ATHABASCA UNIVERSITY

ACCURACY OF TRAUMA TRIAGE AND IMPACT ON CARE IN THE EMERGENCY DEPARTMENT

BY

JEANESSE BOURGEOIS

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF NURSING

FACULTY OF HEALTH DISCIPLINES

ATHABASCA, ALBERTA

OCTOBER, 2022

Athabasca University
FACULTY OF GRADUATE STUDIES

The future of learning.

Approval of Thesis

The undersigned certify that they have read the thesis entitled

ACCURACY OF TRAUMA TRIAGE AND IMPACT ON QUALITY OF CARE FOR MAJOR TRAUMA PATIENTS IN THE EMERGENCY DEPARTMENT

Submitted by

Jeanesse Bourgeois

In partial fulfillment of the requirements for the degree of

Master of Nursing

The thesis examination committee certifies that the thesis
and the oral examination is approved

Supervisor:
Dr. Jennifer Knopp-Sihota
Athabasca University

Committee Member:
Dr. Kimberley Lamarche
Cape Breton University

External Examiner:
Dr. Matthew Douma
University of Alberta

June 16, 2022

Dedication

This thesis is dedicated to my family. To my children, who have been so patient with me and made so many sacrifices. Who have begrudgingly always let me “do my stuff”, even though they can’t comprehend how I am STILL not done my homework!

To my parents, who have supported me through all my challenges and have never given up on me. You have always put your children first and I admire your unconditional love. I hope you have always known how much I love and appreciate all that you have done for me. I would not be who I am and where I am today without you. My mom, who has always been our rock. My dad, who even when he is faced with the biggest challenges, he worries about everybody else being alright.

To my sisters, who always supported me in all that I have done. Who helped me through some of the most difficult times in my life, and continue to do so.

Finally, to my work-husband, you have always believed in me and encouraged me to keep going when I have wanted to give up.

I love you all.

Acknowledgements

I would like to thank my thesis advisor Dr. Jennifer Knopp-Sihota and Dr. Kimberley Lamarche for their patience, readiness to share their knowledge, support, and feedback.

From the Montreal General Hospital Emergency Department, I would like to thank Dr. Greg Clark for taking me under your wing for the MUHC research approval. Dr. Scott Delaney, for your advice, feedback, and encouragement. Carole Filteau, my manager, who provided me with knowledge and support. Natasha Dupuis, Clinical Nurse Specialist, who gave me so much feedback.

I would also like to thank the Trauma and Acute Care Research Group for welcoming me in and giving me so much valuable advice. Particularly Dr. Jeremy Grushka, you were always available to answer my many questions and help me find my way.

Abstract

This thesis is aimed at examining the influence of over and undertriage rates of the trauma team as well as the timing of the involvement of the trauma team in the patient's care on quality indicators. I hypothesize that early trauma team involvement will decrease the time to definitive care thus decreasing patient time in the emergency department without a treatment plan established. I conducted a retrospective medical record review focusing on quality indicators and variables in the care of trauma patients in the emergency department. I compared over and undertriage rates and timing of trauma team activation for trauma patients. I found that pre-hospital trauma team activation improves performance indicators in the emergency department. This research suggests that pre-hospital trauma team activation should be considered the standard of care for all patients meeting pre-hospital field triage criteria for major trauma.

Keywords: triage, trauma systems, pre-hospital triage, Quebec trauma care, quality indicators

Preface

There are multiple co-authors included in the manuscripts for this thesis. I independently developed the thesis project, submitted ethics applications, collected, and analyzed data and drafted the manuscripts. All the co-authors provided guidance and advice throughout different stages of the project, reviewed, and edited the manuscripts.

Dr. Greg Clark served as the local investigator with McGill University Health Center (MUHC) research privileges which is a requirement to carry out a study within the MUHC. Dr. Clark reviewed the research protocol and local ethics applications. Dr. Scott Delaney reviewed the thesis proposal, provided advice on feasibility in the local environment, and provided support during the research protocol development. Dr. Jeremy Grushka provided advice during data collection and analysis and surrounding the publication process. Dr. Kimberley Lamarche reviewed the thesis proposal and provided guidance during the data analysis stage of the project. Dr. Jennifer Knopp-Sihota was my thesis advisor from Athabasca University giving feedback and advice throughout the entire project. All co-authors reviewed, edited, and approved the final versions of both manuscripts.

Table of Contents

List of Tables

Manuscript 1

Manuscript 2

List of Figures and Illustrations

List of Abbreviations

ACS-6: American College of Surgeons - 6

ALS: Advanced life support

BLS: Basic life support

CDC-ACSCOT: Center for Disease Control – American College of Surgeons, Committee on Trauma

CT: Computed tomography

ED: Emergency department

EQTPT: *Échelle québécoise de triage préhospitalier en traumatologie* – Quebec Pre-hospital Trauma Triage scale

GCS: Glasgow coma scale

ICU: Intensive care unit

INESSS: *Institut National D'Excellence en Santé et en Services sociaux Québec*

ISS: Injury Severity Score

MUHC: McGill University Health Center

OR: Operating room

PH: Pre-hospital

QI: Quality improvement

RN: Registered nurse

TAC: Trauma Association of Canada

TTA: Trauma team activation

Chapter 1 - Introduction

1.0 Introduction

In Canada, unintentional injuries are the sixth leading cause of death overall and account for the number one leading cause of death for those aged 1-44 years (Yao et al., 2019a). With the implementation of organized trauma care systems, high-income countries have decreased mortality rates associated with trauma (Maia Ambegaokar et al., 2009). A trauma system delivers full trauma care from injury to recovery and includes rapid transport to appropriate care, emergency services, acute specialized services, rehabilitation, and patient reintegration into the community (**Figure 1**) (Waydhas et al., 2018). A trauma system assures optimal care while at the same time maximizing resource availability to the population that it serves (Trauma Association of Canada, 2011).

Figure 1

The Trauma Chain of Survival

2.0 Background

Worldwide, injuries are a major cause of death and disability. Outcomes of trauma patients can be improved with better organization and planning of trauma services. A hospital alone does not constitute a trauma system, and optimal trauma care should be provided to all using the

human and physical resources available within a healthcare system (WHO, 2009). A mature trauma system includes pre-hospital services, acute care facilities, rehabilitation services, injury surveillance, injury prevention programs, trauma education and emergency preparedness training (Trauma Association of Canada, 2011). These trauma systems aim to provide timely and appropriate care in order to decrease morbidity and mortality associated with injuries. Death can occur quickly when critically injured trauma patients do not receive care. Triage in trauma is used to identify signs of severe injury in order to separate those who have severe injuries from those who have minor injuries and establish who requires transport to a specialized trauma hospital (Jeppesen et al., 2020). Proper resource use is dependent on accurate trauma triage in the pre-hospital and in-hospital settings to assure that patients with life-threatening injuries are assessed by a multidisciplinary trauma team and can benefit from rapid diagnosis and treatment (Waydhas et al., 2020). While there are many debates surrounding strategies to provide optimal trauma care, the goal of all trauma systems remains the same – to decrease patient morbidity and mortality.

2.1 Epidemiology of Trauma

Trauma is a leading cause of death and disability worldwide. For every trauma-related death, it is estimated that 30 more people are hospitalized and 300 more are treated in the emergency department and released (Nasr et al., 2020). Trauma-related injuries are a global public health problem. Approximately 9% of deaths worldwide are the result of injury, which accounts for approximately 5 million deaths worldwide per year (Yao et al., 2019b).

2.1.1 Canadian Statistics.

Most injuries are preventable, yet in Canada, injury is the leading cause of death for Canadians under the age of 44 (Parachute, 2021). Between 2002 and 2016, trauma accounted for

235,471 deaths in Canada (Boucher, 2020). In 2018, trauma was responsible for 231,530 hospitalizations leaving over 61,000 disabled as a result of their injuries (Parachute, 2021). Falls are the leading cause of injury death, followed by self-harm, unintentional poisoning and transport incidents (i.e., cyclists, motorists, animal-drawn vehicles) (Parachute, 2021). Unintentional injuries accounted for 86% of injuries in Canada in 2018. In the province of Quebec, 45.4% of trauma patients treated in Level 1 and Level 2 trauma hospitals between 2013 and 2018 were >65 years old. Similar to these national data, primary mechanisms of injury were falls (60.2%), followed by motor vehicle crashes (20.1%), blunt force trauma (7.6%), and penetrating trauma (3.9%) (Gonthier, 2020). During this time, approximately 30% of the trauma patients admitted to the hospital were considered major traumas with Injury Severity Scores (ISS) ≥12. Of these, 5.6% died while in the hospital (Gonthier, 2020).

Injuries are expensive – both to the health care system and those patients sustaining the trauma and their families and loved ones. It is estimated that by 2035, the cost of injury to Canadians will be $75 billion per year (Parachute, 2015). The total economic cost in 2018 was estimated at $29.4 billion – the equivalent of $80 million every day (Parachute, 2021). Falls accounted for $10.3 billion of the total cost of injuries, followed by transport incidents ($3.6 billion), and suicide/self-harm ($2.9 billion) (Parachute, 2021). The cost of trauma care includes the cost of acute care, operative care, and the long-term costs of caring for those left with permanent disabilities (Parachute, 2015). Trauma leading to permanent disabilities results in an individual's loss of productivity in addition to the cost associated with the care of the person.

2.2 The "Golden Hour" of Trauma

The concept of the *golden hour* of trauma has existed for decades. The *golden hour* is based on the theory that major trauma patients have a better chance of survival when they obtain

definitive medical care within 60-minutes from the time of injury (Schroeder et al., 2019). Studies from 30 years ago found up to 45% of deaths as a result of trauma, occurred in the first hour of injury. More recent studies continue to show a significant number of deaths occuring in the first 60-minutes after injury, particularly for patients with penetrating trauma (Roman et al., 2016). There remains debate of the validity of the *golden hour* in trauma patient care. Trauma systems aim to provide timely care to those critically injured with the goal to decrease morbidity and mortality. Study methods examining the validity of the *golden hour* used retrospective data to examine trauma registry databases, including only patients admitted to the hospital. These studies excluded patients who died prior to arrival to the hospital. Considering that an estimated 50-60% of trauma victims who die, do so prior to arrival to hospital (Roman et al., 2016), it is legitimate to question the validity of the *golden hour* in those studies with methods and limitations that have excluded those patients who may have benefited the most from immediate care (Schroeder et al., 2019).

Within this debate, many recent studies continue to support the concept of the *golden hour.* When reviewing transport times of US soldiers injured in Afghanistan, a 39% reduction in mortality was noted when transport to a medical facility occurred within 60 minutes of injury. Transport teams who could provide blood transfusions were also associated with a decrease in mortality (Howard et al., 2018). Traumatic brain injuries and hemorrhage are the primary causes of death in the immediate phase after trauma (Roman et al., 2016). For patients with penetrating trauma, a 2% increase in mortality for every minute in pre-hospital response time and by 1% for every minute of scene time was found (Nasser et al., 2020). Traumatic brain injury patients benefit from early management to decrease secondary effects of the traumatic brain injury (Dixon et al., 2020).

Alternatively, a multi-centre Canadian study found that patients who arrived in the emergency department with vital signs (i.e., alive) after prolonged pre-hospital time had decreased mortality rates. Patients with blunt trauma (e.g., motor vehicle crashes, falls, assault) presenting to the emergency department with hypotension, have been found to have decreasing mortality rates when pre-hospital time increased, despite the instability in their vital signs (Clements et al., 2017). Researchers in this study reported a 78% decrease in mortality rates of unstable patients demonstrating hypotension on emergency department arrival who were transported 121-150 minutes when compared to those who arrived with <30-minutes of transport time. They found these patients with prolonged transport times had passed a "test of time". Peak mortality was noted in the group who arrived in the emergency department with <30-minutes of transport time. The three Canadian centers in this study are within trauma systems with pre-hospital advanced life support capability.

To address disparate views over the validity of the *golden hour,* Schroeder et al. (2019) used the *Relative Mortality Analysis* to evaluate the validity of the *golden hour.* The researchers used a local trauma database to simulate the populations analyzed in previous retrospective studies that did not support the *golden hour* in trauma care. They found these studies lacked data and appropriate methods for quantifying the severity of patient injuries. These authors supported the concept of the *golden hour* and concluded that the timing of definitive care impacted outcomes for only those patients with high levels of acuity (Schroeder et al., 2019).

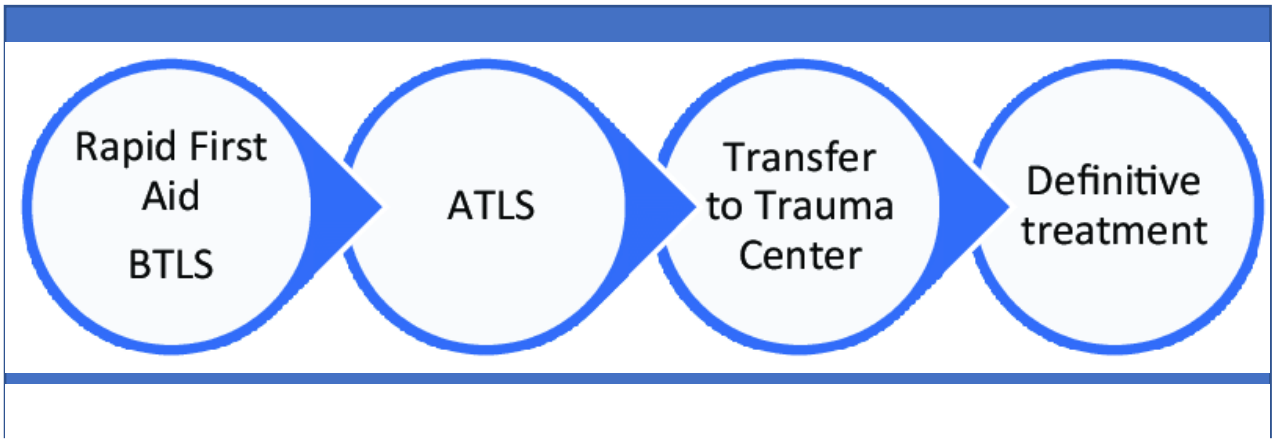
2.3 Pre-Hospital Care in a Trauma System

Trauma systems aim to provide a coordinated effort in injury prevention and management. The trauma *chain of survival* (**Figure 2**) (Popa et al., 2019) includes four links that are intertwined in providing quality care in an effort to improve trauma patient outcomes: pre-

hospital early first aid to prevent immediate deterioration, early basic life support (includes basic trauma life support) and advanced life support (includes advanced trauma life support) to secure vital functions, early advanced therapy to limit or repair injury while transporting to hospital, and definitive treatment. (Bakke & Wisborg, 2017).

Figure 2

Trauma Chain of Survival (Popa et al., 2019)



"The Golden Hour"

Pre-hospital care can take many forms depending on the local trauma system. Pre-hospital management may be done by basic life support teams, advanced life support teams, or physician emergency response teams. The benefit of basic versus advanced life support transport has been debated in recent literature. A primary goal of trauma care is to bring the *right patient* to the *right place* at the *right time* (Farrell et al., 2020). In recent studies, prolonged time spent on scene by pre-hospital personnel was associated with increased mortality, particularly with penetrating trauma (Brown et al., 2016; Nasser et al., 2020). Prolonged scene time was attributed to pre-hospital interventions such as intubation (Brown et al., 2016). It is difficult to ascertain if the scene time itself leads to increased mortality or if the increased mortality results from higher patient acuity and injuries that have a lower probability of survival.

With the implementation of mature trauma systems, what used to be a trimodal distribution of death from trauma has been replaced with a unimodal distribution of deaths. The trimodal distribution consisted of death occurring immediately within 1 hour of injury, early deaths occurring within hours of injury, and later deaths occurring within weeks of injury. With advances in trauma care, most deaths now occur in the first several hours of injury and result from fatal hemorrhage or brain injuries (Wandling & Cotton, 2020). To avoid these deaths, experts argue that early damage control resuscitation should begin in the pre-hospital setting and should include the administration of blood products, the use of tourniquets, and potentially the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) when life-threatening injuries are identified (Wandling & Cotton, 2020).

Increased mortality rates, associated with prolonged pre-hospital times for trauma patients with physical findings related to time-sensitive injuries (i.e., hypotension, penetrating trauma, low Glasgow Coma Scale [GCS] scores), support a *scoop and run* approach to pre-hospital care to decrease time of injury to definitive care. The *scoop and run* approach leaves little time for on-scene interventions to be carried out by pre-hospital personnel (Chen et al., 2019; Nasser et al., 2020). Hypotension, penetrating trauma, and low GCS scores are associated with injuries requiring urgent surgical intervention. These patients benefit most from rapid transport to high-level trauma centres that can provide hemorrhage control and definitive care in a timely manner.

When comparing physician-led emergency response teams (common in Europe) to paramedic-led (basic or advanced life support) emergency response teams (common in North America), pre-hospital times were longer in physician-led teams (Gauss, 2019). Clinician leaders of trauma systems debate the pre-hospital concepts of *scoop and run* to lower pre-

hospital time versus *stay and play* to decrease the time to intervention ratio. In the physician-led emergency response team, increasing total pre-hospital times is associated with an increase in risk of death. There is support for balancing the time required to perform interventions pre-hospital with the potential gain in survival that the intervention will provide (Gauss, 2019). Interventions that will delay definitive care may be inappropriate; however, pre-hospital interventions that can be done en route to a trauma centre may benefit the patient with time-sensitive injuries (Wandling & Cotton, 2020).

2.4 Trauma Triage

Accurate patient triage allows for the right resources to be available for the right patient. Triage is dependent on human judgement and accurate assessment of injuries (Mohan et al., 2018). Accurate and timely trauma team activation (TTA) is essential as undertriage can delay the patient receiving the appropriate and definitive care that they require. Overtriage, resulting in TTA for patients who do not require immediate specialized care, affects flow within the emergency department and the entire hospital. It pulls resources away from other patients unnecessarily (Schwing et al., 2019). Trauma team activation criteria in use at trauma centers should aim for an undertriage rate of <5% and an overtriage rate of <35%; however, a precise definition of over and undertriage is currently ill-defined (Tignanelli et al., 2018). Patients who did not have a TTA who were later found to have injuries that required care from the trauma team are defined as undertriaged, while patients who had a TTA but were found not to have injuries requiring care from the trauma team are defined as overtriaged (Waydhas et al., 2018).

2.4.1 Pre-Hospital Triage.

Appropriate pre-hospital triage tools to identify patients requiring transport to trauma hospitals and pre-hospital personnel competencies in rapid assessment and decision making are

paramount for patients to reach the appropriate hospital emergency department for their injuries (Sewalt et al., 2021). Levels of trauma hospitals range from Level 1 (most comprehensive facility for severe injuries) through Level 5, depending on the population and services that they can offer to the population. Pre-hospital and emergency department personnel must recognize signs of major trauma and injury patterns to triage severely injured trauma patients appropriately. Field triage guidelines include physiological criteria (e.g., GCS scores, systolic blood pressure, respiratory rate), anatomical factors (e.g., penetrating injuries to the head, neck, and torso, chest wall instability, crushed extremities, etc.), mechanism of injury (e.g., falls from >6 meters, high-velocity motorcycle crashes, cyclists or pedestrians hit by automobiles with significant impact, etc.), and factors specific to certain groups (e.g., age, pregnant women, those with bleeding disorders or who take anticoagulants, etc.) (Yoder et al., 2020). Field triage guidelines aid pre-hospital personnel in appropriately triaging trauma patients and provide the necessary information to the emergency department personnel to allow them to establish the need for TTA prior to the arrival of the patient (see **Appendix 1**). TTA with the pre-hospital pre-alert is dependent on the accuracy of information provided by the pre-hospital personnel and the accuracy of the assessment of the patient done by paramedics in the pre-hospital setting (Wandling & Cotton, 2020).

