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Trauma Systems in Canada: Evolution, Challenges, and Strategies for Improving Trauma Care for Rural Patients

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ABSTRACT

This thesis explores the development and current state of trauma systems in Canada, emphasizing the challenges and disparities faced by patients who are injured in rural areas. With trauma being the leading cause of death for Canadians under 40, effective trauma systems are crucial. However, patients injured in rural and remote areas face significant barriers to timely and adequate trauma care, resulting in increased morbidity and mortality. This body of work aims to evaluate some of these disparities and propose strategies for improvement.

The concept of organized trauma systems has its roots in ancient wartime practices, evolving significantly over centuries. Despite significant progress, rural trauma care in Canada remains challenging. Approximately 20% of the Canadian population resides more than one hour away from a Level I or II trauma center. This geographical disparity significantly impacts the timely delivery of trauma care.

To begin to address some of these challenges, this thesis consists of four interconnected projects aimed at addressing rural trauma care disparities:

Historical Review of the Development of Trauma Systems: This comprehensive literature review traces the evolution of trauma systems from their earliest conception to their modern iterations. The goal is to demonstrate how the continuous evolution of trauma systems influences the delivery of trauma care today. It highlights the need for continuous improvement to enhance current systems and ensure care for those who are underrepresented within existing frameworks.

Reinforcing the Role of Rural Trauma Laparotomy: This retrospective matched cohort study compares outcomes of patients undergoing damage control laparotomy

(DCL) at rural hospitals (RH) prior to transfer to lead trauma hospitals (LTH) with those directly admitted to LTHs. The hypothesis is that timely DCL at RHs is associated with comparable outcomes to DCL completed at LTHs. Twenty-one patients who underwent RH-DCL before being transferred to a LTH were compared to 21 matched patients who received DCL directly at the LTH. Analysis demonstrated no statistically significant difference in abdominal-specific complications including surgical site infection, anastomotic leak, and fistula formation. Secondary outcomes including ICU length of stay, overall hospital length of stay, and mortality rates were also similar between the two groups. These findings suggest that with proper training and support, RHs can effectively perform DCL, potentially improving outcomes by reducing delays in hemorrhage and contamination control.

Evaluating the Impact of Advanced Trauma-Team Leader Notification: This pre-post-intervention cohort study assessed a recent policy change in Ontario requiring advanced notification of trauma team leaders (TTL) for incoming hemodynamically unstable patients. By comparing patient outcomes before and after the policy implementation, the study aims to identify the benefits of early TTL involvement, and to serve as a pilot for a larger provincial study. Results indicated a trend towards significance in reduction in time to critical interventions, such as surgery or chest tube placement, following the policy change. The completion of this study solidified methodology to allow for inclusion of the remining four level 1 equivalent trauma centres in the province to address the provincial impact of this new policy.

Survey of Ontario Surgeons and Trauma Directors: These two related but distinct surveys address perspectives of community general surgeons and trauma medical directors (TMDs) with respect to their understanding of the above-mentioned policy change, and to identify perceived barriers to delivering trauma care in rural settings. The survey revealed a varying level of awareness and comfort regarding the new protocols. Community surgeons captured in the study appear to be comfortable in performing emergency surgery for trauma patients, however, barriers such as blood product availability and timely transport were identified. Additionally, TMDs highlighted the challenges in maintaining consistent communication and coordination with RHs and felt that there was a lack of comfort preventing community surgeons from performing emergent surgery for trauma patients. The survey underscored the need for standardized training programs, improved resource allocation, and robust communication systems to ensure rural healthcare providers are well-equipped to handle severe trauma cases.

This thesis underscores some of the unique challenges in improving trauma care for rural populations in Canada. Despite advancements in trauma systems and the establishment of designated trauma centers, geographic and resource-based disparities continue to hinder the delivery of timely and effective care to rural trauma patients. The results of the work contained in this thesis provide data to support opportunities for improvement in care provided at a population level to minimize the impact of severe injury.

LAY SUMMARY

Trauma is the leading cause of death for Canadians under the age of 40. While many people live close to hospitals that specialize in treating severe injuries, those living in rural and remote areas often face significant challenges in getting the urgent care they need. This research aims to understand these challenges and find ways to improve trauma care for rural Canadians.

The first part of the research looked at whether rural hospitals can effectively perform emergency surgery to control severe abdominal bleeding before transferring patients to larger trauma centers. We found that rural hospitals have successfully performed these surgeries with outcomes similar to those patients who initially present to a trauma-designated hospital in an urban area.

We then examined the impact of notifying trauma teams at urban lead-trauma hospitals in advance about incoming patients with severe injuries. The research, designed to be a pilot study testing methodology for a larger, provincial study, showed that early notification may allow trauma teams to prepare better and act faster when the patient arrives, leading to decreased times to potentially lifesaving intervention such as surgery.

The third part involved surveying surgeons in rural areas and trauma leaders in Ontario to understand the perceived challenges impacting rural hospitals. We showed that trauma leaders in Ontario perceive rural surgeon comfort to be a significant barrier in these patients receiving necessary surgery in rural hospitals. Further, while community surgeons felt that comfort was not an issue, barriers such as availability of blood products, surgical assistants, and timely transport may decreased their willingness to performing these operations.

This research, comprised of mainly pilot work, highlights the need to improve trauma care for rural Canadians, who often do not receive the same level of care as those in urban areas.

By ensuring improved communication and coordination with larger trauma centers, and continually updating trauma care practices, we can provide better care to all Canadians, regardless of where they live.

CO-AUTHORSHIP

While this thesis represents my original work, the contributions of the following individuals cannot be understated.

Kelly Vogt, MD, MSc, FRCSC, acted as my supervisor and mentor. She was instrumental in encouraging me to complete this master's thesis and her encouragement was unwavering from its conception to completion. She provided direction and original ideas in the design of all four projects, assisted with obtaining data for collection and review, guided and taught me how to do data analysis, and provided insightful feedback and comments throughout the writing process.

Daryl Gray, MD, FRCSC, acted as my supervisor and mentor. His experience and wisdom surrounding trauma care provided significant contribution to the realization and design of all projects. He provided careful insight into the design of the projects to address our specific research questions, thoughtful commentary and suggestions during the writing process, and was particularly encouraging in developing my ability to present this research in a meaningful manner.

