additionally, we sought to identify patient factors that might have influenced triage decisions in patients with TBI.

4.3 Methods

4.3.1 Study Design and Setting

A population based retrospective cohort design was used for our study. The cohort included all injured adults in Toronto, Canada, who met local TBI field triage criteria for direct transport to a trauma center (GCS ≤10 and traumatic mechanism). The geographic region of the city of Toronto encompasses a population of 3.5 million people and is serviced by two centrally located adult trauma centers and a single EMS provider agency. Field triage criteria are developed and distributed by Toronto EMS, and mandate that patients meeting criteria, and within a driving time of 30 minutes or less, are to be taken to the closest trauma center bypassing other hospitals. Since both trauma centers in Toronto are accessible by vehicle from any area of the city within 30 minutes, theoretically all patients in our study have access to a trauma center.

4.3.2 Data Sources

Our cohort was derived from the Resuscitation Outcomes Consortium (ROC) database. ROC is a consortium of 11 sites each served by individual hospitals and EMS agencies that was established to examine pre-hospital interventions in cardiac arrest and major injury. There are 8 participating centers in the U.S. and 3 in Canada. The regional subset of the database for the city of Toronto, referred to as RescuNET, was used. ROC Epistry-Trauma incorporates consecutive injured children and adults who activate the 9-1-1 system for their regions and meet specific physiologic inclusion criteria for severe injury. Specifically, prehospital inclusion criteria for ROC-Epistry Trauma include any of the following: (i) systolic blood pressure <90,
(ii) GCS <12, (iii) Respiratory rate <10 or >29 breaths per minute, (iv) field intubation or (v) traumatic death in the field.

This study uses a subset of the RescuNET dataset that has previously been described by our group in work by Doumouras et al focusing on trauma triage.\textsuperscript{65}

4.3.3 Patient Inclusion Criteria

To identify patients who met TBI-field triage criteria, those individuals who met the Toronto EMS TBI field triage criteria were selected from the broader Epistry cohort described above. Toronto EMS-TBI field triage criteria identify any patient with a GCS of \( \leq 10 \) and a traumatic mechanism requiring transport to a trauma center. Patients who would have met EMS field triage criteria through any non-TBI criteria (systolic blood pressure <90, pulse <50 or >120 or respiratory rate <10 or >25) were excluded as it is impossible to ascertain if triage decisions were influenced by non-cranial injuries. Patients for whom a trauma center was the closest hospital were excluded. Patients injured as a result of burns, drowning, suffocation, electrocution, poisoning or other non-mechanical causes of injury were excluded from the analysis.

4.3.4 Statistical Analysis

4.3.4.1 Univariate Analysis

First, patients with trauma center access were compared to those without access using t-test for means and chi-square of Fischer’s exact test for categorical variables. Univariate statistics and logistic regression modeling was calculated using Statistical Analysis Software 9.2 (Carey, NC). Values of \( p<0.05 \) were considered significant.

4.3.4.2 Logistic Regression Analysis

Second, a multivariable logistic regression model was generated to identify predictors of trauma center access. Covariates used were age, mechanism, gender and motor GCS score. Age was dichotomized to \( \geq 65 \) or <65. Mechanism was categorized to: fall (from height), fall (same level), pedestrian/bicycle related, motor vehicle collision (MVC), assault and other. Motor GCS was divided into mGCS >4 and mGCS \( \leq 4 \). Discrimination of the logistic regression model was considered acceptable if the ‘c’ statistic was \( \geq 0.75 \).
4.4 Results

4.4.1 Patient Characteristics

We identified 493 patients with a GCS<12 following traumatic injury without other criteria for direct transport to a trauma center. As mentioned previously, all patients in this cohort were, in theory, injured within 30 minutes of a trauma center and met field triage criteria based on GCS alone thereby necessitating transport directly to a trauma center. Table 3 demonstrates characteristics of patients by triage disposition. Patients transported to a non-trauma center were older, female, had higher GCS motor scores and were more often injured as a result of a same level fall.
**Table 3- Description of Cohort Attained from ROC Database**

<table>
<thead>
<tr>
<th></th>
<th>Undertriage (NTC) n=294 (60%)</th>
<th>Proper Triage (TC) n=199 (40%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>62 ±23</td>
<td>48±21</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (%)</td>
<td>147 (50)</td>
<td>149 (74)</td>
</tr>
<tr>
<td><strong>Mechanism (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall from Height</td>
<td>39 (13)</td>
<td>43 (21)</td>
</tr>
<tr>
<td>Fall (Same Level)</td>
<td>158 (54)</td>
<td>43 (21)</td>
</tr>
<tr>
<td>Pedestrian/Bike</td>
<td>4 (1)</td>
<td>5 (3)</td>
</tr>
<tr>
<td>MVC</td>
<td>9 (3)</td>
<td>28 (14)</td>
</tr>
<tr>
<td>Assault</td>
<td>14 (5)</td>
<td>25 (13)</td>
</tr>
<tr>
<td>Other</td>
<td>70 (24)</td>
<td>55 (28)</td>
</tr>
<tr>
<td>Motor GCS &lt;=4 (%)</td>
<td>149 (51)</td>
<td>124 (62)</td>
</tr>
<tr>
<td>Intubated (%)</td>
<td>3 (1)</td>
<td>20 (10)</td>
</tr>
</tbody>
</table>

* p<.05
4.4.2 Identifying Predictors of Triage

We used a logistic regression model to identify factors associated with proper triage to a trauma center as opposed to improper transport to a non-trauma center.

Younger patients (<65) were more likely to be triaged to a trauma center from the scene when compared to the elderly (≥65) (OR 2.2 95%CI 1.4-3.4). Similarly, men were more likely to achieve trauma center access than women (OR2.1 95%CI 1.3-3.2). [Figure 9]

Injury severity, as measured by mGCS did not appear to influence triage to a trauma center. Patients with a mGCS >4 were just as likely to be triaged to a trauma center from the scene as patients with a mGCS ≤ 4 (OR 1.4 95%CI 0.9-2.1).

Compared to same level falls, all mechanisms of injury (except injuries sustained by pedestrians or bicyclists) were more likely to result in triage from the scene to a trauma center. This includes: falls from height (OR 3.0 95%CI 1.7-5.4), assault (OR 2.1 95%CI 0.5-8.4) and other blunt injuries (OR 2.1 95%CI 1.2-3.5). The most profound effect was seen in patients injured by a MVC who were 8 times more likely to be triaged to a trauma center compared to those injured through a same level fall (OR 8.0 95%CI 3.4-18.9)
Figure 9- Predictors of Undertriage by EMS from Scene to Trauma Center

Odds ratios from logistic regression with outcome as appropriate triage to TC. White area decreases likelihood of proper triage to a TC and dark shaded areas increase likelihood of proper triage. Compared to same level falls, MVC are most likely to lead to triage to TC. mGCS plays no significant role. Males are more likely to be triaged appropriately to TC as are younger patients.
4.5 Discussion

Patients treated at a trauma center, in the context of isolated head injury have been shown to attain improved outcomes over those treated at a non-trauma centers. Improved outcomes at trauma centers are likely influenced by the multidisciplinary expert care received at these institutions as well as the ability to fully apply the BTF guidelines through neurosurgeons, critical care physicians and trauma surgeons. Adherence to these guidelines has shown to improve outcome and reduce the cost of acute care.

Access to a trauma center from the scene of injury is achieved through transport by EMS following appropriate identification of patients at high risk of requiring surgical intervention. Established field triage criteria guides triage decisions made in the field by EMS. While adherence to these criteria is encouraged, ultimately EMS providers often use their own judgment on whether or not to triage patients in accordance with field triage criteria. This situation may result in traumatically injured patients who meet field triage criteria for direct trauma center access being taken to non-trauma centers.