When comparing basic and advanced life support pre-hospital transport teams, Yoder et al. (2020) found trauma undertriage rates to be significantly lower for advanced versus basic life support teams. Advanced life support teams were found to have higher overtriage rates than basic life support teams. Undertriage by pre-hospital personnel results in the patient being transported to a centre that is not necessarily equipped to provide the required level of patient care. Overtriage, in the pre-hospital setting, results in a patient being transported to a centre that

is over-specialized and increases the risk of overwhelming the healthcare system by diverting care from other more acute patients (Wandling & Cotton, 2020). Trauma patients who are inappropriately transported to a non-trauma facility prior to being transported to a trauma centre have 3.8 times the mortality rate than those transported directly to a trauma centre (Kool et al., 2017). Pre-hospital personnel reported that they were likely to be influenced by their past experiences and rely less on guidelines when triaging trauma patients. Undertriage of major traumas by basic and advanced life support teams is associated with increased mortality and poor patient outcomes (Yoder et al., 2020). Education and training of pre-hospital personnel are pivotal to ensuring accurate identification of major traumas and adherence to field triage criteria.

2.5 Trauma Team Activation (TTA) Criteria

To determine appropriate TTA, trauma centres primarily use physiological criteria (e.g., systolic blood pressure, respiratory status, GCS scores) to identify those patients with severe injuries associated with increased morbidity and mortality (Waydhas et al., 2020). The American College of Surgeons recommends full TTA based on critical elements known to have a high incidence of morbidity and mortality. These criteria, known as the American College of Surgeons – 6 (ACS-6), include: 1) patients presenting post-trauma with a systolic blood pressure <90 mmHg; 2) penetrating trauma to the head, neck, chest, abdomen, or proximal extremities; 3) a GCS score <9; 4) blood products being required to maintain vital signs; 5) a need for airway management; or 6) the emergency department physician's discretion (Tignanelli et al., 2018). Institution-specific TTA criteria, to accommodate specific populations and available resources, are developed at the institution's discretion (Verhoeff et al., 2019). Early trauma team involvement for major trauma has been associated with shorter door to operating room time,

shorter door to radiology time, and shorter lengths of stay in the emergency department (Yoo & Mun, 2014).

Accreditation Canada criteria demands a TTA compliance rate ≥90%; that is, a TTA should occur ≥90% of the time when a patient meets TTA criteria on audits (Verhoeff et al., 2019). The American College of Surgeons suggests that the rate of overtriage should be <35%, while the rate of undertriage should not exceed 5% (Waydhas et al., 2018). When institutions select TTA criteria, rates of over and undertriage are considered when deciding if specific criteria should be used for TTA. Institutions may choose to have a multi-tiered TTA where less severe traumas receive care from a modified, smaller trauma team (Schwing et al., 2019).

In a retrospective analysis of trauma patients in Michigan, TTA compliance and mortality rates were reviewed. Trauma patients who met one or more of the ACS-6 criteria and were undertriaged were found to have mortality rates of 30%, compared to 21% who had full TTA. For those undertriaged patients, 88% did not have any of the ACS-6 criteria for TTA. The undertriage group who did not exhibit any of the ACS-6 criteria was found to have a 4% mortality rate, despite their high ISS (Tignanelli et al., 2018). The presence of at least one ACS-6 TTA criteria is associated with a need for urgent, often surgical intervention. Undertriage of these patients can have detrimental outcomes when delays to definitive care occur.

Activating a trauma team is necessary to coordinate specialized advanced care for severely injured trauma patients. Pre-hospital triage criteria (see **Appendix 1**) allow more seriously injured patients to be rapidly identified and then transported to the appropriate hospital able to provide the appropriate level of trauma care. Based on information received from pre-hospital personnel, emergency department personnel can choose to activate the trauma team if they feel the incoming patient falls within their activation criteria (see **Appendix 2**). Activation

of the trauma team prior to the patient's arrival allows the team to prepare and coordinate the care they anticipate the patient to require (Waydhas et al., 2020). TTA based on pre-hospital information is dependent on the accuracy of pre-hospital information provided to the emergency department personnel.

A recent survey on activation criteria used around the world identified a set of TTA criteria in high agreement by physicians. These criteria included: GCS score <9, a respiratory rate <9 or >29, need for pericardiocentesis, need for advanced airway management, pulse oximetry <90%, need for emergency surgery, systolic blood pressure <90mmHg, a shock index >0.9, cardiopulmonary resuscitation, a decrease in GCS score of ≥2 points, need for a chest tube, or requiring catecholamine administration (Waydhas et al., 2020). Institutions may also choose to base their activation criteria on identified injuries such as a pelvic fracture, penetrating trauma to the trunk and neck, amputation above the hand or foot, traumatic brain injuries, spinal cord injuries or chest wall instability (Waydhas et al., 2018). Not all injury-based criteria (e.g., presence of pelvic fracture, spinal cord injuries, or chest wall instability) can be accurately identified by pre-hospital personnel. This results in many trauma systems favouring physiological criteria (e.g., systolic blood pressure, respiratory rate, GCS scores) and injury-based criteria for TTA.

Appropriate and consistent TTA is associated with a decreased time spent in the emergency department, decreased time from arrival to diagnostic imaging, decreased missed injuries, a reduced length of stay, and decreased mortality (Verhoeff et al., 2019). Leaving the decision for pre-hospital TTA solely to the emergency department physician’s discretion can result in variability in trauma team involvement for similar cases. Physician heuristics, including the use of intuitive judgements as well as trauma patient pattern recognition, is associated with

undertriage and is amplified when moderately-to-severe patients do not have typical features representative of major trauma (Shreyus et al., 2019). When making the decision for TTA, physicians are often making the decision based on limited information (Jeppesen et al., 2020). Clinicians must use their judgment and all other information provided to decide to activate the trauma team.

2.6 Trauma Team Composition and the Role of the Registered Nurse (RN)

Emergency department RNs play a central role on trauma teams by assisting and coordinating care starting with pre-hospital notification to patient arrival, through the resuscitation phase (i.e., preparing and administering medication, hemodynamic monitoring, patient assessment, administering blood products, assisting in airway management, recording notes), and early stabilization (Tiel Groenestege-Kreb et al., 2014). Accuracy of trauma triage by trained RNs has been found to have over and undertriage rates within the ACS-COT acceptable rates (Linder et al., 2019).

These RNs require extensive critical care and emergency department experience and additional training (i.e., Trauma Nursing Core Course [*Emergency Nurses Association*, 2022], Advanced Trauma Care for Nurses [*Society of Trauma Nurses*, 2022], Advanced Cardiac Life Support [*Heart and Stroke Foundation*, 2022]). The trauma RN is an expert in their field and is knowledgeable of multiple institutional protocols and skilled in advanced techniques and monitoring (Polovitch et al., 2019). While emergency departments adapt the role to the unique aspects of their institution, the trauma resuscitation RN is predominantly a senior RN, frequently with proficiency in triage (Schwing et al., 2019).

Triage-trained trauma RNs receiving pre-hospital reports from emergency medical services personnel are more proficient in appropriately evaluating if a patient meets standardized

TTA criteria compared to physicians (Schwing et al., 2019). Early trauma team activation decreases the time for members of the trauma team to arrive sooner in relation to the arrival of the patient in the emergency department and decreases the time to definitive care (Yoo & Mun, 2014). Standardizing trauma triage and having triage trained RNs responsible for initiating TTA reduces undertriage rates (Jelinek et al., 2014). Patients benefit from the preparation of the multidisciplinary team before the patient's arrival and the coordinating of the resources essential for the trauma patient's care. The trauma RN, coordinating the patient's care, is associated with decreased length of stay and decreases in time to definitive care (Polovitch et al., 2019).

2.7 Trauma Care in Quebec, Canada

In contrast to other major centers in North America, Quebec pre-hospital care is provided primarily by primary care paramedics (basic life support providers). Pre-hospital transport is exclusively done by ground ambulance; air transport is not available outside of evacuation from northern communities to major centres. If remote air transport is required, patients are evacuated to a local airport, and then transported to the hospital via ground ambulance. Pre-hospital primary care paramedics triage trauma patients using pre-set criteria (see **Appendix 1**) and transport those who meet pre-hospital major trauma criteria directly to a trauma center, providing that the transport time is anticipated to be ≤60-minutes. Emergency department staff are notified with a 15-minute pre-hospital warning of their estimated arrival time.

Prior to the implementation of the Quebec adaptation of the Center for Disease Control – American College of Surgeons, Committee on Trauma (CDC-ACSCOT) guidelines for field triage of injured patients (*Echelle quebecoise de triage prehospitalier en traumatologie*, 2016) to transport major trauma patients up to 60-minutes to a Level 1 trauma centre, when outside of

Montreal, trauma patients were brought to the nearest community hospital. Patients would then firstly be evaluated at the community hospital and then, if deemed necessary, transferred for further evaluation by a trauma team in a Level 1 trauma centre. This would result in significant delays in major trauma patients receiving the most appropriate care as many required specialized services are not available at the community hospital level.

TTA criteria at the Montreal General Hospital (see **Appendix 2**) have been consistent for many years. The change in pre-hospital triage of trauma patients, as required by the *Institut National D'Excellence en Sante et en Services Sociaux Quebec* (INESSS), has not been reflected in the criteria being used by the emergency department at the Montreal General Hospital for TTA. As the current TTA criteria are based on findings on patient arrival in the emergency department, at this time, TTA based on the pre-hospital report remains solely at the discretion of the physician.

3.0 Rationale for the Study

For major trauma patients, decreasing time to definitive care is a primary goal in trauma systems. TTA, based on information gathered in the pre-hospital notification, allows for the trauma team to assemble and prepare to resuscitate a critically injured trauma patient (Schwing et al., 2019). Monitoring overtriage and undertriage rates are used as quality of trauma care indicators (Jeppesen et al., 2020; Lorthios-Guilledroit, 2020). Since Quebec pre-hospital care is much different than most other North American systems it is difficult to make comparisons. Quality improvement initiatives and changes in practice are difficult to justify when no comparable literature is available to support them. In this research, I aimed to evaluate pre-hospital trauma patient triage and subsequent trauma team activation practices in the emergency department, including how these practices impacted patient care in a Level 1 trauma centre.

4.0 Purpose of the Study

When evaluating the quality and efficiency of care within the emergency department, each process should be assessed and evaluated for potential improvement. Balance must be found to ensure that resources are patient-centred and available at the right time (Maia Ambegaokar et al., 2009). The purpose of this study was to evaluate pre-hospital trauma patient triage and subsequent trauma team activation practices in the emergency department, including how these practices impacted patient care in a Level 1 trauma centre in Quebec. I aimed to examine if the current practice is accurately triaging major trauma patients who are arriving by primary care paramedic teams via ground ambulance. The impact on the care of major trauma patients, in relation to the timing of the trauma team's involvement in the patient's care in the emergency department, was also assessed.

4.1 Hypothesis

Accuracy in TTA is pivotal in providing safe, systematic trauma patient care (Schwing et al., 2019). Most trauma-related deaths occur within hours of injury, primarily from hemorrhage and brain injury (Wandling & Cotton, 2020). I hypothesized that patients who met field triage criteria for major trauma, using the Quebec pre-hospital trauma triage scale (*Échelle québécoise de triage préhospitalier en traumatology* [EQTPT]) (**Appendix 1**) adapted from the CDC-ACSCOT CDC-ACSCOT pre-hospital trauma triage guidelines (Frieden, 2012), would benefit from timely involvement of the trauma team in their care upon arrival to the emergency department of a Level 1 trauma centre; particularly if patients have minimal pre-hospital interventions being provided for treating life-threatening injuries. As this population is meeting field triage guidelines for major trauma, I hypothesized that early trauma team involvement will decrease the time to definitive care and decrease the time from the arrival of the patient in the

emergency department without a plan established ultimately improving patient outcomes (i.e., reduced morbidity and mortality).

4.2 Research Questions

1. Does pre-hospital TTA, for those patients meeting field triage criteria for major trauma who are directly transported to a Level 1 trauma centre by primary care paramedics, result in over-activation (>35%) of the trauma team?
2. Does timing of trauma team involvement (i.e., pre-hospital versus emergency department TTA), for those patients meeting field triage criteria for major trauma, who are directly transported to a Level 1 trauma centre by primary care paramedics, impact the length of stay and time to definitive care in the emergency department?

5.0 Definition of Terms

Advanced life support paramedic: Highly trained pre-hospital personnel authorized to use advanced procedures including intravenous medication administration and endotracheal intubation (Yoder et al., 2020). Also referred to as advanced care paramedics.

Basic life support paramedic: Pre-hospital personnel who stabilize patients using non-invasive techniques and monitor vital functions during transportation (Yoder et al., 2020). Also referred to as primary care paramedics.

Level 1 trauma centre: The highest level of trauma care. It is usually a university-affiliated hospital in a large metropolitan area with advanced medical technology and a wide range of medical specialists (Tallon et al., 2011).

Major trauma: Injuries resulting from acts of violence against oneself or others, road traffic crashes, burns, drowning, falls, and poisonings, among other causes (Maia Ambegaokar et

al., 2009). An Injury Severity Score (ISS) ≥12 indicates a major trauma (Austin et al., 2020; Lorthios-Guilledroit, 2020).

Overtriage of the trauma team: A patient who had a trauma team activation, however after the patient was evaluated in the emergency department, did not have injuries that required the care from the trauma team. An acceptable rate of overtriage is 25-35% according to the CDC-ACSCOT (Waydhas et al., 2018). For this study, patients were considered overtriaged if they had an ISS (Injury severity score) <12 and were discharged home (alive) from the emergency department.

Quebec pre-hospital trauma triage scale – EQTPT: Field triage guidelines adapted from Center for Disease Control and Prevention – American College of Surgeon – Committee on Trauma (CDC-ACSCOT) in use in the Province of Quebec, Canada (*Echelle quebecoise de triage prehospitalier en traumatologie*, 2016). See **Appendix 1**.

Trauma team: Multidisciplinary team, frequently including physician team leaders, surgeons, anesthetists, RNs, respiratory therapists, and radiology technicians providing coordinated care to trauma patients (Tiel Groenestege-Kreb et al., 2014). Trauma team compositions are developed locally to reflect the uniqueness of each trauma centre (Yoo & Mun, 2014).

Trauma team activation (TTA): Mobilizing of a multi-disciplinary trauma team that facilitates resuscitation, rapid diagnosis and definitive care for trauma patients (Verhoeff et al., 2019).

Trauma team activation (TTA) criteria: A set of conditions which the trauma team is considered to be essential for the initial care of a trauma patient in the emergency department (Waydhas et al., 2020). See **Appendix 2**.

Undertriage of the trauma team: Patients who were not triaged to require a TTA, however, were later found to have injuries or conditions that required care from the trauma team. An

acceptable rate of under-triage is <5% according to the American College of Surgeons – Committee on Trauma (Waydhas et al., 2018). For this study, patients were considered undertriaged if they had an ISS ≥12 and did not have a TTA.

Chapter 2 – Research Design

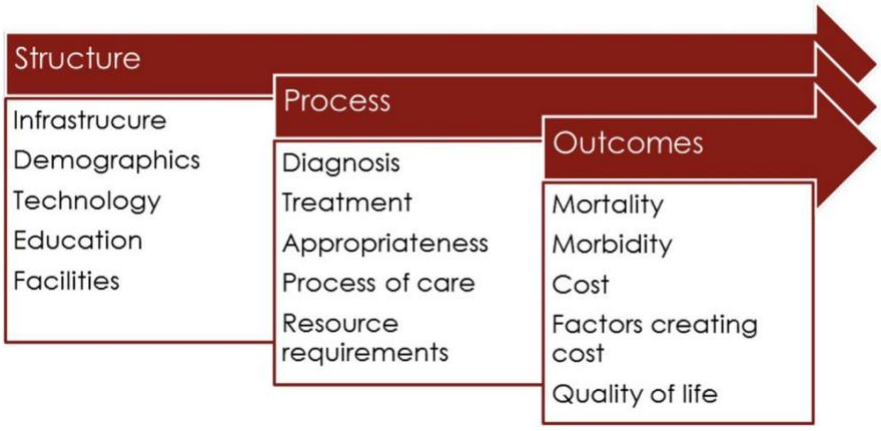
1.0 Methods

1.1 Conceptual Framework

This research was guided by the principles of the Donabedian model (**Figure 3**). In quality improvement, the goal is to evaluate the processes to create interventions to improve performance. The Donabedian model is based on the measurement of quality in healthcare on three components: structure, process and outcomes, and the relationship between the three components (Hanae Ibn El et al., 2013). Within this model, emphasis is placed on examining the structure and processes in relation to the outcomes and evaluating how the different elements of the system contribute to unfavourable outcomes in patient care in order to remove the blame placed on individual care providers (Maia Ambegaokar et al., 2009).

Figure 3

The Donabedian Model (Lighter, 2015)



Quality improvement frameworks based on the Donabedian model aim to identify gaps in the present structure and processes and desired outcomes. The goal is to shift the focus from the performance of individuals and to identify root causes of barriers to quality care in order to create a structure that supports care providers in providing optimal care (Maia Ambegaokar et

al., 2009). High-quality care emergency department patient care is dependent on six domains of care: safe, effective, patient-centred, timely, efficient, and equitable care (Hansen, 2019). Quality improvement initiatives look to identify the root causes of gaps in care allowing one to focus interventions to improve the quality of the care being provided (Hansen, 2019). The six domains of care are intertwined; with finite resources available in healthcare systems, a balance must be obtained between the domains to allow for quality care to be provided for all.

The *structure* in this study is the trauma system in which we are delivering care. With ground transport and care being provided by primary care paramedics in transporting patients to a Level 1 trauma centre in a university teaching hospital. As this is a retrospective study, the characteristics of the *structure* remain constant. No significant changes were made to the structure of the system during the study period. By examining medical records over a period of 2.5 years, seasonal variabilities in patient characteristics, numbers and staffing levels are uniform. The *process* under review involved the relation of the field triage to the pre-hospital notification and the manner in which the personnel in the emergency department process the information received. The timing and extent of the involvement of the trauma team in the care of the major trauma patient was the primary interest of the study. The *outcomes* evaluated within this study involved evaluating the over and undertriage rates of major trauma patients with prolonged pre-hospital time and the impact that the timing of trauma team involvement on the quality of the care being provided within the emergency department.

In this study, I examined how patient care *outcome*s can be improved by decreasing the length of stay in the emergency department and decreasing the time to definitive care. Accuracy in TTA, length of stay in the emergency department for major trauma patients, time of arrival of patients with traumatic brain injuries to obtain diagnostic imaging (i.e., computerized

temography (CT) scans) are among the various quality indicators used to evaluate the care of trauma patients (Lorthios-Guilledroit, 2020). Patient flow within the emergency department is dependent on timely access to diagnostic imaging, physician evaluations, and decisions on dispositions (Martinez et al., 2018). Identifying areas in the process that impact the different quality indicators allows quality improvement initiatives to be developed to improve patient outcomes.

1.2 Research Design

To answer my research questions, I conducted a retrospective cross-sectional descriptive analysis utilizing administrative data derived from electronic medical records from a large Level 1 trauma centre.

1.3 Setting

This retrospective study was conducted within the emergency department at the Montreal General Hospital, an adult Level I trauma centre in Montreal, Québec. This hospital provides care to the southern half of the island of Montreal, the greater Montreal region south of the island of Montreal, and northern Quebec. The metropolitan area of Montreal has a population of 4.2 million; the Montreal General Hospital has a catchment population of 2.9 million. This is one of three Level 1 trauma centers serving adults in the province of Quebec. The Montreal General Hospital cares for an average of 10,000 trauma patients per year with approximately 1,600 being major trauma patients.

1.4 Participants and Sample Size

1.4.1 Inclusion criteria.

Trauma patients aged ≥16 years who met Quebec pre-hospital trauma triage EQTPT criteria (see **Appendix 1**) to bypass transport to community hospitals and be transported directly

to the Montreal General Hospital (Level I trauma centre) between May 15, 2018 and December 31, 2020 were included. All patients meeting the inclusion criteria were included in the sample; therefore, a sample size calculation was not needed.

1.5 Data Collection Procedures

Pre-hospital data were obtained from the local health authority (*Centre intégré de santé et de services sociaux (CISSS) Montérégie-Centre*). This list included all primary ambulance transports from the CISSS Monteregie region to the Level 1 trauma centre. This list was sorted to include only high-priority transports. From this list, registrations in the emergency department were matched to the ambulance arrival times to identify the patients meeting the inclusion criteria.