Brad Moffat, MD, MSC, FRCSC, acted as a member of my thesis committee, and mentor. He provided a particular passion for the care of underserved populations in Canada and significant guidance regarding how we can address these disparities through our research. He was instrumental in the writing process with an impressive attention to detail and continues to offer ongoing support for future work in this field.

Laura Allen, MSc, acted as a vital member of our research team especially with respect to study design, data collection and analysis. She continues to offer me thoughtful guidance in becoming a clinical researcher allowing me to perform data analysis independently while simultaneously ensuring my work is accurate and correct.

ACKNOWLEDGMENTS

While the magnitude of my gratitude is difficult to capture in two pages, I will make an earnest attempt as without the support, guidance, mentorship, friendship, and love provided by the following people, this work would never have been realized.

Early in my educational journey to become a General Surgeon, Dr. Kelly Vogt became my research supervisor as we embarked to explore the role of rural trauma laparotomy. As our initial ideas continued to expand (and eventually became the enclosed), so did her importance in my development as a scholar and clinician. Over the past two years, she has offered me with an immeasurable amount of support and encouragement to achieve nothing short of excellence in our research and in my development as a skilled, knowledgeable, and caring surgeon, demonstrating each of these characteristics with grace in her daily work. While the submission of this thesis closes one chapter in my own research endeavours, I am excited to continue to learn and grow under her guidance.

Dr. Daryl Gray's particular passion for surgical education and expectation of excellence from his residents has been a major catalyst for the motivation to complete the enclosed work and to become the best possible surgeon I can. He continues to offer candid, thoughtful advice regarding my research based in a foundation of knowledge gained only through lived experience. I am excited to continue to learn from him in my own personal pursuit of excellence in research and surgery.

Although quiet in volume, Dr. Brad Moffat's support of my research and surgical education has been resoundingly loud. His passion for learning about and providing service for the underserved, especially the Indigenous population in Canada, should be modeled by all clinicians and researchers. I look forward to continuing to learn under his thoughtful mentorship.

Laura Allen offered me with an invaluable base of knowledge and skill as it pertained to research design and data analysis. She navigates her role in supporting research in the Department of General Surgery with utmost kindness despite our often-late submissions. Her dedication to our research cannot be understated and I look forward to ongoing collaboration.

Lastly, the Department of General Surgery has been immeasurably supportive of my work and in helping me continue to achieve my future career goals. I want to extend special thanks to Dr. JulieAnn VanKoughnett who guides all of her residents in a caring, individualized manner while ensuring our success in becoming the best general surgeons.

While the aforementioned all represent my professional support, my support outside of research and the hospital have been nothing short of a necessity in all my accomplishments. To my parents, thank you for modelling what it means to be a hard-working, caring, kind individual and providing me with unending and relentless support in all of my lifelong endeavours. Without the both of you, I would not be the athlete, musician, doctor, surgeon, partner or person I have become.

Lastly, and most importantly, to my life partner, Jenna. I cannot express the gratitude I possess for your support of my (many and varied) life endeavours. Even without medical knowledge, your wisdom has been a cornerstone of the enclosed work. More importantly though, your patience and love has been a cornerstone of all I have achieved and for that, I thank you endlessly.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

APC, after policy change

ASG, Auxiliary Surgical Groups

ATLS, Advanced Trauma Life Support

BPC, before policy change

CCI, Charleston Comorbidity Index

CI, confidence interval

CNS, central nervous system

DCL, damage control laparotomy

DCS, damage control surgery

DTB, door to balloon

ED, emergency department

GCS, Glasgow Coma Scale

GIS, geographic information systems

ICU, intensive care unit

ISS, injury severity score

LHSC, London Health Sciences Center

LTH, lead-trauma hospital

LTH-DCL, lead-trauma hospital damage control laparotomy

MASH, Mobile Army Surgical Hospitals

MI, myocardial infarction

OAGS, Ontario Association of General Surgeons

OR, odds ratio

PRBCs, packed red blood cells

RH, rural hospital

RH-DCL, rural hospital damage control laparotomy

SBP, systolic blood pressure

SSI, surgical site infection

TAC, Trauma Association of Canada

TMD, trauma medical director

TRISS, trauma injury severity score

TTL, trauma-team leader

Chapter 1

Background and Historical Review of the Development of Trauma Systems

Chapter 1. Background and Historical Review of the Development of Trauma Systems

1.1 Introduction

A systemized and subsequently regionalized approach to trauma care in Canada is a recent development only adopted from the U.S. over the past 50 years. Its inception in the U.S. found its roots through lessons learned from war, but its implementation and recognition began with the "white paper" from the National Committee on Shock and Trauma in 1966. This was a national call to action whereby accidental death was deemed a "neglected disease of modern society" with its origins rooted in "ineffective nonsystems."(1) Through the recommendations made in this report and the subsequent efforts of the American College of Surgeons Committee on Trauma and the Trauma Association of Canada, the past 50 years have seen great advancement in the care of the injured patient in North America.(2)

Despite these efforts, injury remains the leading cause of death and life-years lost for Canadians under the age of 40 with nearly 200,000 Canadians hospitalized each year due to trauma.(3) Furthermore, national healthcare spending in direct and indirect costs related to trauma are estimated to be nearly $20 million, ranking second only to cardiovascular disease.(2,3)

The burden of the significant morbidity and mortality caused by trauma is accentuated when considering populations in rural and remote areas. Despite endeavors to deliver effective trauma care through trauma systems, the advantages of these initiatives still elude specific populations. Labelling the issue as the "tyranny of distance and geography" in their work examining equity within Canadian trauma systems, Zakrison et. al argue that although the establishment of regionalized trauma systems in Canada has been an overall success there

remains significant disparities impacting Canadians living in rural and remote areas.(4) Limited data from Canada exists to determine the exact magnitude of these urban-rural disparities, but studies from the U.S. show that sustaining trauma in a rural setting is associated with significantly increased morbidity and mortality.(5,6) To quantify this risk, one American study quotes a 50% higher mortality for patients who experience trauma in sparsely populated areas and are subsequently treated at a rural hospital.(7) It is estimated that 22.5% or over 7 million Canadians reside in a location that is over a 1-hour drive to a level 1 or level II trauma center.(2) Given this, there remains a significant disparity in the timely and effective delivery of trauma care for numerous Canadians.