The cause of undertriage is likely multifactorial. Broadly, there may be difficulties encountered by EMS with triage in head injury due to difficulties or inexperience with identifying patients who have sustained a severe TBI. Patients with TBI often have very few, if any, external stigmata of injury and this may alter provider behavior and perception. Adherence to field triage criteria may be further complicated by subjective perceptions and experiences of paramedics with TBI patients leading to triage based on experience and not field triage criteria.

At the patient level, significant demographic and injury characteristics were associated with differential triage practices by EMS. Age was found to be the most significant predictor of triage to a trauma center. Young patients (<65) were more than twice as likely to be triaged to a trauma center than those older than 65. Lesser access to trauma center care for the elderly has been described elsewhere and remains consistent in head injury. This differential triage of older patients might occur for one of two reasons. Mechanisms that injure older patients are often lower energy than those injuring younger victims. The mechanistic differences may influence perceptions of injury severity and may lead to oversight in identifying the severity of TBI in older patients. Additionally, the clinical status of an older patient following severe TBI may be
attributed to a non-traumatic mechanism, such as an age related illness, including dementia, delirium, or effects of systemic disease.

Independent of age, mechanism of injury is also significantly related to transport destination. Patients who are injured as a result of a fall, as opposed to those patients injured through a MVC, are significantly less likely to be triaged to a trauma center from the scene. These differences in triage are likely due to perceptions surrounding the types of injuries occurring through specific mechanisms. MVC are commonly perceived as having the capability of creating devastating injury patterns, while falls do not induce the same perception. However, the final mechanistic process in both falls and MVC with respect to TBI can be similar, and can produce commiserate injury.

Motor GCS score in severely head injured patients did not play a role in influencing triage. This was unexpected, as lower motor GCS scores are usually associated with more severe injuries and a higher potential for surgical intervention- requiring trauma center care. The lack of influence of injury severity (as measured by GCS) on transport to a trauma center in the context of head injury, suggests that EMS might be using methods other than field triage criteria or clinical parameters to decide whether to triage a patient to a trauma center.69

Beyond patient characteristics, injury location may also play a role in the appropriate triage to a trauma center for patients with severe head injury. If the location of injury is in close proximity to a non-trauma center, especially in populations such as the elderly or those with lower energy mechanisms, the impulse may be to transport the patient with TBI to a non-trauma center instead of a trauma center. These decisions may be influenced largely by perceptions by paramedics. Specifically, in cases where injury is very close to a non trauma center, paramedics may feel that additional distance or time required to transport the patient to a trauma center may provide no additional benefit to the patient- this may be facilitated by beliefs held by EMS providers about the low likelihood of surgical intervention or good outcome if the patient is transported to a trauma center. EMS triage decisions might be influenced by the perception that the additional distance required to reach a trauma center, bypassing the non trauma center, is prohibitive. However, previous work by Doumouras et al,65 has demonstrated that the additional distance that must be travelled to reach a trauma center over a non-trauma center is minimal and therefore should not play a role in field triage decisions in an urban environment.
Field triage criteria are based on physiologic and mechanistic criteria to identify patients with a high likelihood of requiring surgical intervention. As the data show, EMS providers may apply other, non-physiologic criteria in their decision making of whether a patient requires trauma center care. These may include subjective decisions that may rely on previous experience, perceived likelihood of survival, unfamiliarity with guidelines or proximity to a trauma center. Previous experience with TBI patients may influence provider behavior by creating nihilistic expectations of outcomes for these patients.

Given the wide range of potential subjective factors contributing to field triage criteria, further study is required to understand the decision making process undertaken by EMS at the scene of injury. Evaluating subjective criteria used by EMS providers in decision-making surrounding adherence to triage criteria would require further qualitative analyses. Through these methods we may gain a better understanding of challenges faced by EMS to help inform further iterations of field triage criteria. This study also helps inform the potential role of education sessions for paramedics to help them gain an understanding of injury patterns, intervention and outcome in head injury. Finally, from a systems standpoint, adopting evidence-based field triage criteria established by the US Centers for Disease Control (CDC) might offer additional benefit.

This study has several limitations. First, while the time constraint of the triage guidelines are maximized at 30 minutes, these lengths represent the perceived length of time transport would take by EMS rather than a true objective measure of transport duration. In addition, our data does not account for environmental factors such as time of day or season.

Although attempts were made to remove confounders during generation of the logistic regression models, there may be some inaccuracy or error in the ability to accurately measure and fully account for confounders. Because of this, there is likely some residual confounding affecting the results of our logistic regression model. This might influence some of the associations seen in the models in an unknown direction, thereby leading us to over or underestimate the impact of specific variables on access.

Finally, through exclusion of patients for whom a trauma center was the closest hospital, we are unable to examine triage practices in this subset of patients. If variations in triage exist within this group, there may be factors other than perceived distance that play a major role in affecting triage decisions.
Our study demonstrates that adherence to field triage criteria in the setting of isolated TBI requires improvement. Further study is required to understand what factors influence decision making surrounding application of field triage criteria. However, immediate intervention in the form of education and usage of CDC field triage criteria, may improve adherence.
Chapter 5 Perceptions of Emergency Physicians in the setting of Traumatic Brain Injury at Non Trauma Centers

5.1 Abstract

**Background:** Patients with neurosurgical emergencies require timely access to care in order to attain definitive treatment and maximize outcome. Due to regionalization of neurosurgical centers in Ontario, many patients with neurosurgical emergencies are evaluated, treated and triaged for transfer at non-neurosurgical centers by emergency physicians. We sought to examine the beliefs and challenges non-neurosurgical ED physicians faced in managing neurosurgical emergencies.

**Methods:** A multi question, online survey was generated and distributed to all ED physicians in Ontario. Dissemination was undertaken through the Ministry of Health and the Canadian Association of Emergency Physicians. The online survey was fielded for a total of 3 months with 4 and 8 week reminders. Data were collected and analyzed.

**Results:** A total of 812 surveys were viewed, with 153 completed (19%). After exclusion of survey responses from physicians at neurosurgical centers, a total of 114 surveys were analyzed. In general, most physicians (83%) felt comfortable managing neurosurgical emergencies. However, 12% reported not using any guidelines in managing patients. While most physicians (92%) felt that they could accurately identify a patient for transfer, 25% felt unsatisfied after conversations with a neurosurgeon that did not result in a transfer. The two most common issues ED physicians had with management and transfer of neurosurgical patients was bed availability at the neurosurgical center, and procurement of transportation assets once a patient was accepted for transfer.

**Conclusions:** ED physician perceptions of ability, and competency remain high, resulting in dissatisfaction when patient transfer is not achieved. Specific resource limitations exist that frustrate ED physicians in their ability to care for neurosurgical emergencies.
5.2 Introduction

Neurosurgical emergencies embody a varied set of pathologies ranging from vascular and oncologic disorders to trauma. The underlying challenge of neurosurgical emergencies is the necessity for rapid access to care and the functional implications of delays. Treatment of these disorders requires a combination of specialized critical care and surgical intercession, resources that are only available at neurosurgical centers.