For those meeting inclusion criteria, medical records were accessed, and pre-hospital, nursing, and physician's notes were reviewed. Pertinent data were extracted using a standardized data collection form (see **Appendix 3**) and then entered into an EXCEL spreadsheet. These data included patient demographics, details about the injury (trauma) including severity, pre-hospital transportation time, triage and TTA details, and treatment and outcome indicators. Medical records were reviewed by a single investigator with 25% verified for accuracy.

1.6 Measures and Analytic Approach

Data were analyzed indpenedantly using IBM SPSS 28 (IBM, 2019). Descriptive statistics were calculated to describe sample demographics and describe TTA rates. Each patient was evaluated for over or undertriage and classified as baseline over and undertriage rates. Over and undertriage rates were then established if there were to be 100% TTA compliance based on the present criteria in place, removing the physician's discretion to activate when TTA criteria is

not present. I then calculated and compared to the rates if all patients meeting EQTPT Levels 1, 2, and 3 were to have a TTA, regardless of if they were to meet TTA criteria in the emergency department. This evaluates if the present practice, as well as present TTA criteria, are accurately predicting major trauma compared to the EQTPT criteria. Patients were grouped according to the timing of TTA as (1) pre-hospital notification, (2) on arrival in the emergency department, (3) receiving a trauma consult only, or (4) no trauma team involvement. Quality indicators (Lorthios-Guilledroit, 2020; Schull et al., 2011) including time spent in the resuscitation room, length of stay in the emergency department, length of time from arrival to decision for admission, and time from arrival to final disposition were compared for each subgroup.

Consistent with others, major trauma was defined as an ISS ≥12 (Lorthios-Guilledroit, 2020). Patients with an ISS ≥12 who did not have a TTA were considered *undertriaged*. Undertriaged cases were further reviewed to evaluate if existing TTA criteria were present upon arrival in the emergency department but was missed by the treating team. Those with an ISS of <12 who had a TTA and were later discharged home from the emergency department, were also classified as *overtriaged.*

Due to non-normal data distribution, I used non-parametric statistical tests to compare differences between groups. Data were represented with proportions and presented in tables. The Wilcoxon signed-rank test with 95% confidence intervals (95% CI) was used to compare the over and undertriage rates. For the comparison of the different quality indicators, independent sample Kruskal-Wallis tests with 95% CI were calculated.

2.0 Manuscript Overview

This is a manuscript-style thesis comprising two manuscripts to be submitted for publication. Both manuscripts were accepted for presentation at the Trauma Association of

Canada (TAC) conference on April 7th and 8th, 2022. After the TAC conference, both abstracts will be published in the *Journal of Trauma and Acute Care Surgery*. Both manuscripts will also be submitted to the *Journal of Trauma and Acute Care Surgery* for publication consideration.

2.1 Manuscript 1: Timing of Trauma Team Involvement and the Impact on the Length of Stay and Time to Definitive Care in the Emergency Department: A Retrospective Administrative Data and Chart Review

In this manuscript, I assessed how the timing and level of involvement of the trauma team in a patient's care impacted accepted quality indicators in the emergency department. Patients were grouped according to the timing of TTA as (1) no trauma team involvement, (2) TTA after arrival in the emergency department, (3) TTA with pre-hospital notification, or (4) receiving a trauma consult only. Patients who had a TTA with pre-hospital notification were found to have a statistically significant decrease in their time to diagnostic imaging (CT scan), a decrease in the time spent in the emergency department without a disposition, and a decreased length of stay. There were no significant differences between groups based on time spent in the emergency department resuscitation room. A secondary analysis comparing EQTPT Level 1 patients who had a pre-hospital TTA to those with a TTA after arrival in the emergency department noted a statistically significant difference in the length of time from arrival to CT scan.

2.2 Manuscript 2: Accuracy of the Quebec Pre-Hospital Triage Scale (EQTPT) in Predicting the Need for Trauma Team Activation: A Retrospective Administrative Data Study

In this manuscript, I evaluated over and undertriage rates, and compared them to the acceptable rates allowed by the American College of Surgeons. Baseline over and undertriage rates were calculated and an undertriage rate of 13.2% was observed, while the overtriage rate was found to be 8.4%. Over and undertriage rates were then calculated assuming a 100%

compliance rate with the present TTA criteria based on the presentation of the patients in the emergency department. With a 100% compliance rate, all patients meeting present TTA criteria on arrival, without any pre-hospital TTA at the emergency department's physician's discretion, would have had a TTA. When patients did not meet any of the TTA criteria, this would result in 33.2% (123/371) of patients not having a TTA. This would have resulted in an overtriage rate of 13.2% and an undertriage rate of 12.1%. Over and undertriage rates were then calculated assuming all those who met EQTPT levels 1, 2, and 3 were to have a TTA. This allowed evaluation of pre-hospital triage criteria accuracy in predicting high levels of injury. By activating the trauma team for all patients meeting EQTPT level 1, 2, and 3 criteria in this study, the overtriage rate increased to 25.3% at the same time eliminating undertriage.

Individual TTA criteria associated with patients who were overtriaged were reviewed along with the EQTPT criteria that were met by the patients who were undertriaged. Airway management and hypotension were the TTA criteria that were most frequently associated with overtriage. Similarly, a GCS <14, hypotension, and respiratory compromise were the EQTPT criteria most frequently associated with undertriage. While baseline overtriage rates along with ocertirage rates based on 100% compliance with TTA criteria were found to be well within the acceptable rate of <35%, the undertriage rate was significantly higher than the acceptable rate of <5%. A TTA for all the patients meeting EQTPT level 1, 2, and 3 criteria, undertriage rates are eliminated and overtriage remains within the acceptable levels.

Chapter 3 – Manuscripts

1.0 Manuscript 1: Timing of Trauma Team Involvement and the Impact on the Length of Stay and Time to Definitive Care in the Emergency Department: A Retrospective Administrative Data and Chart Review

Submitted to the *Journal of Trauma and Acute Care Surgery* as an *Original Research* article

Jeanesse Bourgeois, BSc(N)
McGill University Health Centre
Jeanesse.Bourgeois@muhc.mcgill.ca

Greg Clark, MD
McGill University Health Centre
Greg.Clark.med@ssss.gouv.qc.ca

Scott Delaney, MD
McGill University Health Centre
jscott.delaney@mcgill.ca

Jeremy Grushka, MD
McGill University Health Centre
jeremy.grushka@mcgill.ca

Kimberley Lamarche, DNP
Faculty of Health Disciplines, Athabasca University
lamarche@athabascau.ca

Jennifer A. Knopp-Sihota, PhD
Faculty of Health Disciplines, Athabasca University
jknopp@athabascau.ca

ABSTRACT

Background: For patients sustaining major trauma, decreasing time to definitive care remains a primary goal. Specialized trauma team involvement is essential for coordinating the emergency department care of complex major trauma patients. The aim of this study was to evaluate if the timing of trauma team involvement impacts length of stay and time to definitive care in the emergency department.

Methods: This is a single-centre retrospective medical record review, including patients meeting Quebec pre-hospital triage criteria for major trauma from May 15, 2018 to December 31, 2020. We assessed time from patient arrival until departure from the resuscitation room, time to CT scan, time to disposition, and overall length of emergency department stay. Patients were grouped according to the timing of trauma team activation (TTA) as (1) pre-hospital notification, (2) on arrival in the emergency department, (3) receiving a trauma consult only, or (4) no trauma team involvement. Mean times and standard deviations were calculated, and group differences were assessed using the Kruskal-Wallis test and the independent sample Mann-Whitney U test.

Results: We identified 371 patients meeting our inclusion criteria; there were no differences between groups in mean time spent in the resuscitation room based on the timing of trauma team involvement (45-51 minutes, p=0.422). A trauma team activation with pre-hospital notification was associated with a statistically significant shorter time to CT scan (62-81 minutes, p=0.010), time to disposition (6:37-13:41, p<0.001), and total emergency department length of stay (9:22-23:16 hours: minutes, p<0.001).

Conclusion: Appropriate trauma team activation improves performance indicators used to evaluate the quality of care in the emergency department. This research suggests that pre-hospital

trauma team activation should be considered the standard of care for all patients meeting pre-hospital field triage criteria for major trauma.

BACKGROUND

To decrease morbidity and mortality, trauma systems must provide timely and appropriate care to those sustaining life-threatening injuries. Trauma care is provided on a continuum from pre-hospital, the emergency department and other in-hospital services, to post-hospital care including rehabilitation.(1) When critically injured patients do not receive the appropriate care, death may occur within hours of injury, primarily from uncontrolled hemorrhage and brain injury.(2) Appropriate resource utilization is dependent on accurate trauma triage in the pre-hospital and in-hospital settings. Accurate triage ensures that a multidisciplinary trauma team assesses patients with life-threatening injuries, allowing for rapid diagnosis and treatment.(3) While many debate specific strategies to provide optimal trauma care, the goal of all trauma systems remains the same, to decrease patient morbidity and mortality.

Field triage guidelines, including the Quebec pre-hospital trauma triage scale "*Echelle Quebecois de Triage Pre-Hospitalier de Trauma*" (EQTPT) and the Centers for Disease Control – American College of Surgeons Committee on Trauma (CDC-ACSCOT) Guidelines for Field Triage of Injured Patients,(4) assist pre-hospital personnel in identifying trauma patients for transport to the appropriate hospital that can provide the level of trauma care required for the patient. These tools also assist pre-hospital personnel in providing necessary information to emergency department personnel to establish the need for trauma team activation (TTA) before the patient's arrival. TTA with the pre-hospital notification is dependent on the accuracy of information provided by pre-hospital personnel.(5) To determine which patients are appropriate for TTA, trauma centres use physiological criteria (e.g., systolic blood pressure, respiratory status, Glasgow Coma Scale) to identify patients likely to have severe injuries associated with

increased morbidity and mortality.(6) In contrast, field triage guidelines, such as the EQTPT,(7) are not only based on physiological criteria but also high-risk mechanisms of injury.

In the province of Quebec, pre-hospital services implemented the EQTPT pre-hospital triage tool (adapted from the CDC-ACSCOT Guidelines for Field Triage of Injured Patients), on May 15, 2018.(7) These triage tools classify trauma patients based on physiological criteria and mechanism of injury to rank them from level 1 (highest) to level 5. Trauma patients in Quebec who are ranked levels 1-3 are transported ≤60 minutes by ground ambulance (air transport is not available in the province of Quebec) directly to a Level 1 trauma centre. Pre-hospital care is predominantly provided by primary care paramedics who focus on providing basic life support (BLS) while providing rapid transport to the emergency department. Unlike advanced care paramedics authorized to preform procedures such as endotracheal intubation and administer intravenous medications, BLS paramedics use non-invasive techniques and provide basic monitoring and care during transport.(8)

Process indicators used when evaluating the quality of care and performance of trauma centres in the province of Quebec include (1) a length of stay in the emergency department of <4 hours for major trauma patients, (2) appropriate under and over triage/TTA rates, (3) airway management in the emergency department, and (4) stabilizing of hemorrhagic pelvic fractures within ≤3 hours of arrival in the emergency department.(1) Accuracy in TTA is pivotal in providing safe, systematic trauma patient care.(9) We hypothesize that patients who meet field triage criteria for major trauma would benefit from timely involvement of the trauma team in their care upon arrival to the emergency department of a Level I trauma centre. This study aimed to evaluate if timing of trauma team involvement impacts the length of stay and time to definitive care in the emergency department.

METHODS

Study Design

This was a single-site retrospective cross-sectional descriptive study utilizing retrospective administrative and electronic medical records. We included patients aged ≥16 years who sustained a traumatic injury and met the EQTPT pre-hospital triage criteria to bypass community hospitals and be transported directly to a Level 1 trauma centre between May 15, 2018 and December 31, 2020.

Setting

This study was conducted in a Level 1 trauma centre in the province of Quebec, Canada. This trauma centre has a catchment population of 2.9 million people, serving approximately 10,000 trauma patients per year, with 1,600 being major trauma patients. The trauma centre services the southern half of the island of Montreal, the greater Montreal south shore (Monteregie) region, and northern Quebec. In this centre, trauma teams include a trauma team leader (emergency department physician, surgeon, or anesthetist), a trauma surgeon, trauma residents, registered nurses, respiratory therapists, and patient care attendants. The emergency department physician may choose to activate the trauma team at the time of pre-hospital notification of an incoming trauma or decide to firstly assess the patient themselves and determine whether the patient meets TTA or trauma consult (partial team called on a non-emergent basis) criteria after their evaluation.

Data Sources and Sample

Data were collected from the electronic medical files and the local trauma registry. A de-identified list of primary ambulance transports initiated from the Monteregie region between January 1, 2018 and December 31, 2020, were received from the local health authority (*Centre*

intégré de santé et de services sociaux (CISSS) Montérégie-Centre). This list included transport dates and times along with transport codes. We excluded non-urgent transports defined as patients with an EQTPT level >3 as these patients would not require high-priority transportation. We also excluded those patients transported before the official implementation of the EQTPT protocol. From this list, emergency department arrival times were searched identifying patients meeting our inclusion criteria - all major trauma patients (EQTPT levels 1, 2, and 3) aged ≥16 years who originated in the CISSS Monteregie region and bypassed community hospitals to be transported directly to the Level 1 trauma centre. We subsequently excluded those in which the timing of the TTA was unable to be determined and those with any individual missing data points from statistical analysis.

Data Collection and Analysis

A standardized data collection form was created and used to document patient demographics, pre-hospital transport times, mechanism of injury, pre-hospital triage level, triage criteria met, final disposition, along with time spent in the resuscitation room, time from arrival to CT scan, time until disposition decision, and total length of stay in the emergency department. These data were then inputted into an Excel spreadsheet and a second trained reviewer verified 25% of the medical records to ensure accuracy. We classified and grouped subjects by the timing of TTA as (1) no trauma team involvement, (2) TTA after arrival in the emergency department, (3) TTA with pre-hospital notification, (4) receiving a trauma consult only.

Descriptive statistics were used to assess patient characteristics and other quality indicators selected for analysis, including time spent in the resuscitation room, time from arrival until CT scan, length of time from arrival to decision of the final disposition, and total length of stay in the emergency department.(1) Continuous variables are presented as means with standard deviations

and categorical variables as counts and percentages. TTA activation subgroups were compared using the Kruskal-Wallis test and 95% confidence intervals were calculated. We considered *p* values <0.05 as statistically significant. Nonparametric statistical tests were selected due to non-normal data distributions with a negative skew, despite data cleaning. We used SPSS version 28 for statistical analysis.(10)

A priori, we planned to separate the sample and conduct the same analysis including only those subjects who met EQTPT level 1 criteria (GCS <14 or SBP <90, RR <10 or RR >29, or requiring ventilation) as this group would represent the most severely injured with the least variability in the patient population. The same quality indicators were compared for those meeting EQTPT level 1 criteria and had a 1) TTA with pre-hospital notification or 2) TTA after arrival in the emergency department. These groups were compared using the independent samples Mann-Whitney U test using a 95% confidence interval with p <0.05 considered statistically significant.

We calculated the starting time point as the time point recorded on pre-hospital documents for arrival to the emergency department site to avoid time discrepancies associated with any delays from arrival to triage from emergency department personnel. Time in the resuscitation room was determined from documentation in nursing notes of the patient leaving the resuscitation room or from the timestamp of the patient's location change in the electronic medical record. The time for CT scan was determined from the automatic timestamp for the first CT scan in the electronic medical record. Time of disposition was determined by the automatic timestamp applied when the request for admission, transfer, or discharge was registered in the electronic medical record. The total length of stay was determined by departure time recorded in the electronic medical record. For those who died in the emergency department, disposition time,

and end of the length of stay were recorded as the time of death. Ethical approval was obtained by the X Research Ethics Board (file number 24272) and the Y Research Ethics Board (2021-7693).

RESULTS

During the study period, 2,148 patients were transported directly to the Level 1 trauma centre from the CISSS Monteregie region, of which 477 were high-priority transports. Of these, 14 patients were excluded for being from transports that occurred before the implementation of the trauma triage protocol. A total of 371 individual patients were found to meet inclusion criteria and were reviewed; 33 patients were subsequently excluded from statistical analysis as the timing of TTA was undetermined. Sample characteristics are depicted in **Table 1**. Subjects were primarily male (70.1%) with a mean age of 47 years (range 16-96). Motor vehicle crashes (n=185, 49.9%) were the primary source of injury followed by falls (n=91, 24.5%), and penetrating trauma (n=41, 11.1%).

TTA was done for 63.3% (n=214) of patients; of these 121 patients had pre-hospital notification (35.8%), 60 patients had a TTA after arrival in the emergency department (17.8%), and 68 patients (20.1%) had a trauma consult without a trauma team activation. There were 89 patients (26.3%) who did not have any involvement with the trauma team during their stay in the emergency department. A total of 241 patients (65%) met EQTPT level 1 criteria, while 114 patients (30.7%) met level 2 criteria and 16 (4.3%) met level 3 criteria.

Mean times in the resuscitation room ranged from 0:45-0:51 minutes (p=0.147), while mean time to CT scan ranged from 1:02-1:21 minutes (p=0.023). Mean times from arrival to disposition were statistically significant and ranged from 6:37-13:41 minutes (p<0.001) and mean total length of stay ranged from 9:22-23:16 minutes (p<0.001). Mean times in all

categories were found to be shortest for those who had a full TTA with pre-hospital notification and longest for those who had a trauma consult without TTA. Mean time intervals are represented in **Table 2**.

For those patients meeting EQTPT level 1 field triage criteria, when the trauma team was activated with pre-hospital notification as compared to activation on arrival in the emergency department, there were statistically significant decreases in mean time spent in the resuscitation room (0:49 to 0:44 minutes, p=0.039) and mean time to CT scan (1:11 to 1:00 minutes, p=0.005). While not statistically significant, time to disposition increased from 5:07 to 6:29 minutes (p=0.912), and the total length of stay increased from 7:23 to 8:35 minutes (p=0.654).

DISCUSSION

In this single-site retrospective review of administrative data including 371 individual patients, we found that the time to CT scan was shorter when a full TTA was done. Patients who had a TTA with pre-hospital notification were found to have the fastest time from arrival to CT scan. The time from arrival to disposition decision and total length of stay was shortest for those with a full TTA. Time spent in the resuscitation room did not vary significantly between groups. When directly comparing those who had a pre-hospital TTA to those who had a TTA after arrival in emergency department, time spent in resuscitation, time to disposition, and length of stay did not vary significantly. However, the time from arrival until CT scan was found to be shorter when TTA was done before the emergency department arrival of the patient.

Reasons for under-triage and poor TTA compliance have been reported and primarily attributed to subjective TTA criteria, different triage rates based on professional experience, unclear roles and responsibilities of the trauma team, and the emergency department physicians feeling comfortable managing the injuries without the trauma team.(11) Given our extensive

trauma care experience, we speculated that hesitancy to launch a TTA before arrival to the emergency department using only information acquired from the pre-hospital notification, was due to the assumption that the trauma team could be quickly involved after the initial assessment if required. We also considered the perception that the patient would spend longer in the resuscitation room if the trauma team were called to assess the patient and would have a longer length of stay in the emergency department. As the emergency department physician is responsible for supervising the trauma team members until the trauma team leader arrives in the emergency department, decreasing the time that the emergency department physician spends in the resuscitation room is of interest as it allows for more time to manage other patients in the emergency department. In a crowded emergency department, significant time in the resuscitation room with one patient impacts patient flow within all areas of the department. Citizens utilizing the emergency department have a right to access timely assessment and management of their care.(12)

The six domains of health care quality described by the Institute of Medicine aim to provide safe, effective, patient-centred, timely, efficient and equitable care.(13) Assuring timely care involves monitoring the time it takes for clinicians to assess a patient. Patients requiring admission ought to be promptly moved to inpatient units thereby reducing the total length of stay in the emergency department.(12) Involving the trauma team allows the specialized team to focus on the care of the major trauma patient and allows the emergency department physician to focus on the other patients under their care. The American College of Surgeons requires the trauma team leader to be present in the emergency department within 15 minutes of the patient's arrival.(9) By activating the trauma team based on information provided in the pre-hospital notification, which in the trauma centre studied is frequently more than 10 minutes before the

arrival of the patient to the emergency department, the trauma team leader has adequate time to arrive prior to patient arrival thus liberating the emergency department physician to provide other care. Fundamental priorities in emergency medicine include access to critical care when the patient's condition requires and early access to care from specialists.(12) When the trauma team is activated pre-hospital and involved upon patient arrival in the emergency department, the trauma team is able to efficiently organize and evaluate all aspects of care (i.e., specialist referral) as required.