While it constitutes just one part of the comprehensive care provided to the trauma patient, ensuring access to timely surgical intervention in rural trauma settings remains a critical concern in guaranteeing the delivery of safe and appropriate care for these patients. Damage control surgery (DCS) is a key tenant of surgical trauma care for patients presenting with hemodynamic instability and bleeding. Local practice in Southwestern Ontario dictates that for hemodynamically unstable patients in a rural setting, we should attempt to promote DCS at the referring community hospital prior to transfer to our lead-trauma hospital (LTH) as a means for timely control of hemorrhage and contamination. Anecdotally, we are aware, however, that practice patterns and comfort level surrounding this procedure varies amongst rural hospitals (RH) across Ontario. There are also practice differences amongst LTHs in the province, with some promoting for earlier transfer rather than surgery at RHs. This practice, however, has not been systematically evaluated. Further, potential barriers in communication – specifically in the form of advanced pre-hospital notification of hemodynamically unstable trauma patients being transferred to a LTH – may limit the opportunity to advocate for DCS when it may be indicated.

1.2 The Advent of Trauma Systems and Transport

1.2.1 Defining the Foundations of a Trauma System

The modern trauma systems, like many facets of medical practice, originated as a responsive solution to what was initially perceived as an epidemic of severely injured patients receiving insufficient care, oftentimes resulting in unnecessary and severe illness and death. Tracing its origins to ancient wartime practices, specifically dating back to the Roman Empire, trauma systems have evolved into highly efficient, research-based models of care. This historical narrative underscores the evolution, and improvements made in trauma care, acknowledging the complexities and challenges faced during its conception. By understanding this history, it becomes possible to appreciate the fundamental principles that underpin the creation of effective trauma systems. Further, by examining, understanding, and applying the history and principles surrounding trauma system development, we can continue to identify issues and devise solutions to improve the care for rural trauma patients.

The development of trauma systems is a culmination of extensive wartime medical experiences, subject to continuous transformation and evolution. While this evolution frequently reflects advancements in technology and burgeoning medical insights, a return to the earliest days of trauma care reveals enduring principles that remain pillars of contemporary trauma systems. These include timely access to definitive management, regionalization of care, the establishment and maintenance of trauma registries in conjunction with research and the comprehensive education and training of healthcare providers.

Despite not always being explicitly named, the concept of the "golden hour" in trauma care has been a pivotal element since the Ancient Greeks first documented their wartime medical practices. Now considered one of the most widely accepted dogmas in trauma care, the “golden

hour" refers to the critical time from injury to a setting where medical care that is focused on the biggest threats to life can be provided.(8) When considering the widely cited "trimodal distribution of trauma death", the "golden hour" falls within the second peak which occurs within minutes to hours following injury (Figure 1.1).(8) In fact, the "golden hour" of lifesaving trauma care is the basis for the entire Advanced Trauma Life Support Course (ATLS) which focuses on providing quality education and training to medical providers who may be providing trauma care to injuries that are an immediate threat to life. Although the exact timing of the 60-minute window has been become a point of contention, there continues to be extensive consensus amongst scholars, policymakers, and most of all, trauma providers that time to intervention is a crucial aspect of an effective trauma system.

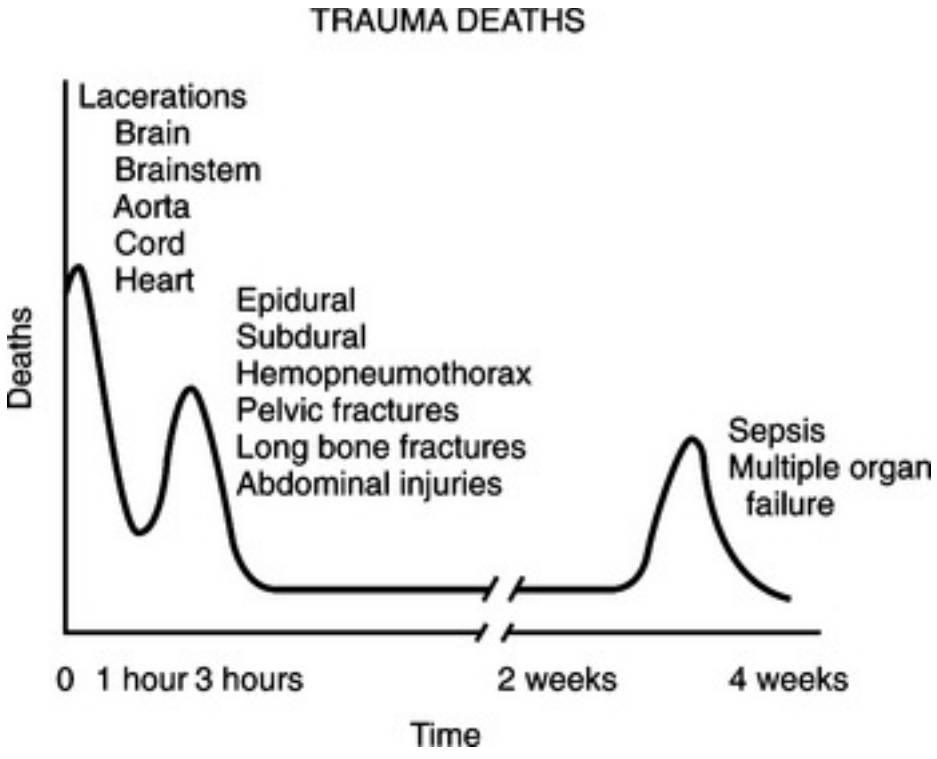

Figure 1.1: The trimodal distribution of trauma deaths

The regionalization of trauma care, a vital facet of trauma systems, was first conceptualized during the American Civil War and has been continually refined since then. The term itself refers to the formation of coordinated systems of care across geographical areas that combine all necessary components (including pre-hospital, in-hospital, and public health factors) to optimize patient outcomes.(9) This is generally done through the process of *categorization* and *designation*.(9) Categorization refers to the classification of facility capabilities against accepted standards.(9) Designation refers to the formal selection for patient referral and transfer by an organized body that has the authority to do so (i.e., Trauma Association of Canada).(9) This approach to trauma care, rooted in historical practice and refined through continuous improvement, underscores the importance of a structured and collaborative network. It ensures that patients receive the highest standard of care in a timely manner tailored to the specific capabilities of each facility.