Neurosurgical centers are institutions with specialized capabilities to diagnose and treat patients with neurosurgical emergencies with specific resources that include: enhanced imaging capabilities, dedicated neuro-critical care physicians, appropriately equipped neurosurgical OR suites and neurosurgeons. Additionally, because TBI makes up a great deal of the neurosurgical emergencies treated, these centers are often trauma centers as well. 70

Algorithms designed to improve and standardize the care delivered to patients guides optimal treatment of neurosurgical emergencies. Specifically in TBI, management of critically ill patients is guided by focus on general physiologic principles as described by the ATLS guidelines 71, and brain directed therapy as encompassed in the brain trauma foundation (BTF) guidelines 72. The latter has been shown to improve outcome and reduce cost in the setting of TBI 44. Pragmatically, many of the interventions outlined in the BTF guidelines can also be applied to most neurosurgical emergencies.

Comprehensive diagnosis and treatment of neurosurgical patients, with application of appropriate guidelines can only be achieved at neurosurgical centers. In Ontario, 11 hospitals have the resources to manage patients with neurosurgical emergencies but due to regionalization of these hospitals, many patients initially present to non-neurosurgical centers. Non-neurosurgical centers have varied resources but, by definition, do not have trauma or neurosurgical capabilities. Patients with neurosurgical emergencies presenting to non-neurosurgical centers are initially evaluated and stabilized by emergency physicians who have varying levels of experience managing patients with neurological disorders which may affect the physician’s experience and comfort with care. Further, protocols and resources to manage
critically ill patients may not be in place, as physicians within these centers might not interact with these types of patients very often.

Emergency physicians who identify that a patient requires neurosurgical center care are able to transfer these patients to neurosurgical centers. In Ontario, following initial stabilization and treatment of the patient, ED physicians make contact with a centralized service (CritiCall) that connects non-neurosurgical center ED physicians with neurosurgeons for advice regarding management and transfer. Through this system, surgeons are able to view CT scans of the patient using image transfer to centralized servers. During the telephone consultation, if the patient requires transfer, the surgeon fielding the call ensures a bed is available at their institution and transfer is arranged, including procurement of the appropriate transport mechanism. If the neurosurgeon feels that no transfer is required, advice is given to the ED physician on how to manage the patient. If no bed is available at the neurosurgical center, the non-neurosurgical center physician is advised to contact another center and speak to a subsequent neurosurgeon until a bed is attained.

Because non-neurosurgical center ED physicians have varying levels of experience and resources to manage neurosurgical emergencies, beliefs, perceptions and knowledge can influence the care delivered to the patient. Through identifying issues related to management and transfer of acute neurosurgical patients, we aim to delineate areas where improvements can be made to facilitate more comprehensive and efficient management of the neurosurgical patient.

5.3 Methods

5.3.1 Study Sample

The study sample included emergency department (ED) physicians in the province of Ontario, Canada. Ontario has a population of approximately 13 million spread out over a geographic area of 1 million square kilometers. While the majority of the population lives in major metropolitan areas, approximately 15% of Ontarians live over 60 miles from any specialty medical care.
Acute medical care in Ontario is delivered through over 190 acute care hospitals. Of these hospitals 11 have neurosurgical resources.

5.3.2 Survey Development

Questions for the survey were developed by experts, including emergency physicians, trauma surgeons and neurosurgeons. Additionally, a member of the research network with significant public and private sector experience in survey development provided input on design and implementation of the questionnaire.

Questions were focused around care for neurosurgical emergencies and issues ED physicians had with management of these patients.

Upon finalization of the survey, it was fielded through an independent survey company, ResearchNow (Ontario, Canada). ResearchNow programmed the submitted survey into an online form. Prior to wide dissemination, ResearchNow also field-tested the survey to ensure its usability. Upon finalization and verification of the survey, it was disseminated and data collection was initiated. [Appendix 1]

5.3.3 Identification of Emergency Department Physicians

Emergency department physicians in Canada are largely certified through two mechanisms. The primary pathway is a 5 year residency leading to a Fellow of the Royal College of Physicians (FRCP) designation as a specialist in emergency medicine. FRCP graduates are trained to practice in academic centers and have the option to complete additional fellowships in critical care or transport medicine. A competing pathway to emergency medicine certification exists through family medicine. In this alternative pathway a physician completes 2 years of family medicine obtaining certification from the Canadian College of Family Medicine (CCFP) and then completes an extra year of emergency medicine specialty training leading to a CCFP-EM designation. CCFP-EM designates largely practice in community centers although a significant number also practice in academic trauma centers.

In some smaller emergency departments family physicians without EM certification or specialists from other disciplines may provide staffing.
5.3.4 Survey Distribution

To disseminate the survey to ED physicians we used two methods. First, we brought the survey to a provincial ED group representing all areas of the province. Representatives from each governmental administrative division of the province, known as local integrated health networks (LHINS), were consulted on their region’s participation in the study. All ED-LHIN representatives agreed to participation in the survey and therefore the survey link was distributed to these LHIN representatives, who then distributed it to the chiefs of emergency medicine in their region with the subsequent goal of dissemination to individual ED physicians through their chiefs. In addition, a formal letter from the chief of the ED-LHIN for province of Ontario sent a letter on behalf of the ministry of health to ED physicians encouraging participation in the study.

In addition to the above method, we also consulted with the Canadian Association of Emergency Physicians (CAEP). This is an independent, academic emergency medicine organization with voluntary membership by all physicians identifying themselves as ED physicians. Through collaboration with CAEP, we distributed the survey link to all members on their email list.

5.3.5 Survey Completion

Upon survey distribution to physicians, we evaluated viewing and completion of the survey. Although the method of recruitment does not allow us to ascertain the total universe contacted, we do know that 821 respondents clicked on the survey link. Of the 821 respondents, 153 (19%) completed the survey. Reminders were sent to ED physicians at 4 and 8 weeks following survey dissemination. Survey dissemination and data collection lasted for a period of 3 months.

5.3.6 Data Analysis

In order to analyze the data, responses were categorized and aggregated. Responses from ED physicians at NC were excluded in an effort to capture only those physicians working at NNC.

For questions in which there was a 10-point scale, responses 1-3 were categorized as very poor/infrequent, 4-7 were grouped as moderate, and 8-10 were categorized as very high/often.
For responses with a 5-point scale categories were 1-2 (very low), 3 (moderate) and 4-5 (very high).

The annual volume of patients managed by individual physicians was categorized using responses on the survey. To stratify ED physician volume, those who had volumes of 10 or more were categorized as ‘high’, those physicians with volumes of 5-10 were categorized as ‘medium’, while those with patient volumes of less than 5 were categorized as low volume physicians.

All analysis was completed using statistical analysis software (SAS version 9.2, Carey NC).

5.3.7 Free Text

In order to collate free text responses, the study coordinators grouped responses into predefined categories. The broad categories into which individual responses were categorized are listed in table 4.