Timely care also involves access to services for those with conditions requiring immediate interventions and treatment requires appropriate access to diagnostic services in the emergency department.(12). Access to CT scan for the trauma patient is a rate-limiting step for those not profoundly hemodynamically unstable requiring immediate surgery. TTA gives the patient priority access to CT scans allowing the trauma team to rapidly diagnose injuries requiring urgent intervention. The benchmark goal for Quebec emergency departments is to have a CT scan of the head, for patients with evidence of traumatic brain injury, within 1 hour of arrival in the emergency department.(1) In a recent study, a CT scan of the head done within the first hour after arrival was defined as an "immediate" CT head, and a CT of the head done within 1-6 hours was considered "delayed". Those who had an immediate CT of the head were found to have shorter times to interventions, such as a craniotomy or intracranial pressure monitor insertion, and shorter lengths of stay in the emergency department.(14) Identifying solid organ injury on CT scan is essential to establish the need for angioembolization. Delays to angioembolization for those patients with solid organ injury have been found to have an increase in 24-hour mortality rates.(15) For patients with pelvic fractures requiring angioembolization, longer times to treatment was also associated with increased in-hospital mortality, with rates rising for each hour

of delay.(16) The length of time from arrival until CT scan ranged from 0:14 minutes to 5:35 hours. The mean time for all groups was >1 hour, with the shortest mean time being 1:02 hours for the group with a pre-hospital TTA. The coordinated care from the entire trauma team being present from the arrival of the patient combined with the CT scan being reserved for major trauma patients once a TTA is called aids in decreasing the time from arrival until CT scan.

Multiple process indicators in use for quality of care evaluation are based on maximum delays from arrival to interventions, including the length of stay in the emergency department of <4 hours and stabilizing pelvic fractures within 3 hours of arrival in the emergency department.(1) Many reasons could be attributed to the significant increase in length of stay for those who had a trauma consult without a TTA. These patients are typically not as acutely injured but still may have substantial injuries. They do not usually require emergent surgery or intervention but require additional care. Those who have no injuries requiring a trauma team consult can be discharged home more quickly, leaving the patients who had a trauma team consult needing more time to establish a care plan.

Limitations

As with most retrospective studies, the accuracy of information gathered is dependent on the accuracy of the information available in the medical records. Incomplete documentation resulted in the inability to establish the timing of trauma team involvement for a portion of the charts reviewed. As most chart data are in narrative form, data collected from documentation pertinent to this study may be subject to interpretation by the reviewer. A second trained reviewer verified information collected in the initial medical record review to ensure accuracy.(17) Conflicting times in the resuscitation room were noted between the documented

times in nursing notes and timestamps in electronic medical records. When the time was recorded in nursing notes, this time was selected for use in the analysis.

CONCLUSION

When trauma team care is required, early involvement of the trauma team through pre-hospital TTA significantly decreases time to CT scan, time spent in the emergency department without a disposition and overall emergency department length of stay. Early TTA improves performance indicators used to evaluate the quality of care in the emergency department. This research suggests that when minutes count, pre-hospital TTA should be considered the standard of care for all major trauma patients meeting TTA criteria.

ACKNOWLEDGEMENTS

We want to thank Dr. Dave Ross (CISSS Monteregie) for his collaboration, medical students Ranuka Sivanathan and Nour Seulami for assistance in data verification, and Natasha Dupuis for her advice and support through this project.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. Specific author contributions are as follows: study concept and design: JB; data acquisition and preparation: JB; data analysis and interpretation: JB, JKS, GC, JG, KL; first draft of the manuscript: JB. All authors critically reviewed the manuscript for important intellectual content and approved the final version to be published.

REFERENCES

1. Lorthios-Guilledroit A. Mise à jour des indicateurs de qualité et de performance en traumatologie (clientèle adulte) 2020:[88 p.]. Available from: https://www.inesss.qc.ca/fileadmin/doc/INESSS/Rapports/Traumatologie/INESSS_IQ_Trauma_GN.pdf.

2. Wandling MW, Cotton BA. Prehospital care is critical to improving outcomes after major trauma. *The British Journal Surgery*. 2020;107(4):329-31.

3. Jelinek L, Fahje C, Immermann C, Elsbernd T. The trauma report nurse: a trauma triage process improvement project. *Journal Emergency Nursing*. 2014;40(5):e111-7.

4. Frieden TR, Jaffe, H.W., Stephens J.W., Thacker, S.B., Zaza, S. Guielines for field triage of injured patients. *Centers for Disease Control and Prevention Mobidity and Motrality Weekly Report*. 2012;61(1):21.

5. McCullough AL, Haycock JC, Forward DP, Moran CG, Howell SJ. Early management of the severely injured major trauma patient. *British Journal of Anaesthesia*. 2014;113(2):234-41.

6. Tignanelli CJ, Vander Kolk WE, Mikhail JN, Delano MJ, Hemmila MR. Noncompliance with American College of Surgeons Committee on Trauma recommended criteria for full trauma team activation is associated with undertriage deaths. *Journal Trauma Acute Care Surgery*. 2018;84(2):287-94.

7. Échelle québécoise de triage préhospitalier en traumatologie Quebec2016 [Available from: https://www.inesss.qc.ca/fileadmin/doc/INESSS/FECST/Publications/EQTPT/Echelle-triage-prehospitalier-SEPT-2016.pdf.

8. Yoder A, Bradburn EH, Morgan ME, Vernon TM, Bresz KE, Gross BW, et al. An analysis of overtriage and undertriage by advanced life support transport in a mature trauma system. *Journal Trauma Acute Care Surgery*. 2020;88(5):704-9.

9. Schwing L, Faulkner TD, Bucaro P, Herzing K, Meagher DP, Pence J. Trauma team activation: Accuracy of triage when minutes count: A synthesis of literature and performance improvement process. *Journal Trauma Nursing*. 2019;26(4):208-14.

10. IBM. IBM SPSS Statistics for Macintosh. 26.0 ed. Armonk, NY: IBM Corp.; 2019.

11. Verhoeff K, Saybel R, Fawcett V, Tsang B, Mathura P, Widder S. A quality-improvement approach to effective trauma team activation. *Canadian Journal Surgery*. 2019;62(5):305-14.

12. Hansen K, Truesdale, M., Boyle, A., Holroyd, B., Phillips, G., Benger, J., Chartier, L., Lecky, F., Webb, E., Vaillancourt, S., Cameron, P., Waligora, G., Kurland, L. An updated framework on quality and safety in emergency medicine. West Melbourne, Australia: I*nternational Federation for Emergency Medicine*; 2019. Available from: https://www.ifem.cc/wp-content/uploads/2019/05/An-Updated-Framework-on-Quality-and-Safety-in-Emergency-Medicine-January-2019.pdf.

13. Six Domains of Health Care Quality Rockville, MD: *Agency for Healthcare Research and Quality*; 2018 [Available from: https://www.ahrq.gov/talkingquality/measures/six-domains.html.

14. Schellenberg M, Benjamin E, Owattanapanich N, Inaba K, Demetriades D. The impact of delayed time to first CT head in traumatic brain injury. *European Journal Trauma Emergency Surgery*. 2021;47(5):1511-6.

15. Chehab M, Afaneh A, Bible L, Castanon L, Hanna K, Ditillo M, et al. Angioembolization in intra-abdominal solid organ injury: Does delay in angioembolization affect outcomes? *Journal Trauma Acute Care Surgery*. 2020;89(4):723-9.

16. Matsushima K, Piccinini A, Schellenberg M, Cheng V, Heindel P, Strumwasser A, et al. Effect of door-to-angioembolization time on mortality in pelvic fracture: Every hour of delay counts. *Journal Trauma Acute Care Surgery*. 2018;84(5):685-92.

17. Kaji AH, Schriger D, Green S. Looking through the retrospectoscope: reducing bias in emergency medicine chart review studies. *Annals Emergency Medicine*. 2014;64(3):292-8.

Table 1

Sample Characteristics

	Total *n* (%)	**TTA PH notification *n* (%)**	**TTA after arrival *n* (%)**	**Trauma consult alone *n* (%)**	**No trauma team *n* (%)**
Total	**338 (100)**	**121 (35.8)**	**60 (17.8)**	**68 (20.1)**	**89 (26.3)**
Sex					
Male	260 (70.1)	89 (37.7)	45 (19.1)	46 (19.5)	56 (23.7)
Female	111 (29.9)	32 (32.4)	15 (14.7)	22 (21.6)	33 (32.4)
Age Category (years)					
16-34	124 (36.7)	48 (38.7)	25 (20.2)	22 (17.7)	29 (23.4)
35-54	100 (29.6)	37 (37.0)	14 (14.0)	24 (24.0)	25 (25.0)
55-74	73 (21.6)	24 (32.9)	13 (17.8)	13 (17.8)	23 (29.3)
75+	42 (12.1)	12 (29.3)	8 (19.5)	9 (22.0)	12 (29.3)
Mean age (*SD*)	46.6 (20.7)	45.8 (20.1)	45.7 (20.8)	46.4 (20.1)	48.9 (22.5)
Age range (years)	16-96	16-96	17-91	16-93	17-96
Mechanism of Injury					
Motor vehicle crash	168 (49.7)	72 (42.9)	33 (19.6)	36 (21.4)	27 (16.1)
Fall	90 (26.6)	19 (21.1)	16 (17.8)	20 (22.2)	35 (38.9)
Penetrating	33 (9.8)	20 (60.6)	4 (12.1)	3 (9.1)	6 (18.2)
Pedestrian	10 (3.0)	3 (30.0)	3 (30.0)	0 (0)	4 (40.0)
Cyclist	13 (3.8)	4 (30.8)	2 (15.4)	5 (38.4)	2 (15.4
Crush	13 (3.5)	2 (15.4)	2 (15.4)	1 (7.7)	8 (61.5)
Assault	9 (2.7)	0 (0)	0 (0)	3 (33.3)	6 (66.7)
Other	2 (0.6)	1 (50.0)	0 (0)	0 (0)	1 (50.0)

Note. TTA (trauma team activation), *SD* (standard deviation)

No significant difference in sex for timing of TTA using the chi-square test, statistical significance level $p<0.05$.

Distribution of age is the same across categories using the Independent-Samples Kruskal Wallis test, statistical significance level $p<0.05$.

Table 2

Emergency Department Times and Timing of Trauma Team Involvement

Timing in Relation to TTA		**Total *n* (%)**	**Mean time (minutes) (SD)**	***p* value***
Time in Resuscitation Room	No TTA	81 (21.6)	0:45 (0:28)	0.147
	TTA after arrival	53 (14.2)	0:49 (0:26)	
	TTA Pre-Hospital notification	107 (28.8)	0:45 (0:27)	
	Trauma consult only	60 (16.2)	0:51 (0:32)	
	Total	301	0:47 (0:28)	
	Missing	70 (18.9)		
Time from arrival to CT scan	No TTA	83 (22.3)	1:17 (0:52)	0.023
	TTA after arrival	55 (14.8)	1:10 (0:32)	
	TTA Pre-Hospital notification	103 (27.8)	1:02 (0:25)	
	Trauma consult only	66 (17.8)	1:21 (0:43)	
	Total	307	1:11 (0:40)	
	Missing	64 (17.2)		
Time from arrival to disposition	No TTA	88 (23.7)	9:28 (7:35)	<0.001
	TTA after arrival	59 (15.9)	6:49 (7:33)	
	TTA Pre-Hospital notification	120 (32.3)	6:37 (8:40)	
	Trauma consult only	67 (18.1)	13:41 (15:58)	
	Total	334	8:49 (10:28)	
	Missing	35 (9.4)		
Total length of stay in emergency department	No TTA	87 (23.5)	12:37 (12:19)	<0.001
	TTA after arrival	60 (16.2)	10:36 (17:26)	
	TTA Pre-Hospital notification	120 (32.3)	9:22 (13:51)	
	Trauma consult only	68 (18.3)	23:16 (23:53)	
	Total	335	14:16 (18:05)	
	Missing	36 (9.7)		

Note. TTA (trauma team activation), PH (pre-hospital), *SD* (standard deviation)
*Independent-Samples Kruskal-Wallis test, statistical significance level $p<0.05$

Table 3

Emergency Department Quality Indicators for EQTPT Level 1 Traumas and Timing of Trauma Team Activation

Timing in Relation to TTA		***n* (%)**	**Mean time (minutes) (SD)****	***p* value***
Time in resuscitation room	TTA after arrival	33 (25.0)	0:49 (0:19)	0.374
	TTA pre-hospital notification	81 (61.4)	0:44 (0:29)	
	Missing	18		
Time to CT scan	TTA after arrival	36 (27.3)	1:11 (0:27)	0.022
	TTA pre-hospital notification	80 (60.6)	1:00 (0:22)	
	Missing	16		
Time from arrival to disposition	TTA after arrival	38 (28.8)	5:07 (6:31)	0.400
	TTA pre-hospital notification	92 (69.7)	6:29 (9:05)	
	Missing	2		
Total length of stay in ED	TTA after arrival	39 (29.5)	7:23 (12:58)	0.620
	TTA pre-hospital notification	92 (69.7)	8:35 (12:19)	
	Missing	1		

Note. TTA (trauma team activation), ED (emergency department)
*Independent samples Mann-Whitney U test, statistical significance level $p<0.05$
** time presented as hours:minutes

2.0 Manuscript 2: Accuracy of the Quebec Pre-Hospital Triage Scale (EQTPT) in Predicting the Need for Trauma Team Activation: A Retrospective Administrative Data Study

Submitted to the *Journal of Trauma and Acute Care Surgery* as an *Original Research* article

Jeanesse Bourgeois, BSc(N)
McGill University Health Centre
Jeanesse.Bourgeois@muhc.mcgill.ca

Greg Clark, MD
McGill University Health Centre
Greg.Clark.med@ssss.gouv.qc.ca

J. Scott Delaney, MD
McGill University Health Centre
jscott.delaney@mcgill.ca

Jeremy Grushka, MD
McGill University Health Centre
jeremy.grushka@mcgill.ca

Kimberley Lamarche, DNP
Faculty of Health Disciplines, Athabasca University
lamarche@athabascau.ca

Jennifer A. Knopp-Sihota, PhD
Faculty of Health Disciplines, Athabasca University
jknopp@athabascau.ca

ABSTRACT

Background: Trauma team activation at a Level 1 trauma centre In Quebec, Canada, is primarily at the emergency department's staff discretion. Trauma teams may be activated prehospital, based on information provided by field paramedics or in the emergency department based on the patient's condition on arrival. In this study, we examined over and undertriage rates based on present trauma team activation criteria. We also examined if trauma team activation, for those patients solely meeting pre-hospital major trauma criteria, would result in significant overactivation of the trauma team.

Methods: This is a single-centre retrospective medical record review. Primary ambulance transport reports from May 15, 2018 to December 31, 2020, were screened to identify patients aged ≥16 years who met pre-hospital trauma triage criteria to bypass community hospitals to arrive directly at the Level 1 trauma centre. We examined pre-hospital triage criteria, trauma team involvement, Injury Severity Scores (ISS) and final disposition. Patients were evaluated for over and undertriage and rates were compared to the rates assuming all patients were to have a trauma team activation. We considered patients overtriaged if they had a full trauma team activation but had an ISS <12 and were discharged from the emergency department. Undertriage was defined as any patient with an ISS ≥12 and did not have a trauma team activation.

Results: Of the 371 patients who met study inclusion criteria, 123 (33.3%) did not meet trauma team activation criteria, while 214 (57.7%) had a trauma team activation. Of these, 49 patients (13.2%) were undertriaged and 31 patients (8.4%) were overtriaged and 25.8% of the major trauma patients (ISS ≥ 12) were undertriaged. A trauma team activation for all meeting field triage criteria increased overtriage to 25.3% and brought undertriage rates to 0%, with statistically significant differences based on the Wilcoxon signed ranks test ($p<0.05$).

Conclusions: In this study, undertriage rates were well above 5%. Trauma team activation, based on local field trauma triage criteria adapted from the CDC-ACSCOT field triage criteria, eliminates undertriage and keeps overtriage rates below 35%. This research suggests that field triage criteria accurately predict major trauma and the need for the involvement of the trauma team and that the condition of the trauma patient in the pre-hospital setting is accurately predicting the need for advanced trauma care.

BACKGROUND

Trauma team activation (TTA) mobilizes a multidisciplinary team of physicians, surgeons, nurses, respiratory therapists, operating room personnel, radiology, and blood bank staff to provide urgent care for major trauma patients. While the primary response of the TTA is within the emergency department, the outcome of the TTA impacts other areas of the hospital. Inappropriately triaged patients resulting in unnecessary TTA, impacts multiple departments when personnel caring for other patients must pause or stop their current activities to receive the new trauma patient in the emergency department.(9)

The American College of Surgeons (ACS) recommends full TTA based on physical signs and symptoms known to be associated with higher rates of morbidity and mortality. These TTA criteria, known as the American College of Surgeons-6 (ACS-6), include: systolic blood pressure <90mmHg; penetrating trauma to the head, neck, chest, abdomen, or proximal extremities; a Glasgow Coma Scale score (GCS) <9; blood products being required to maintain vital signs; the need for airway management; or at the emergency department physician's discretion.(6) Institution-specific TTA criteria, to accommodate specific populations and available resources, are developed at the institution's discretion.(11) Field triage guidelines to bypass non-trauma hospitals include: physiological criteria (e.g., GCS, systolic blood pressure, respiratory rate), anatomical factors (e.g., penetrating injuries to the head, neck, and torso, chest wall instability, crushed extremities, etc.), mechanism of injury (e.g., falls from >6 meters, high-velocity motorcycle crashes, cyclists or pedestrians hit by automobiles with significant impact, etc.), and factors specific to certain patient groups (e.g., age, pregnant females, those with bleeding disorders or who take anticoagulants, etc.).(8)

Accreditation Canada criteria require a TTA compliance rate of ≥90% when monitored on audits.(11) The American College of Surgeons suggests that the rate of overtriage should be <25-35%, while the rate of undertriage should not be >5%.(18) While overtriage impacts resource use within the institution, undertriage results in a delay to definitive care and is associated with adverse events and death.(6) When institutions select TTA criteria, over and undertriage rates are considered when deciding if specific TTA criteria should.(9)

The trauma system in the province of Quebec, Canada is unique in comparison to most trauma systems in North America. Pre-hospital care is provided by primary care paramedics who provide basic life support (BLS), and hospital transfer is done solely by ground transport. In most areas in Canada and the USA, advanced care paramedics (ALS paramedics) who are authorized to perform procedures including endotracheal intubation and administer intravenous medications, dominate pre-hospital care. Primary care paramedics in Quebec use non-invasive techniques and provide basic monitoring and care during transport.(8) With the exception of geographically remote medical evacuation, air ambulances are not currently available in the province of Quebec. Paramedics use the "*Échelle québécoise de triage préhospitalier en traumatologie*" (EQTPT), a pre-hospital trauma triage protocol based on the Center for Disease Control – American College of Surgeons Committee on Trauma (CDC-ACSCOT), pre-hospital trauma triage guidelines.(7) In this protocol, trauma patients who meet EQTPT levels 1-2 and are ≤60-minutes transport time from a Level 1 trauma centre, will bypass Level 2 trauma centers or community hospitals and be transported directly to a Level 1 trauma centre. While patients meeting EQTPT level 3 criteria will bypass non-trauma hospitals, they may be dispatched to a lower-level trauma hospital if located closer to a Level 1 trauma center.