While the other two major facets of trauma systems, education and research, as revealed through historical examination, may not necessitate the precise definitions attributed to concepts like the "golden hour" or regionalization, their significance to the effectiveness and evolution of trauma care systems is profoundly impactful and should not be underestimated.

1.2.2 Ancient Trauma Epidemiology and Surgical Education

The advent of medical records actually pre-dates the Ancient Romans and Greeks with records of early attempts at cranial surgery in the form of trepanation (or what today we would call burr holes) for blunt head injury being depicted in Ancient Egyptian texts from the seventeenth century B.C.(10) However, our first fully formed perspective of trauma systems is in Homer's seventh-century B.C. epic recounting the Trojan War, the *Iliad*. In it, Homer documents

the earliest recorded acknowledgment of the need for trauma systems due to a large influx of severely injured patients, particularly soldiers.(1)

This literary work also serves as the earliest form of a trauma registry as Homer endeavors to identify injury patterns and adapt war tactics to provide care for soldiers ultimately aiming to prevent and treat severe injuries during ancient wartime.(1) Homer quotes a 77% mortality rate from injury among the 147 different types of wounds inflicted upon Achean and Trojan soldiers.(1,11) Upon acknowledging this alarming mortality rate, the ancient Greeks realized the significance of establishing organized systems to manage mass casualties.(1) They developed specialized transport systems and care facilities called “klisiai” and offshore ships dedicated to treating the wounded away from the areas of turmoil.(11)

Recently, contemporary scholars have re-examined Homer's text using the perspective of a modern trauma registry, revealing that his documentation of trauma surpasses the commonly cited epidemiology of the Trojan War presented above.(12) In fact, through modern epidemiological approaches to trauma, Chicco et. al attempt to determine a true victor of the Trojan War through Homer’s accounts.(12) Figure 1.2 shows a univariate analysis completed by the authors demonstrating how Homer’s records of this war, and its subsequent trauma can be applied to our modern practices of trauma record keeping and statistics.

Building on the practices of the Trojan War, Hippocrates further documents early, more advanced trauma systems in the medical care of the Roman Legions in 100 A.D.(1) The Roman soldiers all had basic training in first aid to provide field level care for wounded soldiers, developed the earliest ambulances and had effectively surgeon-traumatologists on call 24 hours a day in recognition of the unpredictable nature of trauma.(1) Further, Hippocrates recognized wartime and trauma care as the ultimate school for early surgeons.(1)

The ancient Greek development of methods for transporting injured soldiers, the creation of field hospitals, and the emphasis on observing and documenting injury patterns highlight the early conceptualization of trauma systems and registries. These origins trace back to the earliest recorded instances of mass casualty, stressing the essential need for swift, effective care and the continuous improvement of such care.

Table 2 Univariate analysis (Chi-square test)

	Total	Mortality[a]	Survival[a]	*p*
Field				
Achaeans	39 (26.4%)	24 (61.5%)	15 (38.5%)	< 0.001
Trojans	109 (73.6%)	101 (92.7%)	8 (7.3%)	
Agent				
Spear	105 (70.9%)	93 (88.6%)	12 (11.4%)	0.001
Sword	15 (10.1%)	15 (100%)	0	
Arrow	12 (8.1%)	6 (50%)	6 (50%)	
Rock	8 (5.4%)	5 (62.5%)	3 (37.5%)	
Multiple/other	8 (5.4%)	6 (75%)	2 (25%)	
Mechanism				
Blunt	12 (8.1%)	6 (50%)	6 (50%)	0.002
Penetrating	130 (87.8%)	113 (86.9%)	17 (13.1%)	
Multiple	6 (4.1%)	6 (100%)	0	
NISS ranks				
Mild < 15	22 (15.2%)	0	22 (100%)	
Moderate 15–25	89 (61.4%)	88 (98.9%)	1 (1.1%)	< 0.001
Severe > 25	34 (23.4%)	34 (100%)	0	
Body system				
External	2 (1.4%)	0	2 (100%)	< 0.001
Limbs	31 (20.9%)	16 (51.6%)	15 (48.4%)	
Head–Neck	40 (27%)	37 (92.5%)	3 (7.5%)	
Chest	24 (16.2%)	23 (95.8%)	1 (4.2%)	
Abdomen	24 (16.2%)	24 (100%)	0	
Multiple	24 (16.2%)	22 (91.7%)	2 (8.3%)	
Unknown	3 (2%)	3 (100%)	0	

[a]Percentages within row

Figure 1.2: A modern representation of trauma recorded in Homer's Iliad(12)

1.2.3 Napoleonic Wars: The Father of Military Surgery

The history of treating severely injured patients, resulting from warfare and various other causes, dates to the eras of Homer and Hippocrates. However, significant strides toward establishing trauma systems that resemble today's organized care structures only began to emerge in the late eighteenth and early nineteenth centuries.

Dominique-Jean Larrey, often hailed as the father of military surgery and systematic trauma care, earned this distinction through his significant contributions to organized wartime medical care extending his services not only to French soldiers but also their adversaries during the Napoleonic wars. Napoleon Bonaparte, in recognition of Larrey's extraordinary virtues, once referred to him as the “most virtuous man” he had ever known.(1) In his comprehensive journals, Larrey documented the clinical progression of tetanus, the pathophysiology of hypothermia and its impact on injuries, techniques for hemorrhage control, drainage of empyema and hemothorax, early pericardial aspiration, and the packing of chest wounds.(13) Despite these remarkable advancements in trauma and surgical care, it is his specific contributions to trauma systems, including the earliest forms of emergent patient transport and triage design, that have firmly established his enduring legacy in medical history.

Until the late Napoleonic wars, wounded soldiers often remained on the battlefield until the conclusion of the engagement, which could extend for more than 24 hours. It was only then that fellow soldiers would collect them and attempt to transport them to a medical facility, often located at a considerable distance.(13) There were some efforts to transport medical facilities closer to the fighting, but the rules of engagement mandated that they remain at least five kilometers away from the army.(1) This restriction posed significant challenges for the timely

transportation of wounded soldiers, resulting in many succumbing to their injuries before reaching field hospitals.(1)

Recognizing this as a major barrier to accessing care, Larrey conceived the idea of an ambulance that was adequate to help the wounded during the actual battle.(1) He called these flexible medical units “ambulances volantes,” which translates to “flying ambulance,” aptly named for their mobility on the battlefield.