**Table 4- Grouping of free text responses by category**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed Availability</td>
<td>Any response that concerns lack of bed as reason for not having patient transferred.</td>
</tr>
<tr>
<td>CritiCall/Process- Delays</td>
<td>Delays in methods used by CritiCall excluding the time taken to find surgeon to answer call.</td>
</tr>
<tr>
<td>Emergency Neurosurgery Image Transfer System (ENITS)</td>
<td>Technical difficulties uploading images to central server.</td>
</tr>
<tr>
<td>Expertise/Comfort</td>
<td>Any response indicating lack of knowledge or confidence in managing patient.</td>
</tr>
<tr>
<td>Lack of Resources</td>
<td>Responses that outline lack of available capital or human resources to adequately care for patient (e.g. CT scan)</td>
</tr>
<tr>
<td>No transfer/discomfort with management</td>
<td>Any response detailing discontent with neurosurgeon providing consultation in which observation in the NNC is advised.</td>
</tr>
<tr>
<td>Patient acceptance by neurosurgery- unspecified</td>
<td>Responses in which patient was not accepted, no reason specified.</td>
</tr>
<tr>
<td>Prognosis/Family Discussion</td>
<td>Responses detailing difficulties with family discussion regarding prognosis due to lack of knowledge.</td>
</tr>
<tr>
<td>Surgeon Access</td>
<td>Delays/difficulties with obtaining surgeon to speak with on the phone.</td>
</tr>
<tr>
<td>Transport</td>
<td>Any response detailing delays or difficulty obtaining transport modalities.</td>
</tr>
<tr>
<td>Variable Advice</td>
<td>In situations where multiple neurosurgeons contacted, responses outlining frustration with variable advice given for same patient.</td>
</tr>
<tr>
<td>Communication (unclear/unhelpful)</td>
<td>Responses outlining communication with neurosurgeon that was obstructive/unhelpful beyond the patient care discussion.</td>
</tr>
<tr>
<td>Manpower</td>
<td>Loss of nursing, RT or ED staff to accompany patient during transfer due to lack of available critical care transport.</td>
</tr>
</tbody>
</table>
5.4 Results

5.4.1 Physician Characteristics

Our survey yielded 153 completed survey results. Upon exclusion of responses from physicians at neurosurgical centers, we analyzed a total of 114 surveys. The characteristics of physicians completing the survey are listed in table 5. Generally, ED physicians were either within their first 10 years of practice or had been in practice for 20 years or greater. The most common certification status was CCFP-EM followed by CCFP. FRCP certification was likely uncommon as responses from neurosurgical centers were excluded. There was no significant difference between practice environments, however responses came largely from non-teaching centers.

Significant variation existed in the number of neurosurgical patients managed by ED physicians per year. [Figure 10]

Examination of methods used by ED physicians to contact neurosurgery largely followed provincial recommendations, which are to exclusively use centralized organizations (in Ontario-CritiCall). ED physicians often (n=31, 28%) or always (n=62, 57%) used a CritiCall to obtain neurosurgical guidance and transfer. However, 15% (n=16) of ED physicians were often, or always, using mechanisms other than CritiCall to obtain neurosurgical expertise.

5.4.2 Hospital Characteristics

Examination of hospital resources revealed that only 12% (n=13) of the ED physicians had neurology consultation services. 82% (n=93) of ED physicians had access to CT imaging facilities, 82% (n=94) had access to 24-hour operating rooms and 82% (n=94) had critical care units where they worked. General surgical services were available in 84% (n=96) of responses however none of these units had a trauma team. There were significant differences between resources physicians had available to them based on their individual volumes. [Table 6]
Figure 10- Histogram of Individual Physician Neurosurgical Emergency Volume per year

Histogram demonstrating variation in physician volume measured by the number of neurosurgical patients seen by a physician per year.
<table>
<thead>
<tr>
<th></th>
<th>Physicians at NNC n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yrs. in Practice</strong></td>
<td></td>
</tr>
<tr>
<td>0-5</td>
<td>19 (18)</td>
</tr>
<tr>
<td>6-10</td>
<td>13 (12)</td>
</tr>
<tr>
<td>11-16</td>
<td>10 (9)</td>
</tr>
<tr>
<td>16-20</td>
<td>3 (3)</td>
</tr>
<tr>
<td>&gt;20</td>
<td>62 (58)</td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td></td>
</tr>
<tr>
<td>FRCP</td>
<td>9 (8)</td>
</tr>
<tr>
<td>CCFP (EM)</td>
<td>68 (60)</td>
</tr>
<tr>
<td>CCFP</td>
<td>38 (33)</td>
</tr>
<tr>
<td>Other</td>
<td>13 (11)</td>
</tr>
<tr>
<td><strong>Practice Environment</strong></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>39 (34)</td>
</tr>
<tr>
<td>Urban</td>
<td>45 (39)</td>
</tr>
<tr>
<td>Suburban</td>
<td>30 (26)</td>
</tr>
<tr>
<td><strong>Institution</strong></td>
<td></td>
</tr>
<tr>
<td>Teaching</td>
<td>13 (11)</td>
</tr>
<tr>
<td>Non-Teaching</td>
<td>93 (82)</td>
</tr>
<tr>
<td>Other</td>
<td>8 (7)</td>
</tr>
<tr>
<td></td>
<td>Low Volume n(%)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Respiratory Therapy</td>
<td>18 (49)</td>
</tr>
<tr>
<td>CT Scanner</td>
<td>24 (65)</td>
</tr>
<tr>
<td>Neurology</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Critical Care Unit</td>
<td>51 (89)</td>
</tr>
<tr>
<td>Orthopedic Surgery</td>
<td>15 (41)</td>
</tr>
<tr>
<td>General Surgery</td>
<td>24 (65)</td>
</tr>
<tr>
<td>Anesthesia</td>
<td>30 (81)</td>
</tr>
<tr>
<td>24 hr. OR Suite</td>
<td>25 (67)</td>
</tr>
</tbody>
</table>
5.4.3 Patient Management

ED physicians felt that, once a patient was identified as a neurosurgical emergency, most or all patients required transfer instead of consultation alone (n=83, 73%). Following discussion with a neurosurgeon 19% (n=21) felt their concerns were usually or always left unaddressed. However, when a subsequent question addressed ED physician satisfaction with transfer, 25% (n=29) of physicians responded that most or all of the time their patients were not transferred, and they did not agree with the decision. 1 physician experienced a patient death, prior to discussion with a neurosurgeon.

When we examined guidelines that were used by ED physicians to manage neurosurgical emergencies we found that physicians in non-neurosurgical centers overwhelmingly applied ATLS guidelines to their patients (n=95, 86%), while 7% (n=8) also used the Brain Trauma Foundation guidelines and 12% (n=13) used no guidelines at all.

5.4.4 Patient Transfer

Identification of neurosurgical patients requiring transfer by ED physicians is essential to proper triage. Almost all physicians, 92% (n=105) felt very confident that they were accurately able to identify patients requiring transfer to a neurosurgical center.

83% (n=95) of physicians felt highly comfortable with the management of neurosurgical emergencies, while 4% (n=4) felt highly uncomfortable. No significant difference existed between physicians who had significant ED expertise measured by 10 or more years in practice and those who were in practice less than 10 years. [Table 7] Similarly, no significant difference existed between physician certification or physician volume and comfort with management as measured by chi squared (P=0.38, P=0.50)

In cases where patients required intensive, frequent monitoring at the non-neurosurgical center, ED physicians were asked if they felt confident their ICU would admit neurosurgical patients. There was considerable variation, as 37% (n=42) felt very confident, 27% (n=31) were not confident and 30% (n=35) were very unconfident that the ICU would admit their patients if advised by neurosurgery. 6 respondents did not have an ICU at their institution.
Table 7- Differences in physician characteristics and comfort level of ED physicians