Definitions of trauma team overtriage and undertriage are inconsistent and vary within the literature.(6) Factors known to negatively influence timely TTA include borderline systolic blood pressures near 90mmHg or borderline GCS scores of 8-14, and failures in judgement of medical staff responsible for TTA.(6) Pre-hospital transport criteria are more plentiful than those criteria used for the initiation of a TTA, and while a patient may meet the EQTPT or CDC-ACSCOT pre-hospital trauma triage guidelines, they may still not meet TTA criteria including the ACS-6 that are in use Quebec emergency departments. In this study, we aimed to examine baseline over and undertriage rates for a population of patients who met EQTPT pre-hospital trauma triage criteria levels 1-3 transported to a Level 1 trauma centre. We evaluated if overtriage rates were above acceptable levels if the trauma team is activated for all patients meeting EQTPT criteria to be transported directly to a Level 1 trauma center. We also evaluated which of the field triage criteria patients met who were found to be undertriaged in the emergency department.

METHODS

Study Design

This was a single-site retrospective medical record review of all patients aged ≥16 years who sustained a traumatic injury and met the EQTPT pre-hospital triage criteria to bypass community hospitals and be transported directly to a Level 1 trauma centre between May 15, 2018 and December 31, 2020.

Setting

This study was conducted at one of three Level 1 trauma centers in the province of Quebec. This trauma centre services a geographic area that spans the southern half of the island of Montreal and the south shore Monteregie region and is the referral center for the northern

regions of Quebec. Serving approximately 2.9 million people, the emergency department sees on average 10,000 trauma patients per year, with 1,600 being major trauma patients.

In this centre, TTA criteria include the ACS-6 criteria on patient arrival in the emergency department, along with the addition of TTA for those patients with a mangled or amputated extremity, acute paralysis, and burns to >20% of the body surface. The vital signs TTA criteria (systolic blood pressure <90mmHg and a GCS <9) are based on those of the trauma patient on arrival in the emergency department, regardless of pre-hospital vital signs, unless the physician used their discretion for TTA based on the pre-hospital notification. Nurse-initiated TTA is reserved for four TTA criteria comprising; penetrating injury to the head, neck or trunk, crush or amputation above the wrist/ankle, paralysis in the context of a significant mechanism, and burns to >20% of the body surface area. It is only when one of these four TTA criteria are met (based on the pre-hospital report), that the nurse can initiate a TTA without physician consultation.

Data Sources and Sample

Data were collected from electronic medical records and the local trauma registry database. A de-identified list of primary ambulance transports initiated from the Monteregie region between January 1, 2018 and December 31, 2020, was received from the local health authority (*Centre intégré de santé et de services sociaux (CISSS) Montérégie-Centre*). This list was then sorted to include only high-priority transports for major trauma (EQTPT level ≤3) of patients aged ≥16 years. Using emergency department arrival times, we linked these data to identify the specific patient hospital identifier associated with the ambulance transport. We then accessed electronic medical records to abstract data pertinent to the study. From the local trauma registry, we obtained the Injury Severity Score (ISS) for all included patients who were either admitted to the hospital or who had died in the ED. For those patients discharged from the emergency

department, ISS scores are not routinely collected; for these patients, the ISS was calculated by the principal investigator and confirmed by a second investigator.

Data Collection & Analysis

A standardized data collection tool was created and used to collect patient level data including, pre-hospital transport times, vital signs pre-hospital and on arrival in the emergency department, EQTPT triage level, EQTPT criteria met, TTA criteria met, trauma team involvement, ISS, and patient's final disposition. These data were then inputted into an Excel spreadsheet and a second trained reviewer verified 25% of these data to ensure accuracy.

Patients were classified as over or undertriaged based on current practice, if the TTA compliance rate were to be 100% using present TTA criteria and compared to the overtriage rates if all were to have a TTA based on meeting EQTPT levels 1, 2, and 3 criteria. An ISS of <12 was used as the cut-off for major trauma as per local regulating bodies.(1) We considered, a patient *undertriaged* if they had an ISS ≥12 and did not have a TTA. Patients with a TTA and an ISS <12 that were discharged home from the emergency department, were classified as *overtriaged*. A patient with an ISS <12 that was not discharged home from the hospital was considered appropriately triaged. When evaluating the TTA criteria met, “need for airway management,” was selected for those with a GCS <9 or who required intubation in the emergency department. When multiple TTA criteria were present, the highest priority in the advanced trauma life support (ATLS) algorithm (airway, breathing, circulation, disability) was recorded. Patients were divided into subgroups based on ISS and undertriage rates were evaluated for major traumas. The EQTPT criteria met by all major trauma patients who were found to be undertriaged were further evaluated.

We created subgroups based on EQTPT triage levels 1, 2, and 3, and over and undertriage rates were examined for each subgroup and presented as counts and percentages. The changes in over and undertriage rates were evaluated for statistical significance using the Wilcoxon signed-rank test and 95% confidence intervals were calculated. We considered p values <0.05 as statistically significant. Nonparametric statistical tests were selected due to non-normal data distributions with a negative skew, despite data cleaning. We used SPSS version 28(10) for all statistical analyses.

RESULTS

There were 2,148 primary transports from the region to the Level 1 trauma center; 477 were high priority transports. Of the 477 high-priority transports, 385 were trauma patients. As the EQTPT protocol was officially implemented on May 15, 2018, 14 patients were excluded from transports that occurred before this date and implementation of the protocol. A total of 371 patients were retained for analysis. Sample characteristics are presented in **Table 1.** The sample population was predominantly male (70.1%) with a mean age of 46.6 years (range 16-96 years). The primary mechanism of injury was motor vehicle crashes (49.9%), followed by falls (24.5%) and penetrating trauma (11.1%). Most patients met EQTPT level 1 criteria (*n*=241, 65.0%), while 114 (30.7%) met level 2 criteria and 16 (4.3%) met level 3 criteria (**Table 2**).

While all patients met field triage criteria for major trauma, 123 (33.2%) did not meet the TTA criteria presently in use in the emergency department. The primary TTA criteria met (**Table 3**) were “need for airway management” (*n*=132, 35.6%), followed by “systolic blood pressure <90” (*n*=51, 13.7%) and “penetrating injury to head, neck, or torso” (*n*=36, 9.7%). TTA at the discretion of the emergency department physician occurred in 37 (10%) patients as they did not

meet any other TTA criteria. Of those who met TTA criteria, 49/248 (19.7%) were found to have an ISS <12 and were discharged from the emergency department.

Of the 371 medical records reviewed, 107 patients (28.8%) were discharged home from the emergency department, 80 patients (21.6%) were admitted to the intensive care unit, 80 patients (21.6%) went directly from the emergency department to the operating room, 80 patients (21.6%) were admitted to an in-patient unit, 16 patients (4.3%) were transferred to another institution, and 8 patients (2.2%) died in the emergency department. Of those who met EQTPT level 1 criteria, 61 patients (25.3%) were discharged home from the emergency department, while 73 patients (30.3%) were admitted to the intensive care unit. Based on ISS, 131 patients (35.3%) were considered to have had a "minor" trauma (ISS<9). Of these, 83 patients (63.4%) were discharged home from the emergency department. Of these "minor" traumas, 12 patients (9.2%) were admitted to the intensive care unit, 5 patients (3.8%) went directly to the operating room, and 24 patients (18.2%) required admission to a hospital in-patient unit (**Table 4**).

A total of 190 patients were found to have an ISS ≥12 (major or profound trauma). The trauma team was not activated in 49 patients (25.8%) with ISS ≥12 and as such were classified as undertriaged (**Table 5**). Of the patients with an ISS ≥12, 45 patients (23.7%) did not meet any TTA criteria, yet 20 of these patients had a TTA based on the emergency department physician's discretion. Of the 49 patients with an ISS ≥12 who were undertriaged, 11 required airway management, 1 needed blood products during the resuscitation, 5 patients had paralysis, and 7 patients had a systolic blood pressure <90 (**Table 3**). For those with an ISS of 12-25 indicating major trauma, 28 patients (31.4%) were considered undertriaged and did not have a TTA in the emergency department. The undertriage rate for profound trauma patients with an ISS of 26-75 was 20.8% as 21 of these patients did not have a TTA (**Table 5**). For those undertriaged patients,

the EQTPT criteria met most frequently was a GCS <14 (*n*=22, 44.9%) followed by a SBP <90mmHg (*n*=6, 12.2%), respiratory compromise (*n*=5, 10.2%), and acute paralysis (*n*=5, 10.2%) (**Table 5**).

Of those who were undertriaged, 67.3% (*n*=34) met EQTPT level 1 criteria, 24.5% (*n*=12) met EQTPT level 2 criteria and 6.1% (*n*=3) met EQTPT level 3 criteria. Overtriage of the trauma team occurred in 8.4% (*n*=31) of the cases (**Table 6**). Of the 241 patients meeting EQTPT level 1 criteria, 8.3% (*n*=20) were overtriaged, and 14.1% (*n*=34) were undertriaged. A total of 10 (8.8%) of patients meeting EQTPT level 2 criteria were overtriaged, and 12 (10.5%) were undertriaged. Patients meeting EQTPT level 3 criteria only accounted for 16/371 (4.3%) of the patients in this study. Of those meeting level 3 criteria, one patient (6.3%) was overtriaged and 3 patients (18.8%) were undertriaged. Overtriage rates for each individual EQTPT criteria within each level are depicted in **Table 2**. "Need for airway management" (*n*=10, 7.6%) was the TTA criteria most frequently met for those who were found to be overtriaged, followed by penetrating injuries (*n*=9, 25%), discretion of the emergency department physician (*n*=8), systolic BP <90mmgh (*n*=3), and paralysis (*n*=1). Discretion of the emergency department physician was the reason for TTA in 37 cases with 8/37 (21.6%) resulting in overtriage and 29/37 (78.4%) being an accurate triage of the trauma team (**Table 3**). If all patients in this study were to have had a TTA, 49/94 (51.2%) overtriaged patients would also meet present TTA criteria. Of these patients, 17 required the need for airway management, 17 had a systolic blood pressure <90mmHg, 12 had a penetrating injury, and 3 had paralysis when they presented to the emergency department.

By automatically activating all patients meeting field triage for major trauma, statistically significant changes were noted, with overtriage increasing from 8.4% to 25.3% ($p<0.001$) and undertriage decreasing from 13.2% to 0% ($p<0.001$). For those meeting the EQTPT level 1

criteria, automatic TTA would increase the overtriage rate from 8.4% to 21.2%. The overtriage rate for level 2 traumas rose from 8.8% to 31.6% and 6.3% to 43.8% for those meeting level 3 criteria. All changes in over and undertriage rates were statistically significant difference using Wilcoxon signed-ranks test, $p<0.05$.

DISCUSSION

This study examined the over and undertriage rates with the present TTA criteria in use at the emergency department of a Level 1 trauma center and compared this to the over and undertriage rates if the trauma team were to be activated for all patients meeting pre-hospital major trauma triage criteria. This study also compared the accuracy of predicting major trauma of the EQTPT pre-hospital trauma triage criteria which are based on the CDC-ACSCOT pre-hospital triage guidelines in comparison to present TTA criteria, which includes the ACS-6, that is in use in the host ED.

In this study, we found that 8.4% of patients who met pre-hospital criteria to go to a trauma center during the study period were overtriaged for TTA in the emergency department, and 13.2% of patients were undertriaged. The undertriage rate in this study is well above the acceptable rate from the American College of Surgeons of 5% while the overtriage rate is far below the acceptable level of 35%. Another quality improvement study carried out in a Canadian trauma center reported an undertriage rate at 41.2% prior to their quality improvement initiative.(11) In this study, TTA compliance rates were evaluated based on their institution's activation criteria, regardless of the patient's ISS. Their interventions to improve TTA compliance included educational sessions along with process changes and regular audits. A similar quality improvement initiative in a pediatric emergency department in the USA reported an inaccurate triage rate (including both over and undertriage) of 27% along with an overly long

delay in the arrival of the trauma team prior to their interventions involving educational activities and policy changes.(9) A systematic review of 21 studies on mis-triage of trauma patients found a vast variability of over and undertriage levels along with large variability in the definitions used for over undertriage. This review found undertriage rates to vary between 1 and 71.9% and overtriage rates to vary between 19 and 79%.(19)

Leaving the decision for TTA to the emergency department physician's discretion is one of the TTA criteria suggested in the ACS-6. It does, however, leave the TTA decision-making to dependant on the emergency department physicians' judgement. Errors in judgement have been reported as a significant contributing factor to medical errors. Experience and training impact the decision-making of the emergency department physician, and failure to activate the trauma team for moderate to severely injured patients, particularly when they have abnormal presentations, is significantly impacted by the physician's past experiences.(20) ACS guidelines and Accreditation Canada allow for an increased overtriage rate in order to keep undertriage rates lower thereby reducing morbidity and mortality (associated with the delay to advanced care). With 33.2% of the patients in this study not meeting any of the TTA criteria in place, the need for accuracy in emergency department physician judgement was required in a large proportion of the cases.

The low level of overtriage of the trauma team observed with a high level of undertriage indicates that the emergency department physician's discretion may not be adequately activating the trauma team to keep undertriage rates below 5%. With almost ¼ of patients with an ISS ≥12 not meeting TTA criteria, even if the compliance rate with the present criteria (excluding emergency department physician's discretion to activate) was 100%, the undertriage rate for all patients in this study would remain over the accepted value and the overtriage rates would

remain low. The actual undertriage rate noted of traumas with an ISS of 12-75 was 25.8% (49/190), while the undertriage rate with 100% compliance in the present TTA criteria which includes the ACS-6 would be 23.7% (*n*=45). Using the EQTPT criteria to activate the trauma team, undertriage rates are eliminated, and overtriage is 25.3% (**Table 6)**. The EQTPT criteria being more comprehensive than the TTA in place in the ED seems to be better predicting severe injury and the need for trauma team involvement in the care of the patients. The emergency department physician's discretion for TTA in the absence of TTA criteria is underestimating the severity of injuries and the need for the care of the trauma team.

While the overtriage rates observed in this study and those calculated assuming 100% TTA criteria compliance are lower than if there was a TTA based on the EQTPT criteria alone, undertriage rates remain above 5% for both the present practice and calculations assuming 100% compliance. Failure to activate the trauma team results in poorer outcomes, increased length of stay in the emergency department, increased time to diagnostic imaging and the operating room and may result in missed injuries.(11) TTA based on all EQTPT level 1 criteria resulted in an overtriage rate <35%. While some of the individual EQTPT level 2 criteria resulted in overtriage >35%, the cumulative overtriage rate was <35%. All level 3 EQTPT criteria resulted in an overtriage rate >35%, however, this was a very small sample size and results should not be generalized to other populations.

Trauma triage audits determining over and undertriage rates on ISS scores alone, is known to have limitations as it accounts for the worst injury in three body regions. Those with multiple significant injuries in only one body region will have a lower ISS score than their injury severity depicts.(21) Single system penetrating traumas and isolated head traumas will often have an ISS associated with minor or moderate trauma, despite the level of advanced care required. Patients

who meet TTA criteria for penetrating trauma were frequently overtriaged on ISS calculations. The need for airway management was often because of a decreased GCS. A GCS <14 was the most frequent EQTPT criteria present on undertriaged patients. The need for airway management was also the most frequent TTA criteria present in overtriaged patients. Intoxication in the context of trauma complicates the assessment of the patient and may impact the physician's discretion in TTA. Clinicians should use caution when disregarding a decreased GCS in the context of an intoxicated trauma patient. A recent study found 30.4% of intoxicated head trauma patients had acute traumatic head injuries.(22) An ISS calculation is done after all injuries are identified. The ISS score is difficult to evaluate when patients die before obtaining a CT scan. Profoundly unstable patients, who died in the resuscitation room or the operating room, were found to have an ISS classification as a minor trauma. These patients had apparent profound injuries documented in the physical assessment; however, the ISS calculation did not reflect these injuries. In this study, we chose to classify these patients as "profound" trauma for analysis.

Monitoring trauma team undertriage rates is an important quality indicator and is used to assess performance in trauma hospitals. It is critical to quickly identify and intervene in life-threatening injuries to minimize morbidity and mortality.(23) When a trauma center is experiencing high undertriage rates, process reviews and modifications to TTA practices are required. Missed traumatic brain injuries are associated with increased mortality.(24) When patients have a moderately depressed GCS, and their condition does not trigger a TTA, delays occur in the time to intervention.(14) In this study, 33.2% of patients did not meet TTA criteria, leaving the decision to activate for these patients solely on the emergency department physician's discretion. With the undertriage rate of 13.2% observed in this study, process

changes, such as activating all patients meeting EQTPT level 1 or 2 criteria, should be considered.

Limitations

The accuracy of information used for analysis is dependent on the information available in the electronic medical records and the interpretation of these data by the reviewer. A second reviewer verified 25% of medical records to assure accuracy in the data collected. ISS calculations are dependent on the injuries identified on diagnostic imaging. As the ISS was developed for use in blunt trauma,(25) and therefore does not reflect the difference in risk of mortality major for injuries in other specific body regions. The ISS scores for single system traumas, such as head traumas or penetrating traumas, frequently do not reflect the gravity of the injuries.(26) The definition of overtriage to exclude those with a lower ISS who were admitted to the hospital was used to account for these patients whose injuries required care from the trauma team, despite their lower ISS.

CONCLUSION

With the current practice in the Quebec-based Level 1 trauma center, undertriage rates were well above the acceptable rate of <5%, yet the overtriage rates were far below the acceptable rate of 35%. Using current TTA criteria, 25.8% of major trauma patients did not have a TTA. When patients are not meeting TTA criteria in place, the emergency department physician's discretion is underestimating the severity of the injuries and the requirements of the trauma team in the care of the patient. This study indicates that quality improvement initiatives, including the evaluation of the present TTA criteria and present practice, should be reviewed to decrease the risk of increased morbidity and mortality associated with delays in definitive care

for major trauma patients. Changes in TTA practices to include TTA based on the EQTPT field triage criteria, eliminates undertriage and keeps overtriage rates below acceptable rates of 35%.

ACKNOWLEDGEMENTS

We want to thank Dr. Dave Ross (CSSS Monteregie) for his collaboration, medical students Ranuka Sivanathan and Nour Seulami for assistance in data verification, and Natasha Dupuis for her advice and support during this project.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. Specific author contributions are as follows: study concept and design: JB; data acquisition, preparation: JB; data analysis: JB, JKS; interpretation of results: JB, JKS, GC, SD, JG, KL; first draft of the manuscript: JB. All authors critically reviewed the manuscript for important intellectual content and approved the final version to be published.

ETHICS APPROVAL

This study was approved by the Athabasca University Ethics Board (file number 24272) and the MUHC Research Ethics Board (2021-7693).

REFERENCES

1. Lorthios-Guilledroit A. Mise a jour des indicateurs de qualite et de performane en traumatologie (clientele adulte)2020:[88 p.]. Available from: https://www.inesss.qc.ca/fileadmin/doc/INESSS/Rapports/Traumatologie/INESSS_IQ_Trauma_GN.pdf.

2. Wandling MW, Cotton BA. Prehospital care is critical to improving outcomes after major trauma. The British Journal Surgery. 2020;107(4):329-31.

3. Jelinek L, Fahje C, Immermann C, Elsbernd T. The trauma report nurse: a trauma triage process improvement project. Journal Emergency Nursing. 2014;40(5):e111-7.

4. Frieden TR, Jaffe, H.W., Stephens J.W., Thacker, S.B., Zaza, S. Guielines for field triage of injured patients. Centers for Disease Control and Prevention Mobidity and Motrality Weekly Report. 2012;61(1):21.

5. McCullough AL, Haycock JC, Forward DP, Moran CG, Howell SJ. Early management of the severely injured major trauma patient. British Journal of Anaesthesia. 2014;113(2):234-41.

6. Tignanelli CJ, Vander Kolk WE, Mikhail JN, Delano MJ, Hemmila MR. Noncompliance with American College of Surgeons Committee on Trauma recommended criteria for full trauma team activation is associated with undertriage deaths. Journal Trauma Acute Care Surgery. 2018;84(2):287-94.