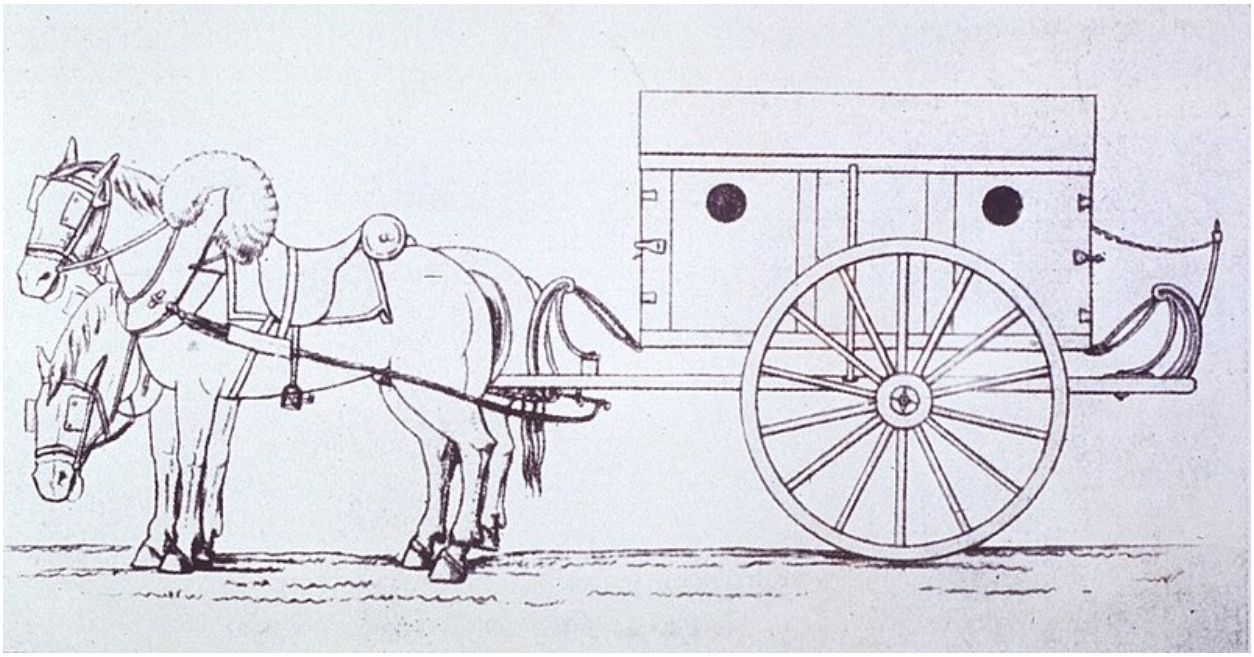

Figure 1.3: Rendition of Larrey’s Flying Ambulance(14)

Mimicking the design of the French’s “flying artillery” which were known for their swift maneuvering on the battlefield, Larrey placed the carriages on springs to minimize patient and caregiver disturbance from often rough terrain.(13) They could easily carry two patients side-by-side at full length with enough room still for the attending medical officers to perform oftentimes lifesaving interventions in the field as the patients were transferred to dressing stations or permanent care fixtures stationed at the rear of the faction.(13)

They were initially tested in the Battle of Metz in 1793 where they were an overwhelming success with noticeably increased chances of survival amongst wounded soldiers and increased morale amongst French soldiers.(13) In response to the success at their initial showcase, Larrey's design was adopted and employed across the entire French army and used on a massive scale for the first time during the campaign of Italy in 1796 led by Napoleon Bonaparte.(13)

Larrey's invention was the first iteration of emergency medical transport in austere environments and reflected his recognition of the necessity of prompt and definitive care for trauma patients. On this topic, Larrey writes, "the first 24 hours is the only period during which the systems remain tranquil, and we should hasten during this time, as in all dangerous diseases, to adopt the necessary remedy."(13) Building on this, Larrey wrote extensively about his observations surrounding patients with instability caused by a severely wounded extremity. In fact, he notes that he was fearful of taking patients directly to field hospitals, ultimately delaying surgery for wounded limbs and increasing the risk of infection and advocated for early amputation for these patients.(13)

As an extension of his values regarding prompt care for trauma patients, Larrey is credited with establishing a precedent-shattering rule for the sorting of injured soldiers according to the observed severity of their injuries and need for medical care, regardless of military rank.(13) In other words, Larrey developed the first iteration of a trauma triage system.

Napoleonic historians have extensively documented Larrey's medical innovations, which significantly bolstered French miliary successes. Some argue that his efficient medical organization, the introduction of early triage, and humane treatment of the injured, regardless of national identity, were pivotal in several French victories.(13)

Analyzing his contributions from a contemporary perspective reveals that Larrey was the initial catalyst for several key principles of modern trauma care. His “flying ambulances” represented the earliest form of rapid emergency patient transport, underscoring the dire importance of prompt access to definitive care or damage control in trauma. Furthermore, his advocacy for early amputation is echoed in modern ideals surrounding DCS as he emphasized the necessity of rapid hemorrhage management and control of contamination to prevent potentially devastating consequences of these injures. Lastly, his conception of triage standards in war is an early iteration of what has become a standard amongst all facets of medical care, not just trauma. Collectively, these contributions establish the foundation for our current models of trauma systems in nearly all facets of care, influencing everything from direct patient care to broader organizational aspects like patient transport and triage protocols.