<table>
<thead>
<tr>
<th>Certification Status</th>
<th>Comfortable n(%)</th>
<th>Some Discomfort n(%)</th>
<th>Very Uncomfortable n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCFP</td>
<td>28 (74)</td>
<td>6 (16)</td>
<td>4 (11)</td>
</tr>
<tr>
<td>CCFP (EM)</td>
<td>53 (90)</td>
<td>6 (10)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>FRCP</td>
<td>7 (78)</td>
<td>2 (22)</td>
<td>0(0)</td>
</tr>
<tr>
<td>Other</td>
<td>7 (87)</td>
<td>1 (13)</td>
<td>0(0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physician Experience</th>
<th>Comfortable n(%)</th>
<th>Some Discomfort n(%)</th>
<th>Very Uncomfortable n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (0-10 yrs.)</td>
<td>15 (79)</td>
<td>4 (21)</td>
<td>0(0)</td>
</tr>
<tr>
<td>High (&gt;10 yrs.)</td>
<td>80 (84)</td>
<td>11 (12)</td>
<td>4(4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physician Volume</th>
<th>Comfortable n(%)</th>
<th>Some Discomfort n(%)</th>
<th>Very Uncomfortable n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (&lt;6 pts/yr)</td>
<td>28 (75)</td>
<td>5 (13)</td>
<td>4 (11)</td>
</tr>
<tr>
<td>Medium (6-20 pts/yr)</td>
<td>48 (84)</td>
<td>9 (16)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>High (&gt;20 pts/yr)</td>
<td>19 (95)</td>
<td>1 (5)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Because neurosurgical emergencies often leave patients with significant disability or devastating injury, ED physicians were asked about the frequency with which they had goals of care discussions with family members or patients. 64% (n=73) of ED physicians responded that they always or usually had family discussions prior to neurosurgical consultation while 36% (n=41) never or rarely had discussions with family regarding prognosis and goals of care.
5.4.5 Free Text

Apart from bed availability and transfer resources, ED physicians were asked what their top 3 challenges were with respect to managing, and then transferring neurosurgical emergencies. When examining management challenges, physicians responded that expertise with managing neurosurgical emergencies was the most difficult challenge, followed by access to a surgeon over the phone and discomfort with managing patients at the NTC when a transfer was not deemed necessary by the consulting surgeon. [Figure 11] Following this, we examined free text responses surrounding challenges of transferring patients (apart from bed availability and transfer resources). ED physicians responded that process delays with CritiCall were the most significant challenge, followed by patient acceptance by a neurosurgeon, access to a neurosurgeon on the phone and demands placed on manpower at the NTC in sending the patient to the TC.[Figure 12]

5.4.6 Volume-Comfort Relationship

ED physician perception of their comfort with management of neurosurgical emergencies was independent of their individual neurosurgical patient volume. In this question, we used comfort with management as a proxy for self-assessment for performance. No significant relationship existed between physician volume and comfort with managing patients (weighted kappa 0.004 95%CI -0.32-0.42).
Figure 11- ED Physician Challenges with Management of Neurosurgical Emergencies

Free-text responses to ED physicians asking their top 3 difficulties in managing neurosurgical emergencies. Duplicate responses have been omitted. Bed availability at the neurosurgical center remains the most common difficulty with management.
Free-text responses to ED physicians asking their top 3 difficulties in transferring neurosurgical patients to neurosurgical centers. Duplicate responses have been omitted. Bed availability at the neurosurgical center remains the most common difficulty with transfer followed closely by the availability of transfer assets.
5.4.7 Discussion

Management of patients with TBI requires dedicated resources and expertise to maximize outcome. Caring for patients with neurosurgical emergencies is resource intensive and comes at significant cost\textsuperscript{73}. The intensity of resources required influences the fact that most neurosurgical centers are regionalized to urban cities. In Ontario, NC’s are almost exclusively regionalized to trauma centers, providing comprehensive care for neurosurgical emergencies.

The vast geography of Ontario coupled with regionalization of services necessitates that many patients with neurosurgical emergencies are first transported to NNC for management. At these institutions emergency physicians with variable supportive resources manage patients.

Our results suggest that considerable variation exists in the skill, resources and attitudes of ED physicians in managing patients with neurosurgical emergencies. Hospital resources available to the ED physician varied across the province. While most hospitals had intensive care units, our results suggest that the confidence of ED physicians in having their patient admitted to these facilities was poor. This may be due to a variety of reasons such as bed availability or discomfort of the intensive care physician with management of neurosurgical issues. Ultimately, if patients are intubated, or critically ill and are not admitted to the ICU, they remain in the ED leading to disruptions in workflow and efficiency\textsuperscript{74}. Additionally, hospitals were often lacking neurologists, and therefore had no local resources to provide consultation on immediate management of neurological disorders. CT scan imaging was available in the majority of centers, however it is unclear how many of the ED physicians had 24-hour access to this capability. Further, based on free-text responses, even if institutions have CT scan capability, limitations may exist with transferring the images to the Emergency Neurosurgical Image Transfer System (ENITS) which considerably hampers the consultation and transfer process.

Regardless of a centers resource capability, definitive management of neurosurgical emergencies requires transfer to a neurosurgical center. Our results indicate that most ED physicians use provincially established mechanisms (CritiCall) for consultation and transfer requests for their patients. This helps quantify the volume of patients requiring neurosurgical care for governmental organizations, but also helps maintain quality control and efficient resource
allocation through a centralized process. Centers that do not use CritiCall as their major mechanism of placing neurosurgical patients, most likely use established hospital agreements that are largely dependent on proximity. It is unclear if these regional relationships provide efficient care to patients.

Responses taken from the survey suggest that while variation exists in the comfort level and ability of ED physicians to manage neurosurgical emergencies, most physicians feel confident in their abilities. This confidence is independent of years in practice or the volumes seen by the physician. However, these responses are completely based on the physician’s perception, as no feedback or objective evidence is communicated to the ED physician regarding the quality of care delivered or the accuracy of identifying patients who require transfer.

ED physicians largely felt that most of the patients they encountered in their departments required transfer to a neurosurgical center. Further, ED physicians often felt that they were able to accurately delineate between patients that required transfer and those who did not. Often, ED physicians responded that the plan conveyed to them by the neurosurgeon-helped address their concerns regarding the patient. However, in the free-text of the survey results, one of the key issues the physicians identified, as a challenge to management was when patients were not transferred and required observation in the non-neurosurgical center. Difficulties in managing neurosurgical patients when not transferred may be due to physician discomfort, or may be a function of the inability of ED physicians to get their patients admitted to the ICU. Additionally, this may lead ED physicians to consult several neurosurgeons until someone accepts the patient, even though the first neurosurgeon contacted may only have recommended observation. This multiple consultation process has implications for resource utilization. First, if an ED physician consults several neurosurgeons, CritiCall resources are utilized inappropriately in an effort to connect the ED physician to another neurosurgeon. This process impedes the efficiency with which other calls can be processed. Further, by engaging in multiple consultations until an physician willing to accept the patient is found, transport and hospital resources may be utilized inappropriately which are then unavailable for the next patient.

The free text responses help delineate specific challenges that ED physicians face in the management and transfer of acutely ill neurosurgical patients. The most common barrier to efficient care, in the opinion of ED physicians, was the lack of available beds at neurosurgical
centers. In order for a neurosurgeon to accept a patient at a NC, they must have an available bed to place the patient in. If no bed is available, the neurosurgeon is compelled to refuse the transfer and advise the ED physicians to attempt contacting another center through CritiCall. This process may continue across every neurosurgical hospital until a bed is found. This not only delays definitive care for the patient but also consumes tremendous time and resource at non-neurosurgical centers, in many of which the ED physician is the sole physician in the hospital.

The second most commonly cited barrier to efficient management and transfer was the availability of transportation assets to move patients from a non-neurosurgical center to a neurosurgical center. In cases where a bed is found and a neurosurgeon accepts the patient, transport of the patient often requires specialized care. Intubated patients, or patients who are on specialized medications cannot be transported by conventional ambulances. In Ontario, a provincial transport medicine program exists that has the capability of transporting patients both by air or land, with specialized equipment and personnel. However, delays in obtaining this transport lead to delays in definitive care and leads to the patient remaining in the non-neurosurgical center for extended periods of time. This may have significant implications on the patient’s outcome as well as the outcome of other critically ill patients at the non-neurosurgical ED.