7. Echelle quebecoise de triage prehospitalier en traumatologie Quebec2016 [Available from: https://www.inesss.qc.ca/fileadmin/doc/INESSS/FECST/Publications/EQTPT/Echelle-triage-prehospitalier-SEPT-2016.pdf.

8. Yoder A, Bradburn EH, Morgan ME, Vernon TM, Bresz KE, Gross BW, et al. An analysis of overtriage and undertriage by advanced life support transport in a mature trauma system. Journal Trauma Acute Care Surgery. 2020;88(5):704-9.

9. Schwing L, Faulkner TD, Bucaro P, Herzing K, Meagher DP, Pence J. Trauma team activation: Accuracy of triage when minutes count: A synthesis of literature and performance improvement process. Journal Trauma Nursing. 2019;26(4):208-14.

10. IBM. IBM SPSS Statistics for Macintosh. 26.0 ed. Armonk, NY: IBM Corp.; 2019.

11. Verhoeff K, Saybel R, Fawcett V, Tsang B, Mathura P, Widder S. A quality-improvement approach to effective trauma team activation. Canadian Journal Surgery. 2019;62(5):305-14.

12. Hansen K, Truesdale, M., Boyle, A., Holroyd, B., Phillips, G., Benger, J., Chartier, L., Lecky, F., Webb, E., Vaillancourt, S., Cameron, P., Waligora, G., Kurland, L. An updated framework on quality and safety in emergency medicine. West Melbourne, Australia: International Federation for Emergency Medicine; 2019. Available from: https://www.ifem.cc/wp-content/uploads/2019/05/An-Updated-Framework-on-Quality-and-Safety-in-Emergency-Medicine-January-2019.pdf.

13. Six Domains of Health Care Quality Rockville, MD: Agency for Healthcare Research and Quality; 2018 [Available from: https://www.ahrq.gov/talkingquality/measures/six-domains.html.

14. Schellenberg M, Benjamin E, Owattanapanich N, Inaba K, Demetriades D. The impact of delayed time to first CT head in traumatic brain injury. Eur J Trauma Emerg Surg. 2021;47(5):1511-6.

15. Chehab M, Afaneh A, Bible L, Castanon L, Hanna K, Ditillo M, et al. Angioembolization in intra-abdominal solid organ injury: Does delay in angioembolization affect outcomes? J Trauma Acute Care Surg. 2020;89(4):723-9.

16. Matsushima K, Piccinini A, Schellenberg M, Cheng V, Heindel P, Strumwasser A, et al. Effect of door-to-angioembolization time on mortality in pelvic fracture: Every hour of delay counts. J Trauma Acute Care Surg. 2018;84(5):685-92.

17. Kaji AH, Schriger D, Green S. Looking through the retrospectoscope: reducing bias in emergency medicine chart review studies. Annals Emergency Medicine. 2014;64(3):292-8.

18. Waydhas C, Baake M, Becker L, Buck B, Düsing H, Heindl Br, et al. A consensus-based criterion standard for the requirement of a trauma team. World Journal of Surgery. 2018;42(9):2800-9.

19. Najafi Z, Abbaszadeh A, Zakeri H, Mirhaghi A. Determination of mis-triage in trauma patients: a systematic review. European Journal of Trauma and Emergency Surgery : Official Publication of the European Society for Trauma and Emergency Surgery. 2019;45(5):821-39.

20. Shreyus SK, Barry D, Baruch F, Matthew RR, Derek CA, Melissa S, et al. Defining the representativeness heuristic in trauma triage: A retrospective observational cohort study. PLoS ONE [Internet]. 2019; 14(2).

21. Kuo SCH, Kuo P-J, Chen Y-C, Chien P-C, Hsieh H-Y, Hsieh C-H. Comparison of the new Exponential Injury Severity Score with the Injury Severity Score and the New Injury Severity Score in trauma patients: A cross-sectional study. PLOS ONE. 2017;12(11):e0187871.

22. Matthew KM, Nikathan SK, Elizabeth HT, David JS, Rifat L. Clinical characteristics predict the yield of head computed tomography scans among intoxicated trauma patients:

Implications for the initial work-up. Journal of Emergencies, Trauma and Shock. 2020;13(2):135-41.

23. Jeppesen E, Cuevas-Ostrem M, Gram-Knutsen C, Uleberg O. Undertriage in trauma: an ignored quality indicator? Scand J Trauma Resusc Emerg Med. 2020;28(1):34.

24. Schellenberg M, Benjamin E, Bardes JM, Inaba K, Demetriades D. Undertriaged trauma patients: Who are we missing? J Trauma Acute Care Surg. 2019;87(4):865-9.

25. Baker SP, O'Neill B, Haddon W, Jr., Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma. 1974;14(3):187-96.

26. Shi J, Shen J, Caupp S, Wang A, Nuss KE, Kenney B, et al. A new weighted injury severity scoring system: Better predictive power for pediatric trauma mortality. J Trauma Acute Care Surg. 2018;85(2):334-40.

Table 1

Sample Characteristics

	Undertriage *n* (%)	**Overtriage *n* (%)**	**Appropriate triage *n* (%)**	**Total *n* (%)**
Total	**49 (13.2)**	**31 (8.4)**	**291 (78.4)**	**371 (100)**
Sex				
Male	34 (13.1)	22 (8.5)	204 (78.5)	260 (70.1)
Female	15 (13.5)	9 (8.1)	87 (78.4)	111 (29.9)
Age Category (years)				
16-34	8 (5.9)	16 (11.8)	112 (82.4)	136 (36.7)
35-54	18 (16.4)	9 (8.2)	83 (75.4)	110 (29.6)
55-74	14 (17.1)	6 (7.3)	62 (75.6)	82 (22.1)
75+	9 (20.9)	0 (0)	34 (79.1)	43 (11.6)
Mean age (*SD*)	53.5 (19.8)*	38.2 (15.3)*	46.23 (21.0)	46.6 (20.7)
Age range	19-94	17-65	16-96	16-96
Mechanism of Injury				
Motor vehicle crash	22 (11.9)	18 (9.7)	145 (78.4)	185 (49.9)
Fall	19 (20.9)	4 (4.4)	68 (74.7)	91 (24.5)
Penetrating	0 (0)	8 (19.5)	33 (80.5)	41 (11.1)
Pedestrian	1 (6.7)	1 (6.7)	13 (86.7)	15 (4.0)
Cyclist	5 (35.7)	0 (0)	9 (64.3)	14 (3.8)
Crush	0 (0)	0 (0)	13 (100)	13 (3.5)
Assault	2 (22.2)	0 (0)	7 (77.8)	9 (2.4)
Other	0 (0)	0 (0)	3 (100)	3 (0.8)
Trauma Team Involvement				
TTA	0 (0)	31 (14.5)	183 (85.5)	214 (57.7)
Trauma consult	40 (58.8)	0 (0)	28 (41.2)	68 (18.3)
No TTA or consult	9 (10.1)	0 (0)	80 (89.9)	89 (24.0)

Note. TTA (trauma team activation), *SD* (standard deviation)

No significant difference between sex and triage accuracy using chi-square test, significance level $p<0.05$.

*Statistically significant difference, using Independent-Samples Kruskal-Wallis test, in age between patients who were undertriaged (mean 53.5 years) compared to patients who were not undertriaged (mean 45.5), significance level $p<0.05$.

*Statistically significant difference, using Independent-Samples Kruskal-Wallis test, in age distribution between patients who were overtriaged (mean 38.2 years), compared to patients who were not overtriaged (mean 47.31), significance level $p<0.05$.

No statistically significant difference, using the Independent-Samples Kruskal-Wallis test, in age between patients who were accurately triaged (mean 46.3 years) and patients who were not accurately triaged (mean 47.59), significance level $p<0.05$.

Table 2

Pre-Hospital Trauma Triage Level Criteria met by Triage Status

EQTPT Level & Criteria	Undertriage *n* (%)**	Overtriage* *n* (%)**	Total *n* (%)
Level 1	**34 (14.1)**	**51 (21.1)**	**241 (65.0)**
Glasgow coma scale <14	22 (13.5)	37 (22.7)	163 (43.9)
Systolic blood pressure <90	7 (14.3)	11 (22.4)	49 (13.2)
Respiratory rate <10 or >29 or ventilation support	5 (17.2)	3 (10.3)	29 (7.8)
Level 2	**12 (10.5)**	**36 (31.2)**	**114 (30.7)**
Penetrating injury	1 (2.9)	16 (45.7)	35 (9.4)
Suspected pelvic fracture	3 (11.5)	5 (19.2)	26 (7.0)
Acute paralysis	5 (27.8)	8 (44.4)	18 (4.9)
Crush/mangled extremity	0 (0)	4 (23.5)	17 (4.6)
Two or more long bone injuries	2 (28.6)	0 (0)	7 (1.9)
Open/depressed skull fracture	0 (0)	2 (40.0)	5 (1.3)
Chest wall deformity	1 (25.0)	0 (0)	4 (1.1)
Amputation above wrist/ankle	0 (0)	1 (33.3)	3 (0.8)
Level 3	**3 (18.8)**	**7 (43.8)**	**16 (4.3)**
High risk motor vehicle crash	1 (16.7)	3 (50.0)	6 (1.6)
Motorcycle crash >30kph	1 (16.7)	3 (50.0)	6 (1.6)
Pedestrian/cyclist >30kph	1 (50.0)	1 (50.0)	2 (0.5)
Fall >6m	0 (0)	0 (0)	1 (0.3)

Note. EQTPT : Quebec pre-hospital trauma triage scale (*Echelle Quebecois de triage prehospitalier de trauma*)

*overtriage is based on if all cases were to have a trauma team activation

**percent of criteria that is overtriaged if all cases were to have a trauma team activation

Table 3

Primary Reason for Trauma Team Activation (TTA) and Triage Status per TTA Criteria

TTA Criteria	Undertriage *n* (%)	Overtriage *n* (%)	Total *n* (%)
Need for airway management	11 (8.3)	10 (7.6)	132 (35.6)
Systolic blood pressure <90	7 (13.7)	3 (5.9)	51 (13.7)
Penetrating injury to head, neck, or torso	0 (0)	9 (25)	36 (9.7)
Mangled extremity	0 (0)	0 (0)	13 (3.5)
Paralysis	5 (41.7)	1 (8.3)	12 (3.2)
Need for blood transfusion	1 (25.0)	0 (0)	4 (1.1)
Discretion of emergency department physician	0 (0)	8 (21.6)	37 (10.0)
None	25 (29.1)	0 (0)	86 (23.2)
Total	49 (13.2)	31 (8.4)	371 (100)

Note. TTA: trauma team activation

Table 4

Final Disposition from Emergency Department and Severity of Trauma by Injury Severity Score (ISS)

Injury Severity Scores (ISS)		**Disposition from Emergency Department *n* (% by row)**						
		Discharge from ED	Transfer to another institution	Admission to ICU	OR	Admission to in-patient unit	Death in ED	Total
	Minor (0-8)	83 (63.4)	6 (4.6)	12 (9.2)	5 (3.8)	24 (18.3)	1 (0.8)	131 (35.3)
	Moderate (9-11)	12 (24.0)	5 (10.0)	7 (14.0)	9 (18.0)	17 (34.0)	0 (0)	50 (13.5)
	Major (12-25)	12 (13.5)	5 (5.6)	18 (20.2)	28 (31.5)	26 (29.2)	0 (0)	89 (24.0)
	Profound (26-75)	0 (0)	0 (0)	43 (42.6)	38 (37.6)	13 (12.9)	7 (6.9)	101 (27.2)
Total		107 (28.8)	16 (4.3)	80 (21.6)	80 (21.6)	80 (21.6)	8 (2.2)	371 (100)

Note. ED (emergency department), ISS (Injury Severity Score), ICU (intensive care unit), OR (operating room)

Table 5

EQTPT Criteria met for Major or Profound Trauma of Patients who did not Have a Trauma Team Activation

EQTPT CRITERIA	Major trauma ISS 12-25 *n (%)*	Profound trauma ISS 26-75 *n (%)*	Total *n* (%)
GCS <14	12	10	22 (44.9)
SBP <90 mmHg	4	2	6 (12.2)
Respiratory rate <10, >29, or assisted	2	3	5 (10.2)
Penetrating injury to the head, neck, torso, extremities above the elbow or knee	1	0	1 (2.0)
Instability or deformity of the chest	1	0	1 (2.0)
Two or more long bone injuries	0	2	2 (4.1)
Suspected pelvic fracture	2	1	3 (6.1)
Acute paralysis	3	2	5 (10.2)
High risk motor vehicle crash	1	0	1 (2.0)
Pedestrian or cyclist hit >30kph or rolled over	0	1	1 (2.0)
Motorcycle crash >30kph	1	0	1 (2.0)
Total (% of total in ISS range)	**28 (31.2%)**	**21 (20.8%)**	**49**

Note. EQTPT: Quebec pre-hospital trauma triage scale (*Echelle quebecoise de triage prehospitalier de traumatologie*), GCS: Glascow Coma Scale, ISS: Injury Severity Score, SBP: systolic blood pressure

Table 6

Over and Under Triage Rates Per Present Trauma Team Activation Criteria and Pre-Hospital Triage

EQTPT level *n* (%)	**Current practice**			**Trauma team activation for all**	
	Overtriage *n* (%)	**Undertriage *n* (%)**	**Accurate *n* (%)**	**Overtriage *n* (%)**	**Undertriage *n* (%)**
Level 1 241 (65.1)	20 (8.3)*	34 (14.1)*	187 (77.6)	51 (21.2)*	0 (0)*
Level 2 114 (30.1)	10 (8.8)*	12 (10.5)*	92 (80.7)	36 (31.6)*	0 (0)*
Level 3 16 (4.3)	1 (6.3)*	3 (18.8)	12 (75.0)	7 (43.8)*	0 (0)*
Total 371 (100)	**31 (8.4)***	**49 (13.2)***	**291 (78.4)**	**94 (25.3)***	**0 (0)***

Note. EQTPT (*Échelle québécoise de triage préhospitalier en traumatologie*" pre-hospital trauma triage scale), TTA (trauma team activation), PH (pre-hospital)

Present practice: over and undertriage rates based on actual practice from medical records reviewed

Trauma team activation for all: over and undertriage rates based on TTA for all patients meeting EQTPT levels 1-3

*Statistically significant difference using Wilcoxon signed-ranks test, $p<0.05$

Chapter 4 - Conclusion

1.0 Significance of Findings

Findings from this thesis project have the potential to apply to multiple areas of trauma patient care. By reviewing the cases that have met pre-hospital criteria to bypass secondary hospitals and be transported directly to a Level 1 trauma centre, I provided data on the type and severity of traumas being cared for in the Montreal region of Quebec, Canada. Medical records were reviewed spanning 2.5 years and began when the current pre-hospital triage protocol was implemented, providing a relatively large sample size. This study provides insight into the accuracy of field triage guidelines presently in use in the provinces pre-hospital system in predicting significant injuries and the need for trauma team involvement in the emergency department. By describing the types of trauma patients who bypass secondary hospitals, I have brought forth data that can be used to develop strategies to imrpove patient-centred care. The decrease in time from arrival to diagnostic imaging (i.e., CT scan) that was evident with a pre-hospital TTA indicates a benefit to the patients with a pre-hospital TTA. The total length of stay in the emergency department and the time spent in the emergency department without a plan established were significantly longer for those who did not have a TTA. While the reasons for an increased length of stay and time spent without a plan in the emergency department are multifaceted, these results encourage further investigation into how to improve these quality indicators.

Data and results can be used to modify TTA criteria to reflect pre-hospital field triage criteria. The analysis of the timing of trauma team involvement in relation to different quality indicators may justify the addition of TTA criteria to decrease the time to definitive care. Data may also be considered an indicator that the accuracy of the EQTPT pre-hospital triage tool is

providing reliable information to allow emergency department staff to make decisions surrounding TTA with the pre-hospital notification. By reviewing over and undertriage rates, I have identified an area of care that demands evaluation for further quality improvement initiatives. This study served to assess the care presently being provided in comparison to quality indicators that are monitored by accreditation bodies, identifying gaps in current processes.

2.0 Limitations

As with most retrospective studies, the accuracy of information gathered is dependent on the accuracy of the information available in the electronic medical record. Incomplete patient data was anticipated. Medical records with missing data points were excluded from individual statistical analysis. In the first manuscript, those patients for which the timing of TTA could not be accurately determined were excluded from the analysis. To ensure data collection and transcription reliability, 25% of the medical records were reviewed by a second reviewer, (Kaji et al., 2014a). As medical records are in narrative form, data collected from documentation pertinent to this study were subject to interpretation by the reviewer. This was partially mitigated by using a standardized data collection form and having 25% of medical records independently confirmed by a second reviewer.

In some of the documentation, conflicting times were noted for when patients left the resuscitation room and the timing of the TTA (i.e., pre-hospital vs. in the emergency room). There is an electronic time stamp that is user-dependant and may not be consistently accurate. When a time was documented in the written nursing notes for leaving the resuscitation room, this was the time recorded for all patients. This inconsistency may have impacted data quality and possibly contributed to the lack of statistical significance of the differences for this quality

indicator. All other time stamps recorded were not user-dependent to be entered into the electronic medical record. They are automatically recorded when the CT scan is performed, when the request for admission or discharge is entered or when the patient's departure is registered from the emergency department.

Patients who died prior to arrival in the emergency department were not included in this study as no data were available. This leaves a survivor bias on the study sample and results may have been different if included. Patients who met field triage criteria for transfer to a Level I trauma centre, who were undertriaged by pre-hospital personnel or diverted to secondary centers due to instability in transport, are also not captured in the medical record available for analysis. ISS is calculated based on diagnosed injuries, particularly on radiographic imaging. Patients who died prior to CT scans have an inaccurately low ISS due to the inability to have all injuries identified. Most of the patients who died in the emergency department had an ISS <12 recorded in the trauma registry, despite their obvious severe fatal injuries on exam. For this study, those who have obvious profound injuries with a low documented ISS were classified as profound traumas (vs. minor or moderate traumas) based on the physician's physical assessment.

ISS was developed for use in blunt trauma due to motor vehicle crashes (Baker et al., 1974). As an ISS is calculated using the most severe injury in three body systems, patients with a single system injury, such as isolated head trauma or penetrating trauma may not have an ISS that accurately reflects their level of injury. Regardless of initial ISS, penetrating trauma to the chest and abdomen requires an automatic TTA according to the ACS-6 as these patients have a high risk of requiring surgical intervention. When evaluating these patients for over and undertriage, the criteria used for undertriage reflected a low ISS (<12), yet all were admitted to the hospital and were not undertriaged.

3.0 Contribution to Nursing Knowledge

This master's thesis contributes to new knowledge in several ways. Triage in the emergency department falls typically under the RN's scope of practice. Yet in Quebec, the decision to activate a trauma team outside of specific indications remains at the discretion of the emergency department physician. When evaluating care using LEAN management concepts, processes are reviewed to identify inefficiencies (Austin et al., 2020). Areas, where work is duplicated and found to be inefficient, should be minimized or eliminated. To identify areas of potential inefficiency, data must be purposely collected and analyzed considering the local context. This study validated the local perception that undertriage rates were above the accepted standard of care. In addition, local assumptions that the trauma centre performed better on certain quality indicators when the trauma team was involved in the major trauma patient's care were confirmed. Furthermore, this study validated that when the TTA is done pre-hospital, the delay in time for a CT scan is decreased, allowing for a quicker time to definitive care.

Other findings confirmed that the undertriage levels were above the acceptable Accreditation Canada levels of <5%. This study further evaluated if TTA for all patients meeting pre-hospital major trauma triage criteria would result in overactivation of the trauma team. In this study, we found that this would not result in the overactivation of the trauma team. By LEAN management concepts, once inefficiencies are identified, teams ought to proceed with making plans to minimize these inefficiencies. During the study period, RNs who receive pre-hospital major trauma notification must discuss the individual case with the emergency department physician, who then decides if there should be a TTA solely based on the pre-hospital report. This process results in duplication of effort from the pre-hospital personnel to the RN to the physician. In turn, this may result in variability in TTA habits that were found to

include excessive undertriage rates, thus decreasing the quality of care for patients in the emergency department.