1.2.4 American Civil War

As a response to significant advances in firearms and subsequently devastating injury with over 2% of the entire population dying during the conflict, Americans during the Civil War were forced to employ extensive infrastructure in order support medical professionals in their care for wounded soldiers.(1,15) Although the Napoleonic Wars demonstrated various levels of care for wounded soldiers, this only really extended to the field hospitals located just outside the battlefield. Recognizing that this structure could not support the massive casualties largely caused by the development of more advanced firearms, Americans on both sides of the conflict developed various levels of care centers.(1)

Similar to previous wars, there were care centers within kilometres of the battlefield that were strategically located near creeks to provide water that was vital to the care of the injured soldiers.(1) These were referred to as “regimental hospitals.”(1) However, when numerous

regimental hospitals were involved in the same battle, they often banded together to form what was then known as a "brigade hospital."(1) Beyond this, the next level of treatment for severely injured patients who were able to be transferred was a "division hospital" and the ultimate care center was the "general hospital."(1) The latter two levels of care were generally stationed in larger cities and required transfer of soldiers by train or ship.(15)

In addition to this, given the massive mortality occurring during the American Civil War, President Abraham Lincoln recognized the necessity of creating trauma care standards and the utility of reporting injury patterns and their associated morbidity and mortality.(1) In other words, Lincoln was advocating for the development of one of the earliest trauma manuals and registries. Following the war, the Union published the "Medical and Surgical History of the War of the Rebellion" in a six-volume set reporting the epidemiology of injuries and mortalities that occurred during the rebellion.(1)

Driven by dramatically increased morbidity and mortality because of progressively more destructive weapons, the American Civil War played host to two major developments which, as previously described, are now considered cornerstones of modern-day trauma systems: regionalized care centers and trauma registries. Although their approach to regionalized care is a battlefield-centric model and is not directly transferable to peacetime technological advancements in injury causation, the system created correctly identified the importance of various levels of care and their role in caring for severely injured patients. Moreover, the creation of the first dedicated trauma registry again reflects early recognition of the importance of trauma epidemiology and its role in improving care.

1.2.5 World War I

With its staggering 20 million casualties, the First World War unsurprisingly laid a critical foundation for today's civilian trauma systems. The most significant advancement in trauma care at the time arose from mechanical innovations—specifically, the transformation of patient transport.(1) Vehicles that were once horse-drawn were replaced by motorized ambulances, enabling faster and more efficient modes of transporting the severely injured patient.(16)

This invention allowed militaries to expand on previously established patient evacuation systems and care pathways for injured soldiers. As mentioned previously, the American Civil War was the first to establish a model of regionalized, tiered trauma care; however, due to its massive amount of morbidity and mortality, medical personnel during the First World War were forced to devise a system that could be employed on a global stage. This was largely made possible by massive advances in means of transport.

Figure 1.4 illustrates an evacuation chain for the Americans wounded during the First World War. The various tiers were referred to as “echelons” of treatment whereby each level of care granted injured soldiers with greater treatment capacity. The first tier involved injured soldiers being transported from the frontlines by stretcher-bearers to “regimental aid stations” or “dressing stations.”(16) Initial treatments including narcotic administration, control of obvious hemorrhage and splinting of fractures were completed at this stage and following this, a decision was made by the physician on whether the patient would return to the frontlines or move to a higher treatment facility.(1) The seriously wounded were then evacuated to clearing stations where surgeons would perform emergency surgery, mainly consisting of debridement of severe

wounds.(1) Definitive care was then delivered at base hospitals with the main goal of treatment being for the injured to eventually return to the battlefield.(16)

An additional contribution from the First World War is the concept of a blood bank. It was during this time that surgeons began treating hemorrhagic shock with whole blood transfusion and one surgeon, Oswald H. Robertson, began storing citrated blood on ice to use during times of battle.(16)

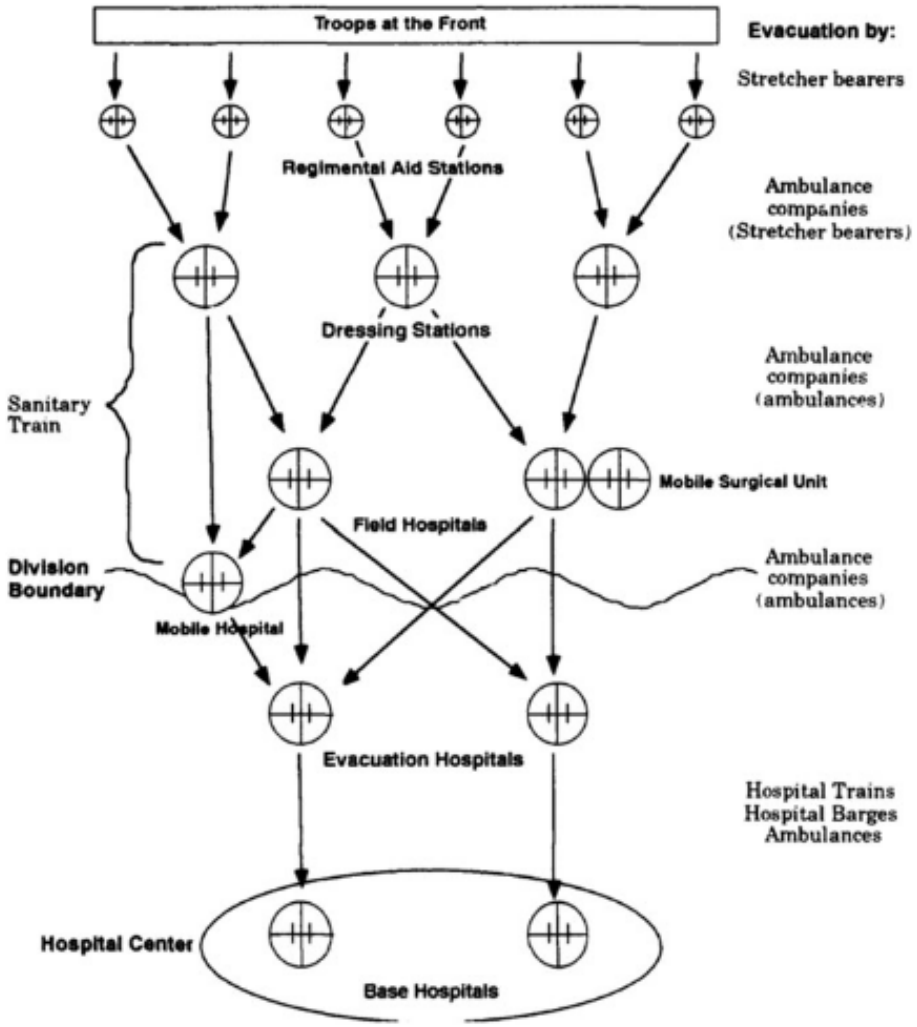

Figure 1.4: American evacuation chain for the wounded during World War I(16)

The tiered trauma care system, first introduced during the American Civil War, was expanded significantly due to the extensive casualties of World War I. This period saw not only the large-scale application of these trauma systems but also significant advances in transport technologies and the pioneering of blood transfusions. The trauma care protocols developed during World War I laid the groundwork for the sophisticated mass civilian trauma systems we rely on today.