Additionally, in the responses pertaining to challenges with management, ED physicians identified expertise or comfort with management of neurosurgical emergencies a major challenge to overall patient care. This was unexpected as when asked to self-report their level of comfort most ED physicians rated themselves as very comfortable. It is unclear why such a discrepancy exists between numeric self assessment and free text responses.

Finally, pertaining to management, surgeon availability and communication posed a significant challenge to ED physicians. Essentially, surgeons were either unable to speak on the phone, and when they were on the phone, ED physicians found the communication to be unsatisfactory. This identifies a potential communication gap between ED physician and neurosurgeon which can be addressed. Aligning expectations of ED physicians and neurosurgeons may help them communicate in a more efficient manner, thereby preventing conversations that leave either physician unsatisfied.
The major limitation of our study was the nature of the survey. Because we asked physicians to think about encounters and beliefs they’ve had over the past year- our results may be subject to a significant amount of recall bias. It would be difficult to mitigate this without asking the questions in real time with every patient encounter. Literature exists, however, that demonstrates that self reported data is a valid and accurate means of capturing statistics. Another limitation of our study is the fact that it is difficult to characterize specific challenges posed to each individual physician. Because practice environments and physician volumes are variable, it is not possible to comprehensively capture all the pertinent themes with respect to challenges faced by ED physician, as they may be significantly different between institutions and individuals. We attempted to mitigate some of this through polling emergency physicians, both established and in training, during the generation of our study questions. Finally, as with most surveys, there is a significant potential for selection bias in our study. It is possible that only those physicians who face challenges with neurosurgical emergencies or who specific vested interests in TBI responded, while those physicians who did not have challenges or were comfortable with TBI did not respond. This could greatly impact the validity of our results, however, it is difficult to capture the degree of selection bias and its influence on the direction of our results.

Conclusion

Our results demonstrate that considerable variation exists in the capabilities, resources and challenges faced by ED physicians with the management of neurosurgical patients. These results could be used to help inform policy in the development of educational programs for physicians to create consistent management and expectations of physicians across all centers. Also, an understanding of the environmental and system challenges faced by ED physicians may help appraise neurosurgeons of the ED environment and improve communication.

Further, an inventory of hospital resources may help guide policy decisions with respect to capital investments and resource allocation. Finally, identifying key challenges with management and transfer (e.g. bed availability, transfer resources) we can help inform policy on strategic policy initiatives that can be undertaken in areas that can improve the efficiency with which neurosurgical patients can be managed and transfer.
Through these initiatives our goal is to improve the environment in which ED physicians work and improve communication between ED physicians and neurosurgeons with the ultimate goal of improving outcome of patients with neurosurgical emergencies.
6.1 Thesis Summary

Chapters 3, 4 and 5 of this thesis present results that evaluate major components of access to trauma center care for patients with severe TBI in the province of Ontario. Specifically the chapters follow the pathway of a patient who has sustained a TBI, and where they ultimately receive definitive care. To do this, triage practices in pre-hospital care, knowledge and beliefs of physicians at non trauma centers and transfer practices for patients from non-trauma centers to trauma centers were evaluated.

Chapter 3 explored access to trauma center care for patients with severe TBI. Access to a trauma center can be realized through two pathways, the first being direct transport from the scene to a trauma center and the second, transfer from a non-trauma center to a trauma center. We demonstrated that 58% of all TBI patients in Ontario attain access to a trauma center through either pathway. Further, of the approximately 40% of patients who were transported to a non-trauma center from the scene of injury, only 30% eventually were transferred to a trauma center for definitive care. This suggests that although comprehensive networks exist in Ontario to help facilitate trauma center access for TBI patients, they are not being efficiently employed. Upon further analysis, specific patient factors were identified which mitigated direct access to a trauma center as well as transfer. Age was the most robust factor associated with a step-wise reduction in the likelihood of access with increasing age. This reduced likelihood of access associated with age was consistent across both direct transport from the scene to trauma center, as well as transfer from a non-trauma center to a trauma center. Injury mechanism also played a major role in modifying the likelihood of trauma center access following severe TBI. Compared to MVC’s, all other mechanisms of injury were less likely to eventually reach trauma center care and this trend was also seen in transfer from non-trauma center to trauma center. These results imply that providing resources (potential access) in the setting of TBI does not result in optimal access to care. Chapter 3 demonstrates potentially modifiable gaps in perceptions and behaviours of EMS and physicians at non-trauma center in utilization of appropriate resources for patients with TBI.
Chapter 4 builds on the results of chapter 3 through examination of practices of EMS providers and their triage of TBI patients to trauma centers. In this study, a regional EMS service served by two large trauma centers was evaluated. The entire population of the region examined, Toronto, Ontario, has potential access to a trauma center in accordance with the stipulations detailed in the Toronto FTC. It was determined that of all patients who met FTC, only 40% were taken from the scene of injury directly to a trauma center. This demonstrates that while guideline development and implementation in the triage of TBI patients is important, guideline implementation alone does not facilitate access. Patient level factors such as increasing age and injury mechanism increased the likelihood of undertriage, while severity of head injury as measured by GCS did not influence triage practices. This suggests that criteria other than those outlined in the FTC were being used to triage patients in some cases. These subjective factors may include preformed judgments regarding the cause of a patient's depressed level of consciousness, as well experience or inexperience with TBI patients in general. Chapter 4 demonstrates the need to not only re-evaluate the current iteration of the FTC, but also prompts evaluation of perceptions and potential gaps in knowledge at the EMS level.

Finally, chapter 5 addresses the knowledge and beliefs of physicians at non-trauma centers. As our previous chapters have shown, many patients with severe TBI are initially brought to non-trauma centers for initial care of their injuries. It is at these institutions where stabilization and initial care is undertaken, as well as decision-making regarding transfer to a trauma center. Our study examined the beliefs and knowledge of physicians at non-trauma centers, which in Ontario also represent non-neurosurgical centers. Generally ED physicians felt comfortable with the management and identification of neurosurgical emergencies. However, when trying to transport patients to a neurosurgical center, the physicians had significant challenges with resource availability in the province. The two main resources deficiencies that made optimal management challenging were bed availability at the trauma center and availability of transportation assets to transport patients to a trauma center from a non-trauma center. This project helped demonstrate that although provincial transfer networks exist, resource limitations may prevent efficient use and function of these networks. Further, this study identified the opportunity to increase education for physicians, particularly in the ICU and ED, at non-neurosurgical centers, with respect to optimal management of TBI patients.
6.2 Implications and Recommendations

6.2.1 Variations between potential and realized access to resources

This work demonstrates that although governmental organizations have attempted to provide access to trauma centers for patients with TBI, significant gaps exist between potential access and realized access. The chapters demonstrate that the presence of a resource alone, does not ensure its effective utilization. Most measures of access only focus on the relationship between population and resource distribution; this thesis has demonstrated that those factors alone are not sufficient to optimize access in TBI.

Policy decisions made regarding access to care for TBI patients based purely on potential access comes with significant detriment. Potential access ignores qualitative factors and judgments used by providers to make decisions regarding care. Further, potential access may undervalue the importance of factors other than resource distribution when attempting to make decisions regarding resource distribution. Focusing on potential access does not compel organizations or decision makers to evaluate the efficiency with which resources are being utilized and the effectiveness with which TBI patients are attaining the required definitive care. Therefore, using potential access as a guide based solely on the interplay between populations and geographic resource distribution grossly misrepresents real world scenarios.