Once an area of inefficiency is identified, potential ways to improve the inefficiency must be implemented and tested. The outcomes of this study suggest that efficiencies in trauma tirage could be established. For example, the RN who receives the pre-hospital incoming trauma notification, could be authorized to proceed directly in activating the trauma team based on the pre-hospital triage tool. This would eliminate the extra step and potential subjectivity when a TTA is left to a single provider's judgement. Assembling the multi-disciplinary trauma team prior to the arrival of the trauma patient is known to allow necessary preparation, ultimately increasing system efficiency, and improving patient outcomes. When areas of patient care are not meeting benchmarks, a root-cause analysis must be carried out to identify the potential causes to plan quality improvement initiatives (Verhoeff et al., 2019). The correlations in this study indicate areas that can potentially be addressed to increase efficiency and direct quality improvement initiatives.

4.0 Future Research

The impact of prolonged pre-hospital time on patients transported by ground ambulance deserves further investigation. This research lends to further studies exploring over and undertriage rates in relation to increased pre-hospital times. Other areas of potential research include patient instability in reference to their transport time, evaluating if there is an impact on the admission rate to the intensive care unit, urgent operating room, or examining abnormal lab values on presentation (e.g., abnormal blood gas values or coagulation profiles) and their relation to patient outcomes. Future research could extend out of the emergency department to evaluate if there is an impact on the total length of stay in the hospital and increased morbidity

and mortality rates when comparing patients with similar levels of injury who have shorter pre-hospital times. This research could also be duplicated at other trauma hospitals in the province to evaluate if the results obtained in this study are transferrable to other centers.

5.0 Conclusion

Every trauma system is unique and elements of early trauma patient care and ideal elements of a trauma system remain debatable. While I hypothesized that the timing of trauma team involvement would impact quality indicators monitored in the emergency department, data to support this hypothesis was not available. Baseline data for over and undertriage rates needed to be measured to evaluate if a quality improvement intervention is warranted. With the undertriage rates identified as being above the recommended rates, a further evaluation of potential areas for improvement needs to be done – which was the basis of the manuscript comparing the timing of trauma team involvement in quality of care.

With the number of patients who were found to be undertriaged, and the number of patients who did not meet present TTA criteria, there is an indication for the review of current practices surrounding TTA criteria and practice. As the time to CT scan is significantly shorter for those who had a pre-hospital TTA, along with a decreased length of stay and time in the emergency department without a disposition identified, this evidence emphasizes the appropriateness of pre-hospital TTA in the quality of care of the major trauma patient. Baseline undertriage rates being too high were not found to be remedied if there were to be 100% compliance with TTA criteria in the emergency department. Educational activities to increase compliance would not eliminate the elevated undertriage rate. With the overtriage rates remaining below 35% with the activation of all EQTPT levels 1 and 2, I would advocate for a

TTA to be done at the time of pre-hospital notification, regardless of meeting current TTA criteria.

REFERENCES

Austin, E. E., Blakely, B., Tufanaru, C., Selwood, A., Braithwaite, J., & Clay-Williams, R. (2020). Strategies to measure and improve emergency department performance: a scoping review. *Scand J Trauma Resusc Emerg Med*, *28*(1), 55. https://doi.org/10.1186/s13049-020-00749-2

Baker, S. P., O'Neill, B., Haddon, W., Jr., & Long, W. B. (1974). The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*, *14*(3), 187-196. https://www.ncbi.nlm.nih.gov/pubmed/4814394

Boucher, F. (2020). Spotlight on traumatic brain injuries across the life course. *Injury in Review 2020 Edition*, 155. https://www.canada.ca/en/public-health/services/injury-prevention/canadian-hospitals-injury-reporting-prevention-program/injury-reports/2020-spotlight-traumatic-brain-injuries-life-course.html#ack

Brown, J. B., Rosengart, M. R., Forsythe, R. M., Reynolds, B. R., Gestring, M. L., Hallinan, W. M., Peitzman, A. B., Billiar, T. R., & Sperry, J. L. (2016). Not all prehospital time is equal: Influence of scene time on mortality. *Journal Trauma Acute Care Surgery*, *81*(1), 93-100. https://doi.org/10.1097/TA.0000000000000999

Chehab, M., Afaneh, A., Bible, L., Castanon, L., Hanna, K., Ditillo, M., Khurrum, M., Asmar, S., & Joseph, B. (2020). Angioembolization in intra-abdominal solid organ injury: Does delay in angioembolization affect outcomes? *J Trauma Acute Care Surg*, *89*(4), 723-729. https://doi.org/10.1097/ta.0000000000002851

Chen, X., Guyette, F. X., Peitzman, A. B., Billiar, T. R., Sperry, J. L., & Brown, J. B. (2019). Identifying patients with time-sensitive injuries: Association of mortality with increasing prehospital time. *Journal Trauma Acute Care Surgery*, *86*(6), 1015-1022. https://doi.org/10.1097/TA.0000000000002251

Clements, T. W., Kirkpatrick, A. W., Grondin, S. C., Dixon, E., McKee, J., Ball, C. G., Vogt, K., Parry, N., & Hameed, S. M. (2017). Does increased prehospital time lead to a "trial of life" effect for patients with blunt trauma? *Journal of Surgical Research*, *216*, 103-108. https://doi.org/10.1016/j.jss.2017.04.027

Dixon, J., Comstock, G., Whitfield, J., Richards, D., Burkholder, T. W., Leifer, N., Mould-Millman, N. K., & Calvello Hynes, E. J. (2020). Emergency department management of traumatic brain injuries: A resource tiered review. *Afr J Emerg Med*, *10*(3), 159-166. https://doi.org/10.1016/j.afjem.2020.05.006

Echelle quebecoise de triage prehospitalier en traumatologie. (2016). Retrieved 2020/11/-3 from https://www.inesss.qc.ca/fileadmin/doc/INESSS/FECST/Publications/EQTPT/Echelle-triage-prehospitalier-SEPT-2016.pdf

Emergency Nurses Association. (2022). Retrieved 2022/05/14 from https://www.ena.org/

Farrell, M. S., Emery, B., Caplan, R., Getchell, J., Cipolle, M., & Bradley, K. M. (2020). Outcomes with advanced versus basic life support in blunt trauma. *The American Journal of Surgery*, *220*(3), 783-786. https://doi.org/10.1016/j.amjsurg.2020.01.012

Frieden, T. R., Jaffe, H.W., Stephens J.W., Thacker, S.B., Zaza, S. (2012). Guielines for field triage of injured patients. *Centers for Disease Control and Prevention Mobidity and Motrality Weekly Report*, *61*(1), 21. https://www.cdc.gov/mmwr/pdf/rr/rr6101.pdf

Gauss, T., Ageron, F-X., Devaud, M-L., Debaty, G., Travers, S., Garrigue, D., Raux, M., Harrois, A., Bouzat, P. (2019). Association of prehospital time to in-hospital trauma mortality in a physician-staffed emergency medicine system. *JAMA Surgery*, *154*(12), 1117-1124. https://doi.org/10.1001/jamasurg.2019.3475

Gonthier, C., Belcaid, A. (2020). *Evaluation des installations de soins aigus designees en traumatologie tertiaire adulte et secondaire regionale - tendances 2013-2018*. Gouvernement du Quebec.

Hanae Ibn El, H., Mohamed, L., & Noureddine, R. (2013). Quality of care between Donabedian model and ISO9001V2008. *International Journal for Quality Research*, *7*(1), 17-30.

Hansen, K., Truesdale, M., Boyle, A., Holroyd, B., Phillips, G., Benger, J., Chartier, L., Lecky, F., Webb, E., Vaillancourt, S., Cameron, P., Waligora, G., Kurland, L. (2019). *An updated framework on quality and safety in emergency medicine*. International Federation for Emergency Medicine. https://www.ifem.cc/wp-content/uploads/2019/05/An-Updated-Framework-on-Quality-and-Safety-in-Emergency-Medicine-January-2019.pdf

Heart and Stroke Foundation. (2022). Retrieved 2022/05/14 from https://www.heartandstroke.ca/

Howard, J. T., Kotwal, R. S., Santos-Lazada, A. R., Martin, M. J., & Stockinger, Z. T. (2018). Reexamination of a battlefield trauma golden hour policy. *Journal Trauma Acute Care Surgery*, *84*(1), 11-18. https://doi.org/10.1097/TA.0000000000001727

IBM. (2019). *IBM SPSS Statistics for Macintosh*. In (Version 26.0) IBM Corp.

Jelinek, L., Fahje, C., Immermann, C., & Elsbernd, T. (2014). The trauma report nurse: a trauma triage process improvement project. *Journal Emergency Nursing*, *40*(5), e111-117. https://doi.org/10.1016/j.jen.2013.12.018

Jeppesen, E., Cuevas-Ostrem, M., Gram-Knutsen, C., & Uleberg, O. (2020). Undertriage in trauma: an ignored quality indicator? *Scand J Trauma Resusc Emerg Med*, *28*(1), 34. https://doi.org/10.1186/s13049-020-00729-6

Kaji, A. H., Schriger, D., & Green, S. (2014a). Looking through the retrospectoscope: reducing bias in emergency medicine chart review studies. *Annals of emergency medicine*, *64*(3), 292-298. https://doi.org/10.1016/j.annemergmed.2014.03.025

Kaji, A. H., Schriger, D., & Green, S. (2014b). Looking through the retrospectoscope: reducing bias in emergency medicine chart review studies. *Annals Emergency Medicine*, *64*(3), 292-298. https://doi.org/10.1016/j.annemergmed.2014.03.025

Kool, B., Lilley, R., & Davie, G. (2017). Prehospital injury deaths: The missing link. *Injury*, *48*(5), 973-974. https://doi.org/10.1016/j.injury.2017.03.001

Kuo, S. C. H., Kuo, P.-J., Chen, Y.-C., Chien, P.-C., Hsieh, H.-Y., & Hsieh, C.-H. (2017). Comparison of the new Exponential Injury Severity Score with the Injury Severity Score and the New Injury Severity Score in trauma patients: A cross-sectional study. *PLoS ONE*, *12*(11), e0187871. https://doi.org/10.1371/journal.pone.0187871

Lighter, D. E. (2015). How (and why) do quality improvement professionals measure performance? *International Journal of Pediatrics & Adolescent Medicine*, *2*(1), 7-11. https://doi.org/10.1016/j.ijpam.2015.03.003

Linder, F., Holmberg, L., Eklöf, H., Björck, M., Juhlin, C., & Mani, K. (2019). Better compliance with triage criteria in trauma would reduce costs with maintained patient safety. *European journal of emergency medicine : official journal of the European Society for Emergency Medicine*, *26*(4), 283-288. https://doi.org/10.1097/MEJ.0000000000000544

Lorthios-Guilledroit, A. (2020). Mise a jour des indicateurs de qualite et de performane en traumatologie (clientele adulte). 88. https://www.inesss.qc.ca/fileadmin/doc/INESSS/Rapports/Traumatologie/INESSS_IQ_Trauma_GN.pdf

Maia Ambegaokar, R. A., Carlos Arreola Risa, Kenneth Boffard, Gerard, Castro, W. C., Ian Civil, Gerald Dziekan, Dominique, Egger, R. E., Thomas Esposito, Atul Gawande, Russell Gruen,, Laura Hawken, V. K., Christine Keyes, Etienne Krug, Ari Leppaniemi,, Ronald Maier, M. M., Thai Son Nguyen, Eric Ossmann, Andres, Rubiano, P. R., Scott Sasser, Sandro Scarpelini, Heather, & Sherman, M. V., Ahmed Zakariah. (2009). *Guidelines for trauma quality improvement programmes*. World Health Organization; International Society of Surgery and International Association for Trauma Surgery and Intensive Care. http://whqlibdoc.who.int/publications/2009/9789241597746_eng.pdf

Martinez, D. A., Kane, E. M., Jalalpour, M., Scheulen, J., Rupani, H., Toteja, R., Barbara, C., Bush, B., & Levin, S. R. (2018). An electronic dashboard to monitor patient flow at the Johns Hopkins Hospital: Communication of key performance indicators using the Donabedian Model. *Journal of Medical Systems*, *42*(8), 1-8. https://doi.org/10.1007/s10916-018-0988-4

Matsushima, K., Piccinini, A., Schellenberg, M., Cheng, V., Heindel, P., Strumwasser, A., Benjamin, E., Inaba, K., & Demetriades, D. (2018). Effect of door-to-angioembolization time on mortality in pelvic fracture: Every hour of delay counts. *J Trauma Acute Care Surg*, *84*(5), 685-692. https://doi.org/10.1097/ta.0000000000001803

Matthew, K. M., Nikathan, S. K., Elizabeth, H. T., David, J. S., & Rifat, L. (2020). Clinical characteristics predict the yield of head computed tomography scans among intoxicated trauma patients: Implications for the initial work-up [article]. *Journal of Emergencies, Trauma and Shock*, *13*(2), 135-141. https://doi.org/10.4103/JETS.JETS_74_19

McCullough, A. L., Haycock, J. C., Forward, D. P., Moran, C. G., & Howell, S. J. (2014). Early management of the severely injured major trauma patient. *British Journal of Anaesthesia*, *113*(2), 234-241. https://doi.org/10.1093/bja/aeu235

Mohan, D., Fischhoff, B., Angus, D. C., Rosengart, M. R., Wallace, D. J., Yealy, D. M., Farris, C., Chang, C. H., Kerti, S., & Barnato, A. E. (2018). Serious games may improve physician heuristics in trauma triage. *Proc Natl Acad Sci U S A*, *115*(37), 9204-9209. https://doi.org/10.1073/pnas.1805450115

Najafi, Z., Abbaszadeh, A., Zakeri, H., & Mirhaghi, A. (2019). Determination of mis-triage in trauma patients: a systematic review. *European Journal of Trauma and Emergency Surgery : Official Publication of the European Society for Trauma and Emergency Surgery*, *45*(5), 821-839. https://doi.org/10.1007/s00068-019-01097-2

Nasr, A., Saavedra Tomasich, F., Collaço, I., Abreu, P., Namias, N., & Marttos, A. (2020). *The trauma golden hour : a practical guide*. Springer.

Nasser, A. A. H., Nederpelt, C., El Hechi, M., Mendoza, A., Saillant, N., Fagenholz, P., Velmahos, G., & Kaafarani, H. M. A. (2020). Every minute counts: The impact of pre-hospital response time and scene time on mortality of penetrating trauma patients. *The American Journal of Surgery*, *220*(1), 240-244. https://doi.org/https://doi.org/10.1016/j.amjsurg.2019.11.018

Parachute. (2015). The Cost of Injury in Canada.

Parachute. (2021). Potential Lost, Potential for Change. The Cost of Injury in Canada 2021. (2022/03/01). https://www.parachute.ca/en/professional-resource/cost-of-injury-in-canada/

Polovitch, S., Muertos, K., Burns, A., Czerwinski, A., Flemmer, K., & Rabon, S. (2019). Trauma nurse leads in a level I trauma center: roles, responsibilities, and trauma performance improvement outcomes. *Journal Trauma Nursing*, *26*(2), 99-103. https://doi.org/10.1097/JTN.0000000000000431

Popa, O., Cimpoesu, D., & Nedelea, P. (2019). Prehospital emergency care in acute trauma conditions. In *Emergency Medicine and Trauma*. https://doi.org/10.5772/intechopen.86776

Roman, P., Michel, T., Hagen, A., Bilal, M. B., & Hans-Christoph, P. (2016). Mortality patterns in patients with multiple trauma: A systematic review of autopsy studies. *PLoS ONE*, *11*(2).

Schellenberg, M., Benjamin, E., Bardes, J. M., Inaba, K., & Demetriades, D. (2019). Undertriaged trauma patients: Who are we missing? *J Trauma Acute Care Surg*, *87*(4), 865-869. https://doi.org/10.1097/ta.0000000000002393

Schellenberg, M., Benjamin, E., Owattanapanich, N., Inaba, K., & Demetriades, D. (2021). The impact of delayed time to first CT head in traumatic brain injury. *Eur J Trauma Emerg Surg*, *47*(5), 1511-1516. https://doi.org/10.1007/s00068-020-01421-1

Schroeder, P. H., Napoli, N. J., Barnhardt, W. F., Barnes, L. E., & Young, J. S. (2019). Relative mortality analysis of the "golden hour": A comprehensive acuity stratification approach to address disagreement in current literature. *Prehospital Emergency Care*, *23*(2), 254-262. https://doi.org/10.1080/10903127.2018.1489021

Schull, M. J., Guttmann, A., Leaver, C. A., Vermeulen, M., Hatcher, C. M., Rowe, B. H., Zwarenstein, M., & Anderson, G. M. (2011). Prioritizing performance measurement for emergency department care: consensus on evidencebased quality of care indicators. *Canadian Journal of Emergency Medicine*, *13*(5), 300-309. https://doi.org/10.2310/8000.2011.110334

Schwing, L., Faulkner, T. D., Bucaro, P., Herzing, K., Meagher, D. P., & Pence, J. (2019). Trauma team activation: Accuracy of triage when minutes count: A synthesis of literature and performance improvement process. *Journal Trauma Nursing*, *26*(4), 208-214. https://doi.org/10.1097/JTN.0000000000000450

Sewalt, C. A., Gravesteijn, B. Y., Nieboer, D., Steyerberg, E. W., Den Hartog, D., & Van Klaveren, D. (2021). Identifying trauma patients with benefit from direct transportation to Level-1 trauma centers [journal article]. *BMC Emergency Medicine*, *21*(1), 1-12. https://doi.org/10.1186/s12873-021-00487-3

Shi, J., Shen, J., Caupp, S., Wang, A., Nuss, K. E., Kenney, B., Wheeler, K. K., Lu, B., & Xiang, H. (2018). A new weighted injury severity scoring system: Better predictive power for pediatric trauma mortality. *J Trauma Acute Care Surg*, *85*(2), 334-340. https://doi.org/10.1097/ta.0000000000001943

Shreyus, S. K., Barry, D., Baruch, F., Matthew, R. R., Derek, C. A., Melissa, S., Donald, M. Y., & Deepika, M. (2019). Defining the representativeness heuristic in trauma triage: A retrospective observational cohort study. *PLoS ONE*, *14*(2).