1.2.6 World War II

Although civilian death because of war was not a new concept, its widespread recognition by government bodies did not occur until the Second World War. For the first time, the British government consolidated its resources to provide trauma care indiscriminately to both civilians and military personnel.(1)

As we have seen previously with trauma care organization, the British government divided care centers into factions, but now with the care of citizens and not just soldiers in mind. There were three classes of hospitals based on the resources and services they provided.(1) Class 1A hospitals were those with over 50 beds and full surgical capabilities.(1) There were also class 1B facilities that were smaller than 50 beds, but still possessed surgical capabilities.(1) Class 2 were hospitals designed for convalescence of injured patients and chronic medical disease and Class 3 were designated infectious disease hospitals.(1)

In his book, Principles and Practice of War Surgery written in 1943, Josep Trueta writes, “Surgical aid to casualties in the frontline is impeded by many factors and has to be adapted to varying conditions, but the main basis of success is to have the wounded patient on the operating table at the earliest possible moment.”(1) Despite advances in the motorized medical transport system during World War I, the average time to definitive care remained to be approximately 12

hours.(1) The solution to this delay – and the high number of casualties from both Axis and Allied forces – came during World War II with the advent of aeromedical evacuation thus decreasing the time to definitive care and overall mortality following injury. The primary mode of aeromedical transport was by airplane, which presented ongoing challenges in remote areas far from established airfields. Despite this, in conjunction with advances in anti-sepsis techniques, resuscitation, and DCS, the time to definitive care was reduced by 50% and thus mortality rates also fell significantly.(17) These developments also enabled the global transportation of injured civilians and soldiers for specialized care.(17)

The advent of the helicopter occurred during the Second World War, however, its use in combat for medical evacuation was sparse.(17) Despite this, its use did prove it to be exceptionally useful in transferring patients to care destinations and thus set the stage for what would become the standard for aeromedical patient transport.

1.2.7 Korean War

Perhaps the most significant advancement in military and trauma surgery emerging from the Korean War was the introduction of Mobile Army Surgical Hospitals (MASH). This innovation addressed the shortcomings observed in World War II, where immediate care for troops was often inadequate. In that conflict, despite progress in aeromedical evacuation, Class 1A field hospitals were typically located far from the front lines, resulting in prolonged transport times that frequently proved too long for the most critically injured soldiers to survive.(18)

During the latter part of World War II, there were initial attempts to establish primitive versions of what would later be known as MASH units and were then known as Auxiliary Surgical Groups (ASGs).(18) These units, a concept developed by Dr. Michael DeBakey and his colleagues in the U.S. military's "surgical consultants division," were small, mobile and designed

to work alongside larger field and evacuation hospitals.(18) An ASG typically comprised a chief surgeon, an assistant surgeon, an anesthesiologist, a surgical nurse, and two enlisted technicians with most surgeons in these units having under three years of surgical training.(18) Despite their relative inexperience, these units were remarkably effective in providing immediate and essential care to severely wounded soldiers.(18) The success of ASGs during World War II led to their evolution into MASH units, which were renamed and extensively deployed for the first time during the Korean War in 1950.

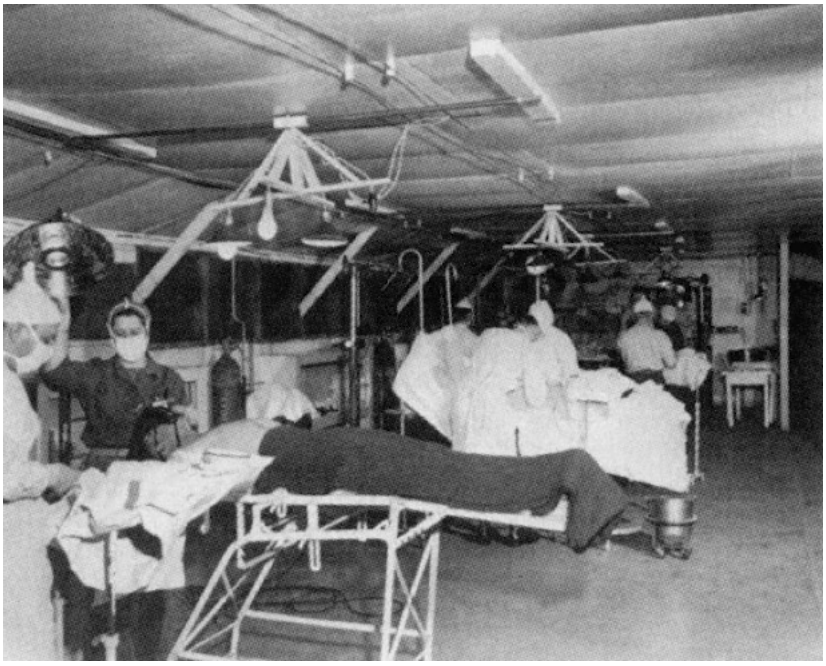

Figure 1.5: Surgery being performed at the 1st MASH in Korea(18)

Ten MASH units supported the four Army divisions during the Korean War comprised of 15,000-20,000 soldiers per division. The experiences drawn from the deployment of these units resulted in massive advances in resuscitation and trauma care, patient transport, blood storage and distribution, patient triage, and evacuation.(18) Perhaps the most crucial benefit of the addition of MASH units was that patients were now able to be transported to definitive care

within the “golden hour” of trauma thus decreasing the overall mortality experienced during the conflict.(1)

To facilitate the goal of ensuring patients received treatment within this crucial timeframe, the Korean War also marked the first large-scale deployment of helicopters for patient transport.(1) In 1951, the 8063rd MASH was the first unit to use helicopters for patient evacuation.(18) The Bell H-13 helicopter was the primary model used for medical evacuation whereby two patients were transported on skids placed outside each helicopter.(18) Recognizing then the utility of treatment and resuscitation during transport in 1953, Medical Officers were trained to pilot the helicopters and the aircrafts were modified to have patients transported within the vessel.(18)