To improve resource utilization and patient management, physicians, organizations and governments must examine the gap between potential and realized access. Evaluating systems in this manner allows measurement of efficiency, and further helps delineate gaps in knowledge, perceptions or resources that prevent effective use of existing networks. Additionally, through measuring the gap between potential and realized access, effects of specific interventions on access can be monitored. Using this paradigm may help organizations and governments make more effective decisions with greater impact on improving healthcare availability to specific populations such as those with TBI. This issue becomes even more relevant in highly specialized and regionalized services such as neurosurgical and trauma care.
6.2.2 Determinants of Access to Trauma Centers

A major theme in chapters 3 and 4 is the impact of non-clinical factors such as sex and age on access to definitive care in TBI. These non-clinical factors impact patient access in: (i) overall access to a trauma center (ii) inter-facility transfer and (iii) triage from the scene to a trauma center by EMS. Age appears to have the most dramatic association with access followed closely by mechanism of injury, as falls lead to the lowest likelihood of access to a trauma center. These findings suggest that education needs to be disseminated to providers regarding the importance of aggressive care in the elderly, given their significant burden of injury. Furthermore, additional education regarding the impact of seemingly trivial mechanisms of injury resulting in major TBI needs to be conveyed.

In cases where guidelines do not exist (i.e. interfacility transfer) the development of coherent guidelines that detail specific criteria that could be used in the decision making process should be generated in order to aid physicians with identifying patients requiring urgent trauma center care.

6.3 Thesis Limitations

Although care has been taken to reduce bias and confounding, this thesis has some significant limitations that should be disclosed.

6.3.1 Outcomes

The outcomes in chapter 3 are only measured by mortality. Given the large administrative databases used for analysis in chapter 3 there was no informational on functional outcome following injury. In TBI, functional outcome can often be as or more important than mortality due to the potential to have survivors who are functionally devastated (e.g. persistent vegetative state). Severely disabled TBI survivors may pose significant emotional and financial burden on family members, as well as increasing costs to society as a whole. Assessing the impact of access on functional outcome as opposed to mortality would likely have provided a more relevant analysis of the impact of reduced trauma center access in TBI.
6.3.2 Risk Adjustment

For both chapters 3 and 4 we used risk adjustment to account for differences in populations. Data for both these chapters were taken from large administrative databases. As such, key clinical parameters of injury were missing and therefore unable to be adjusted for. Variables such as pupillary reflex were not present in any of the databases, or were inconsistent, and may significantly impact the validity of logistic regression analyses undertaken. Further, in TBI, a major component of assessing injury is the CT scan image as graded by the Marshall score. The Marshall score is a validated method of assessing CT scan images and pairing specific scores with outcome\textsuperscript{75}. The absence of Marshall score data in the databases may have further impacted the results of risk adjustment in this thesis.

Conversely, although Marshall scores are important, in the field and occasionally in non-trauma centers, CT scanning is not available. Hence, triage decisions are made devoid of imaging to accurately identify the brain lesion generated following TBI. This may, at least partially, mitigate the absence CT head information in our models.

6.3.3 Injury Coding

In chapter 3, we were unable to delineate between patients with acute SDH and those with chronic SDH as these patients are coded similarly. This is a limitation of the risk adjustment as chronic SDH and acute SDH represent significantly different injury patterns and are predominant in different subsets of patients. While chronic SDH can create severe neurological injury, it is not considered to be an acute TBI, and is not as life threatening as an acute SDH. As a result, these chronic SDH patients are often monitored at non-trauma centers and occasionally require no intervention. Not being able to separate between the two types of injuries confounds our results, at least partially, as a subset of less severely brain injured patients may have contaminated our data, resulting in residual confounding.

We have mitigated some of this contamination by only including severely injured patients in our study in chapter 3. Because patients with acute SDH are injured with more violent mechanisms than those with chronic SDH, they are more likely to have other associated injuries. This raises the injury severity of patients with acute SDH, and by excluding less severely injured patients, we may have partially excluded those individuals who sustained a chronic SDH.
6.3.4 Sampling Bias

In survey analysis, there is an inherent potential for sampling bias. In our study, the response rate of those physicians that opened the email link for the survey was approximately 19%. This indicates that some physicians may have read the survey and decided not to answer. There may be inherent differences in characteristics of physicians who answered the survey and those who did not. This would potentially bias the results of our study in an unknown direction. It is possible that physicians who answered the survey found it more relevant because they were more experienced, more confident and worked at larger centers with greater TBI volumes.

Upon review of the types of institutions the completed surveys were collected from, we found a great deal of variability, which may potentially reduce some of the bias. However, given the nature of the survey and its distribution, there is likely some amount of sampling bias in the results.

6.4 Future Studies

6.4.1 Evaluation of the Transfer Timeline

As this thesis demonstrates, a significant number of patients with TBI are first transported to a non-trauma center from the scene of injury. When this occurs, physicians use provincial mechanisms and transfer resources in order to provide their patients access to a trauma center. As we have demonstrated in the introduction, there are multiple steps to the completion of a successful transfer, and delays can occur in any portion of this chain. With access to CritiCall resources, as well as Ministry of Health data, an understanding of the time taken to complete each step can be delineated. Through this, the chronology of the transfer chain and potential delays can be identified. A study into these variables would help target policy and educational interventions at specific parts of the transfer process that require attention rather than the transfer process in general.
6.4.2 Beliefs and Perceptions of EMS Providers

In chapter 4 it was shown that a significant proportion of patients who sustain TBI and meet the TBI FTC, are undertriaged to a non-trauma center. While demographic factors have been shown to play a role, there are likely significant value judgments and qualitative factors that result in undertriage. Surveying EMS providers regarding their perceptions of TBI patients and how they choose to apply FTC is vital to understanding the role non-physiologic criteria play in the triage process. Further, an understanding of the shortcomings or challenges presented by the current FTC would help focus any further iterations of the FTC in a way that would prompt EMS to use and follow them more frequently.

6.4.3 Emergency Department Length of Stay for TBI Patients

The transport of significant proportions of TBI patients to non-trauma centers necessitates that these patients must be cared for and evaluated in non-trauma center emergency departments. Caring for patients with TBI requires considerable time and resource, often leading to withdrawal of human and technological resources from other patients in the ED. If patients spend extended time periods in the ED before being taken to the ICU or being transferred, physicians and nurses are likely unable to care for other patients as efficiently.

A study using CritiCall, NACRS and DAD may be undertaken that identifies time periods in non-trauma center emergency departments when patients with severe TBI are present. An evaluation of the number of patients discharged or admitted during this time, as well as hospital readmission rates and number of patients seen could be identified for each specific ED. This analysis could potentially quantify, for specific emergency departments, if the presence of a severe TBI patient not only reduced efficiency, but also increased complication rates.

6.4.4 Cost Analysis of Transfer and Undertriage

The interfacility transfer of a patient from a non-trauma center to a trauma center uses additional resources coming at financial cost to the healthcare system. Given the high direct costs of treating TBI in Canada, additional non-medical costs generated by these injuries can be restrictive to funding other portions of the healthcare system, and may not be an effective use of funds. In the setting of patients who meet FTC in Toronto who are initially taken to a non-trauma
center, a cost analysis of the additional funds required to eventually transfer those patients to a
TC would be an effective way of quantifying financial repercussions of undertriage. If costs are
significant enough, this may be used to inform policy to direct funds to the generation of
educational programs as well as enhancement of the current FTC.

6.5 Conclusions

The focus of this thesis was to identify gaps in access to trauma center care for patients with
severe TBI and behaviour of providers who triaged patients to trauma centers (EMS and non-
trauma center physicians). Through the analyses undertaken we have explored 3 key themes
pertinent to the access of patients with severe TBI to TC, being: (i) Overall access of patients
with TBI to a trauma center as well as proportions of patients acquiring access through inter-
facility transfer (ii) adherence to FTC by EMS in the setting of TBI and (iii) the knowledge and
perceptions of ED physicians at non-trauma centers and how they relate to neurosurgical
emergencies.