Six Domains of Health Care Quality. (2018). Agency for Healthcare Research and Quality. https://www.ahrq.gov/talkingquality/measures/six-domains.html

Society of Trauma Nurses. (2022). Retrieved 2022/05/24 from https://www.traumanurses.org/atcn

Tallon, J., Taulu, T., Simons, R., Poirier, P., Brenneman, F., Razek, T., Yanchar, N., Logsetty, S., Cleghorn, G., & Rizoli, S. (2011). *Trauma System Accreditation Guidelines*. Trauma Association of Canada. https://www.traumacanada.org/wp-content/uploads/2019/05/Accreditation_Guidelines_2011.pdf

Tiel Groenestege-Kreb, D., van Maarseveen, O., & Leenen, L. (2014). Trauma team. *British Journal of Anaesthesia*, *113*(2), 258-265. https://doi.org/10.1093/bja/aeu236

Tignanelli, C. J., Vander Kolk, W. E., Mikhail, J. N., Delano, M. J., & Hemmila, M. R. (2018). Noncompliance with American College of Surgeons Committee on Trauma recommended criteria for full trauma team activation is associated with undertriage deaths. *Journal Trauma Acute Care Surgery*, *84*(2), 287-294. https://doi.org/10.1097/TA.0000000000001745

Verhoeff, K., Saybel, R., Fawcett, V., Tsang, B., Mathura, P., & Widder, S. (2019). A quality-improvement approach to effective trauma team activation. *Canadian Journal Surgery*, *62*(5), 305-314. https://doi.org/10.1503/cjs.000218

Wandling, M. W., & Cotton, B. A. (2020). Prehospital care is critical to improving outcomes after major trauma. *The British Journal Surgery*, *107*(4), 329-331. https://doi.org/10.1002/bjs.11589

Waydhas, C., Baake, M., Becker, L., Buck, B., Düsing, H., Heindl, B. r., Jensen, K. O., Lefering, R., Mand, C., Paffrath, T., Schweigkofler, U., Sprengel, K., Trentzsch, H., Wohlrath, B., & Bieler, D. (2018). A consensus-based criterion standard for the requirement of a trauma team. *World Journal of Surgery*, *42*(9), 2800-2809. https://doi.org/10.1007/s00268-018-4553-6

Waydhas, C., Trentzsch, H., Hardcastle, T. C., Jensen, K. O., & World-Trauma, T. S. G. (2020). Survey on worldwide trauma team activation requirement. *European Journal Trauma Emergency Surgery*. https://doi.org/10.1007/s00068-020-01334-z

Yao, X., Skinner, R., McFaull, S., & Thompson, W. (2019a). Aperçu - Décès attribuables à des blessures au Canada en 2015. *Health promotion and chronic disease prevention in Canada : research, policy and practice*, *39*(6-7), 225-231. https://doi.org/10.24095/hpcdp.39.6/7.03

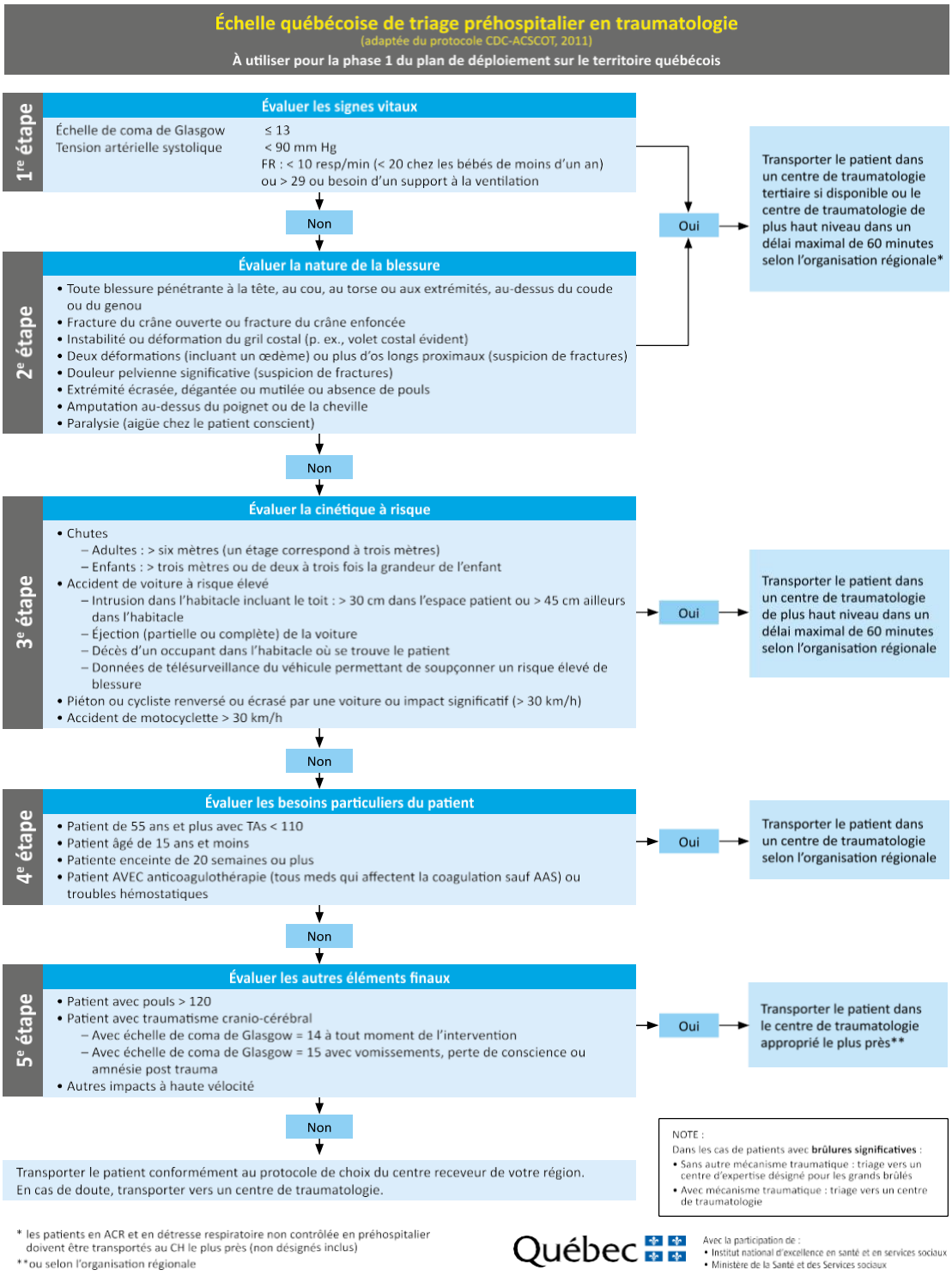
Yao, X., Skinner, R., McFaull, S., & Thompson, W. (2019b). At-a-glance - 2015 injury deaths in Canada. *Health Promotion Chronic Disease Prevention Canada*, *39*(6-7), 225-231.

https://doi.org/10.24095/hpcdp.39.6/7.03 (Apercu - Deces attribuables a des blessures au Canada en 2015.)

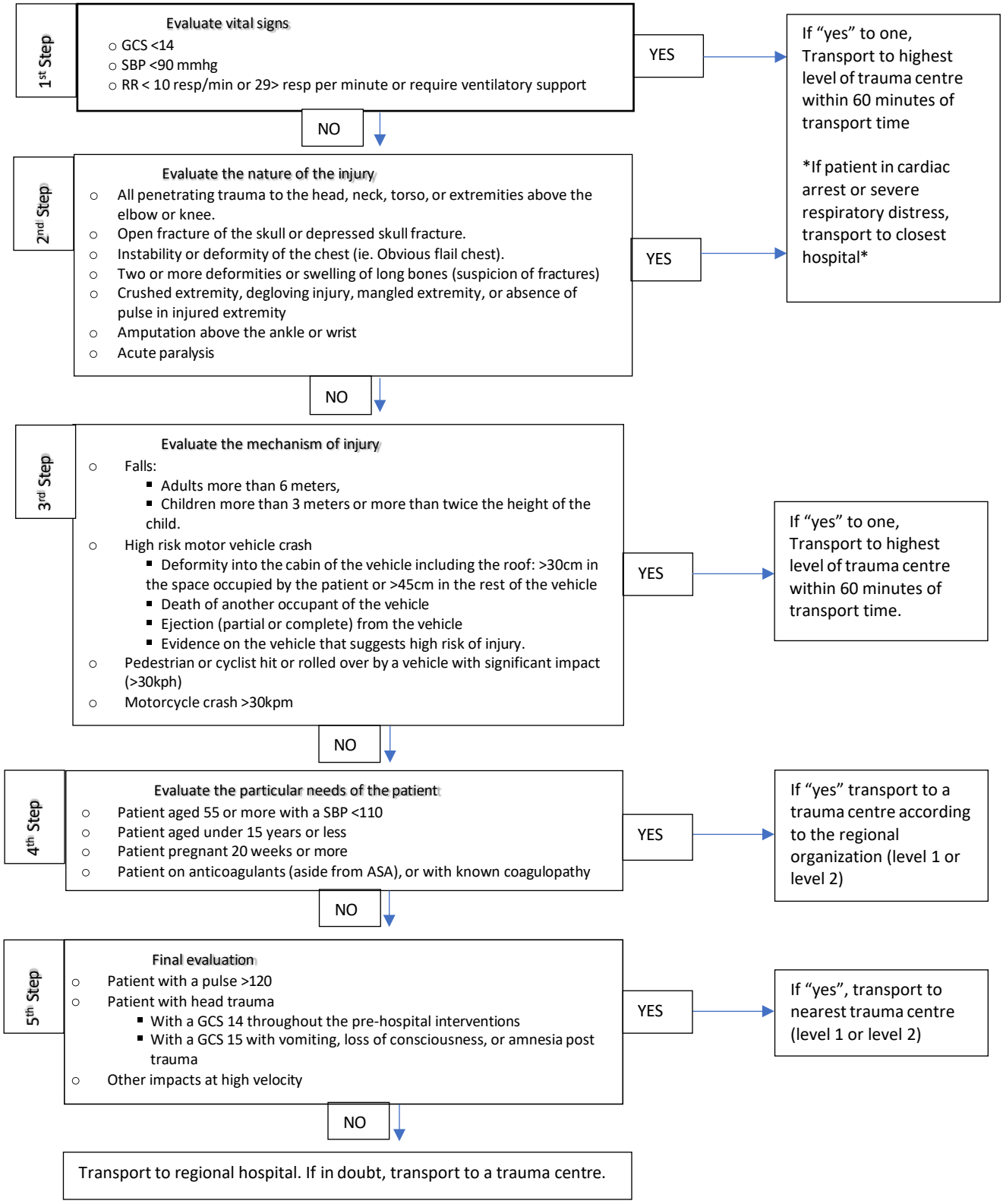
Yoder, A., Bradburn, E. H., Morgan, M. E., Vernon, T. M., Bresz, K. E., Gross, B. W., Cook, A. D., & Rogers, F. B. (2020). An analysis of overtriage and undertriage by advanced life support transport in a mature trauma system. *Journal Trauma Acute Care Surgery*, *88*(5), 704-709. https://doi.org/10.1097/TA.0000000000002602

Yoo, Y., & Mun, S. (2014). The advantages of early trauma team activation in the management of major trauma patients who underwent exploratory laparotomy. *Annals Surgical Treatment Research*, *87*(6), 319-324. https://doi.org/10.4174/astr.2014.87.6.319

Appendix 1: Quebec Pre-Hospital Trauma Triage Scale – EQTPT



Un-official Translation of "Echelle quebecoise de triage prehospitalier en traumatologie"



Appendix 2: Trauma Team Activation and Consultation Criteria – Montreal General Hospital

		URGENCE **FEUILLE D'ÉVALUATION DU POLYTRAUMATISÉ** EMERGENCY	**DDN**/DOB ( ) , **NAM**/RAMQ **Exp.** , **Admission-Visite**/Visit **Site:** **Emplacement**/Location

Critère d'activation de l'équipe de trauma (Cochez tout ce qui s'applique)
Trauma Team Activation (check all those that apply)

☐	**Nécessite le contrôle des voies respiratoires** / Need for airway management
☐	**Pression systolique < 90 à l'urgence** / Systolic BP < 90 in the emergency department
☐	**Trauma pénétrant tête, cou ou tronc** / Penetrating injury to head, neck or trunk
☐	**Extrémité mutilé ou amputation au-dessus du poignet ou de la cheville** / Mangled extremity or amputation above wrist/ ankle
☐	**Besoin de CGR à l'urgence (RESUS)** / Need for PRBC in the RESUS
☐	**Paralysie** / Paralysis
☐	**Brûlure > 20 % surface corporelle** / Burn > 20 % body surface area
☐	**Transfert accepté par le TTL (à la discrétion du TTL)** / Trauma transfer accepted by TTL (at discretion of TTL)
Si aucun des critères mentionnés n'est présent, l'urgentologue peut activer à sa discrétion, en particulier : **→ si l'urgentologue, après une évaluation initiale, pense qu'une activation est nécessaire;** **→ si l'urgentologue ne peut prendre en charge un patient traumatisé à cause de la charge de travail dans la salle d'ambulance** If none of the above criteria are present, the emergency department physician may activate at his/her discretion, in particular: → if the emergency staff, after an initial assessment feel that the patient requires a TTA, this will occur if the emergency department physician is unable to attend to a trauma patient due to increased workload in the ambulance room	

Critère de consultation en traumatologie (cochez tout ce qui s'applique)
Trauma Consult Criteria (check all those that apply)

☐	**Saignement intracrânien / fracture de la base du crâne /** Traumatic intracranial bleed / basilar skull fracture
☐	**GCS < 10 à l'urgence (excluant CVM) /** GCS < 10 in the emergency department (excluding MVC mechanism)
☐	**Preuve de lésion de la moelle épinière /** Evidence of spinal cord injury
☐	**Fracture instable de la colonne vertébrale /** Unstable spinal column injury
☐	**Médiastin élargi avec mécanisme significatif /** Wide mediastinum with a significant mechanism of injury
☐	**Trauma abdominal non-pénétrant avec douleur à la palpation /** Blunt abdominal trauma with tenderness
☐	**Blessure significative à un simple système /** Significant injury to a single system: → **blessure viscérale à la tomographie /** solid organ injuy on CT scan → **volet thoracique / fracture de côtes multiples /** flail chest / multiple rib fractures
☐	**Blessures à deux systèmes ou plus /** Injuries to two or more body regions
☐	**Fractures du bassin /** Pelvis fractures
☐	**Fracture fémorale (excluant fracture de hanche isolée) /** Femur fracture (excluding isolated hip)
☐	**Blessure par balles aux extrémités /** Proximal extremity gunshot wound
☐	**Patiente enceinte > 20 semaines /** Pregnant patient > 20 weeks
☐	**Blessures thoraco-abdominale, patient doit être admis /** Thoraco-abdominal injury, patient needs admission
☐	**Si aucun des critères n'est présent, l'urgentologue peut consulter à sa discrétion /** If none of the above criteria are present, the emergency department physician may consult at his discretion

Appendix 3: Data Collection Form

DATA COLLECTION FORM: TRAUMA PATIENTS WITH PROLONGED PRE-HOSPITAL TIME

DEMOGRAPHICS:

Study ID Number:

Date of trauma: mm / dd / yyyy

Age (in years): Gender: male female X

Mechanism of injury: penetrating fall motor-vehicle cyclist assault pedestrian self-harm

Quebec pre-hospital trauma triage scale -EQTPQ level: step 1 step 2 step 3 step 4 step 5

PH transport time: minutes

Injury Severity Score: 0 - 75

Vital Signs:

PH: BP / HR RR Sat % O2

ED: BP / HR RR Sat % O2

Glascow Coma Scale (3-15): PH: ED:

Trauma Team Activation:

Was the trauma team activated with pre-hospital notification? (yes / no / unclear)

If yes, which criteria was met?

- Need for airway management
- Systolic BP < 90
- Penetrating injury to head, neck, or trunk
- Mangled extremity or amputation above wrist/ankle
- Need for PRBC in resuscitation
- Paralysis
- Burns >20% body surface area
- Discretion of the emergency department physician

Was the trauma team activated after arrival in the emergency department? (yes/no/unclear)

If yes, which criteria was met?

- Need for airway management
- Systolic BP < 90
- Penetrating injury to head, neck, or trunk
- Mangled extremity or amputation above wrist/ankle
- Need for PRBC in resuscitation
- Paralysis
- Burns >20% body surface area
- Discretion of the emergency department physician

Was the trauma team activation criteria met, but activation not done? (yes/no/unclear/NA)

If yes, which criteria was met?

- Need for airway management
- Systolic BP < 90
- Penetrating injury to head, neck, or trunk
- Mangled extremity or amputation above wrist/ankle
- Need for PRBC in resuscitation
- Paralysis
- Burns >20% body surface area
- Discretion of the emergency department physician

Consults:

Did the patient have a trauma consult during their stay in the emergency department? (yes/no)

If yes, which trauma consult criteria was met?

- Traumatic intracranial bleed/basilar skull fracture
- GCS <10 in the emergency department (excluding MVC)
- Evidence of spinal cord injury
- Unstable spinal column injury
- Wide mediastinum with significant mechanism of injury
- Blunt abdominal trauma with tenderness
- Significant injury to a single system: Solid organ injury on CT scan, Flail chest/multiple rib fractures
- Injuries to two or more body regions
- Pelvis fractures
- Femur fractures (excluding isolated hip)
- Proximal extremity gunshot wound
- Pregnant patient >20 weeks
- Thoraco-abdominal injury requiring injury
- emergency department physician's discretion

Did the patient have consults from other specialty services?

- Orthopedics
- Plastics
- Neuro-surgery

- Vascular
- Other

Triage Accuracy:

Was the patient over-triaged? (yes/no)

- On ISS score? (yes/no)
- On present TTA criteria? (yes/no)

Was patient under-triaged? (yes/no)

- On ISS score? (yes/no)
- On present TTA criteria? (yes/no)

Disposition:

What was the final disposition for the patient?

- Admission (to which service).
- Transfer to another institution.
- Discharge from the emergency department.
- Death in the emergency department.

Length of Stay:

Time spent in resuscitation room (in minutes)
Time from arrival in emergency department until CT scan (in minutes)
Time from arrival in emergency department to decision to admit or discharge (in minutes)
Length of stay in the emergency department (in minutes)

Reviewed by: Date:

Appendix 4: Certificate of Research Ethics Approval – Athabasca University

CERTIFICATION OF ETHICAL APPROVAL

The Athabasca University Research Ethics Board (REB) has reviewed and approved the research project noted below. The REB is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2) and Athabasca University Policy and Procedures.

Ethics File No.: **24272**

Principal Investigator:
Ms. Jeanesse Bourgeois, Graduate Student
Faculty of Health Disciplines\Master of Nursing

Supervisor:
Dr. Jennifer Knopp-Sihota (Supervisor)

Project Title:
Caring for Major Trauma Patients with Prolonged Pre-Hospital Times in the Emergency Department of a Level I Trauma Centre in Quebec, Canada

Effective Date: March 15, 2021 **Expiry Date**: March 14, 2022

Restrictions:

Any modification or amendment to the approved research must be submitted to the AUREB for approval.

Ethical approval is valid *for a period of one year*. An annual request for renewal must be submitted and approved by the above expiry date if a project is ongoing beyond one year.

A Project Completion (Final) Report must be submitted when the research is complete *(i.e. all participant contact and data collection is concluded, no follow-up with participants is anticipated and findings have been made available/provided to participants (if applicable))* or the research is terminated.

Approved by: **Date: March 15, 2021**

Barbara Wilson-Keates, Chair
Faculty of Health Disciplines, Departmental Ethics Review Committee

---

Athabasca University Research Ethics Board
University Research Services, Research Centre
1 University Drive, Athabasca AB Canada T9S 3A3
E-mail rebsec@athabascau.ca
Telephone: 780.213.2033

Appendix 5: Certificate of Research Ethics Approval – McGill University Health Centre

2021-05-25
Dr. Gregory Clark
email: greg.clark@muhc.mcgill.ca
Re: MUHC Authorization (Trauma team triage/activation / 2021-7693)

"Caring for Major Trauma Patients with Prolonged Pre-Hospital Times in the Emergency Department of a Level I Trauma Centre in Quebec, Canada"

Dear Dr. Clark,

We are writing to confirm that the study mentioned above has received research ethics board approval and all required institutional approvals, namely:

Access to adult health records

You are hereby authorized to conduct your research at the McGill University Health Centre (MUHC) as well as to initiate recruitment.

Please refer to the MUHC Study number in all future correspondence relating to this study.

In accordance with applicable policies it is the investigator's responsibility to ensure that the staff involved in the study is competent and qualified and, when required, has received certification to conduct clinical research.

Should you have any questions, please do not hesitate to contact the support for the Personne mandatée at personne.mandatee@muhc.mcgill.ca.

We wish you every success with the conduct of the research. Sincerely,

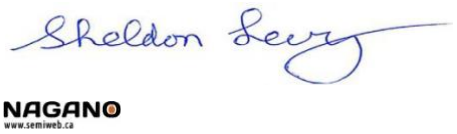
Mandatée (SL) Personne

Sheldon Levy

for:

Marie Hirtle, LL.B. LL.M.

Personne Mandatée
Centre Universitaire de Santé McGill



NAGANO
www.semiweb.ca

PM / Final Authorization Single Site 1 / 1

Exported on 2022-03-07 20:56 by Bourgeois, Jeanesse --- NAGANO VALIDATION CODE: muhc-e5e6af2d-5f9a-4ddd-b889-8873d61415b7https://muhc.nagano.ca/verification/muhc-e5e6af2d-5f9a-4ddd-b889-8873d61415b7

*Ethics approval from the McGill University Health Center (MUHC) requires a local investigator with MUHC research privileges to oversee research projects. For this, the name of the local investigator goes on the ethics application and approval.