We have demonstrated that a significant proportion of TBI patients in Ontario are first taken to a
non-trauma center following their injury. Of these patients at a non-trauma center, only a fraction
ever attain access to a trauma center. The likelihood of access is dependent on age, injury
characteristics and mechanism. We have also shown that in a settings where all patients have
potential access to a trauma center, and guidelines exist on which patients are to be transported to
a trauma center, a significant proportion of patients with TBI who meet criteria are not triaged to
a trauma center. The likelihood of triage also appears to be dependent on factors such as age and
injury mechanism. Finally, we have shown that while ED physicians feel competent in caring for
TBI patients, significant resource deficiencies at the non-trauma center, the trauma center and in
the transport network make caring for TBI patients at non-neurosurgical centers challenging for
ED physicians.

This thesis helps provide evidence that is actionable and can be used to inform policy directions
and decisions regarding resource allocation at the organizational and governmental levels.
Through this, society can ensure that patients with TBI are cared for with the right resources in
an expedient manner- overall improving outcome.
40. Gabbe, B. & Cameron, P. TRISS: does it get better than this? Academic emergency ... (2004).
41. Palmer, C. Major trauma and the injury severity score--where should we set the bar? Annu


59. Ergh, T. C., Rapport, L. J., Coleman, R. D. & Hanks, R. A. Predictors of caregiver and


65. Doumouras, A. et al. Impact of Distance on Triage to Trauma Center Care in an Urban Trauma Syst. *Prehospital Emergency Care* **66**.


Appendices

Appendix 1- Questions asked in ED survey

A) In a typical month, approximately what percentage of your practice is dedicated to the following:

(Your total must add to 100%)
1. Emergency medicine
2. Family medicine
3. 98. Other

B) Please indicate your specialty:
1. Emergency Medicine
2. Family Physician
3. General Practice
4. Internal Medicine
5. 98. Other (specify)

C) Which of the following, if any, certifications do you hold?

(Please select all that apply)
1. FRCP
2. CCFP
3. CCFP (EM)
4. 98. Other (specify)__________
D) Which of the following best describes the setting where you work the majority of your Emergency Department (ED) shifts?

(Please select one response only)
1. Teaching/academic hospital
2. Community hospital/non-academic hospital
98. Other (specify)

E) How many years have you been in practice in Emergency Medicine?

_____ years

F) Which of the following best describes the type of Emergency Department where you work the majority of your shifts?

(Please select one answer)
1. Level I Trauma Centre
2. Level II Trauma Centre
3. Non-trauma centre
98. Other

1. Does your hospital have coverage 24 hours per day, 7 days per week of any of the following services?

(Please select all that apply)
1. Respiratory therapist
2. CT scan
3. Neurologist
4. Intensive Care Unit
5. Neurosurgeon
6. Orthopedic Surgeon
7. General Surgeon
8. Anesthesiologist
9. Plastic Surgeon
10. Operating room availability

2. Does your hospital have any of the following type(s) of Intensive Care Units (ICU)

(Please select one response)
1. An Intensive Care Unit (ICU) that DOES NOT support intubated patients
2. An Intensive Care Unit that DOES support intubated patients

99. None of the above

3. Which of the following best describes the environment where you spend the majority of your Emergency Department shifts

(Please select one response only)
1. Rural
2. Urban
3. Suburban

4. In an average year, approximately how many patient visits occur at your hospital’s Emergency Department?

________

5. Thinking of the patients that you care for in your Emergency Department in an average year, approximately how many require admission or transfer to another hospital?

1. Less than 5
2. 6-10
3. 11-30
4. 31-50
5. 51-100
6. More than 100

6. Of the trauma patients who you have cared for in your Emergency Department, approximately what percent have you:

(Your total must add to 100%)
1. Transferred to a trauma centre
2. Transferred to a non-trauma hospital
3. Admitted to your hospital (not transferred)

98. Something else

97. Don’t know/can’t recall

7. Please now focus on the trauma patients who you transferred from your Emergency Department to a lead trauma hospital (trauma centre) in the past year. To the best of your knowledge, how many were transferred by the following methods.

(Please select one option for each mode of transport)

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Most</th>
<th>Some</th>
<th>Few</th>
<th>None</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Air Ambulance</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2. Land Ambulance</td>
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</tbody>
</table>
8. In the past year (365 days), for approximately how many Emergency Department patients have you initiated a neurosurgical consultation because you suspected neurosurgical care was necessary?

(Please consider all your emergency neurosurgical consultations, regardless of whether they were admitted to your hospital, transferred, discharged, etc.)

1. 0 (SKIP TO q21)
2. 1-5
3. 6-10
4. 11-20
5. >20
6.

9. Thinking of these Emergency Department patients for whom you suspected a neurosurgical emergency in the past year, how often did you seek advice from the following:

(Please select one option for each scenario)

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurosurgery, through</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Critical Care</td>
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</tr>
<tr>
<td>Neurosurgery, <strong>without</strong></td>
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<tr>
<td>Critical Care involvement</td>
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<tr>
<td>Neurology, through</td>
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<tr>
<td>Critical Care</td>
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<tr>
<td>Neurology, <strong>without</strong></td>
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<tr>
<td>Critical Care involvement</td>
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</tbody>
</table>
10. How many of these patients did you feel were candidates to be transferred to a neurosurgical centre (Please consider all potential patients, regardless of whether they were transferred in the end)

1. All
2. Most
3. Some
4. A few

99. None

11. Again, thinking of those patients you felt were candidates to be transferred to a neurosurgical centre, approximately how many:

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>A few</th>
<th>Some</th>
<th>Most</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were transferred to a neurosurgery centre and you agreed/felt comfortable with the decision</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Were not transferred to a neurosurgery centre and you did NOT agree/NOT feel comfortable with the decision</td>
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<tr>
<td>Died prior to initiation/completion of neurosurgical</td>
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</tbody>
</table>
12. When patients with neurosurgical emergencies present to your ER, overall how comfortable are you with resuscitation/stabilization/initial management of these patients?

1=Not at all comfortable; 10=Completely comfortable

13. How confident are you that you can accurately identify a patient who requires urgent transfer to a neurosurgical centre?

1=Not at all confident; 10=Completely confident

14. When discussing management plans for neurosurgical patients with a neurosurgeon, how often do you feel the final plan outlined by the neurosurgeon addresses your specific concerns for that patient?

1. Always
2. Often
3. Sometimes
4. Rarely
5. Never

15. In some situations, a neurosurgeon might advise that a patient be monitored in the ICU because a neurosurgical intervention may not be necessary. In this scenario, how likely is your ICU to admit this type of patient for care?

1=Not at all likely; 10=Extremely likely;

99. N/A- no ICU at institution.
16. What guidelines, if any, do you use for management of a patient with traumatic brain injury? (choose all that apply)

1. ATLS

2. Brain Trauma Foundation Guidelines.

98. Other (specify)____________

99. None

17. For this question, please consider your experiences caring for patients who have neurosurgical emergencies with significantly depressed level of consciousness. How often do you have discussions with family or others addressing goals of care* prior to your consultation with a neurosurgeon.

1. Always

2. Often

3. Sometimes

4. Rarely

5. Never

18. What are the top three challenges you typically encounter when managing a patient with a neurosurgical emergency?

1_______________________________________________________________________

2_______________________________________________________________________

3_______________________________________________________________________

19. What are the top three challenges you typically encounter when attempting transfer of a patient with a neurosurgical emergency to a neurosurgical centre.

1_______________________________________________________________________

2_______________________________________________________________________
3.__________________________________________