Another cornerstone of trauma care that was initially conceived from the experiences of MASH units, was the importance of blood transfusion in the initial treatment of severely injured patients in shock. MASH surgeons performed numerous retrospective studies during the ongoing conflict and discovered that intravenous vasoconstrictors were inferior to blood products in the resuscitation of hemorrhagic shock.(18) Additionally, they noted the importance of warming the injured patient and the impact that hypothermia had on coagulation.(18) These studies set the stage for the development of blood programs during the Korean War whereby type-O blood was shipped directly from the continental United States to Korea by air.(18)

Other notable advancements to trauma surgery during the Korean War, all of which were made possible by the development of MASH units, were advancements in immediate debridement and irrigation of wounds, initial attempts at major vascular reconstruction leading to higher rates of limb salvage, and the use of narcotics for induction with nitrous oxide becoming the most widely used anesthetic.(18)

Regarding the evolution of trauma systems, the Korean War represented a significant advancement towards contemporary care models. The introduction of MASH units and helicopter medical evacuation underscored the critical importance of rapid access to definitive care. As these trauma systems were further incorporated into civilian healthcare in the United States, the invaluable lessons gleaned from this conflict played a central role in their ongoing development.

1.2.8 Vietnam War

The full potential of helicopters for medical evacuation was significantly realized and extensively employed during the Vietnam War. Due to the challenging mountainous terrain and the Viet Cong's adept use of guerrilla tactics, which were unfamiliar to American forces, the need for helicopters for medical evacuation in Vietnam was greater than in any previous conflict. In addition to their use on a larger scale, medical evacuation destinations depending on injury severity patterns were refined. Recognizing that time to care was of utmost importance for the severely injured patient, helicopters would bypass battalion and regimental aid stations in favor of larger hospitals where definitive surgical care could be deployed.(1)

The progression of in-flight technology enabled a strategic shift in healthcare during the Vietnam War. It allowed for the bypass of closer aid stations without significantly extending flight times, ensuring that even severely injured trauma patients could reach care destinations within the critical "golden hour" of trauma treatment. This advancement was crucial in maintaining the effectiveness of rapid medical evacuation despite the longer distances covered.

In addition to locoregional medical evacuation for wounded soldiers, the ability for the American military to transport patients back to the continental U.S. was expanded. In comparison to World War II where overseas transportation ranged between four and six months,

injured soldiers could arrive at the Naval Hospital in Illinois within 72-96 hours from the time of injury.(1)

The Vietnam War's paramount legacy in medical advancement was the dramatic expansion of medical evacuation capabilities. This period also signified a pivotal moment in medical history as it was the last major conflict before the global realization of the necessity for civilian-focused trauma care systems. The development of these systems, evolving concurrently with the Vietnam conflict, marked a significant transition in the approach to both military and civilian trauma care, setting the stage for future advancements in trauma treatment and emergency response.

1.2.9 Civilian Trauma Care in the United States

In the early 1960s, the annual toll of fatalities on American highways exceeded the total number of deaths in the Vietnam War.(1) This stark statistic motivated American trauma surgeons and healthcare professionals to leverage the insights and practices developed from military trauma systems to begin to improve outcomes for injured American civilians. The central basis of the civilian trauma systems built primarily in the U.S. were based on the regionalization and tiered deployment of trauma care systems, well-trained ground level first responders providing pre-hospital care for injured patients, rapid emergency evacuation, and the specialization of trauma surgeons working out of designated trauma centers.

In 1966 the Committee on Shock and Trauma of the National Research Council, armed with multiple studies dubbed the “preventable death studies” illustrating inadequate care received by injured Americans, created the sentinel report, “Accidental Death and Disability: The Neglected Disease of Modern Society.”(19–22) This report synthesized the lessons learned from the aforementioned military conflicts, consolidating them into a series of recommendations

aimed at rectifying the critical deficiencies in trauma care across the United States. These crucial recommendations included pre-hospital communication systems, categorization and regionalization of trauma and hospital systems, the development of trauma registries, and calls for extensive research into the concepts surrounding trauma care and the areas of shock, resuscitation, and injury prevention.(1) As a result of this report, the United States Congress enacted the National Highway Safety Act of 1966 in an effort to decrease motor vehicle collision deaths, conduct research into car safety, and to coordinate pre-hospital care for those injured on roads in America.(1) Building off of this, a second movement was put forward by the U.S. Congress to develop program guidelines and technical assistance to create a nationally coordinated and comprehensive system of regionalized emergency and trauma care for all American citizens ultimately leading to the Emergency Medical Services Act of 1973.(1)

The first civilian designated trauma hospitals were built in Cook County Hospital in Chicago and at San Francisco General Hospital in California in 1966.(1) By 1974, two states, Illinois and Maryland had established fully operational regionalized trauma systems and witnessed an 8% decline in highway related mortality in spite of an overall increase in highway accidents and injuries.(1)

In tandem with these developments, the once known Committee on Fractures developed in 1922 evolved to include all types of trauma and the American College of Surgeons Committee on Trauma was born in 1939.(23) In an attempt to provide developing trauma systems aid and support, they published the first edition of “Optimal Hospital Resources for Care of the Seriously Injured”.(1) It was with this report that, for the first time, the categories or ‘levels’ of trauma care within these systems were defined.(1) With these definitions now in place, the Committee on

Trauma were able to show a significant relationship between the levels of care and outcomes for seriously injured patients.(1)

The first major landmark study critically evaluating this revolutionary system of regionalized civilian trauma care was conducted by West, Trunkey, and Lim in 1979.(1,24) A retrospective cohort study was conducted examining 100 consecutive motor vehicle mortalities in two separate counties, San Francisco and Orange County between 1974 and 1975.(24) During the study period, in San Francisco patients were taken to a single trauma centre and the patients in Orange County were transported to the nearest receiving hospital with 39 total hospitals receiving injured patients.(24) Notably, these 39 hospitals were not part of an established trauma system. Mortalities were classified as clearly preventable, potentially preventable, and not preventable by an expert panel.(24) The study showed that 37% of non-central nervous system (CNS) related deaths in Orange County were clearly preventable compared to none in the San Francisco cohort. Moreover, another 37% of deaths in Orange County were judged to be potentially preventable, compared with only one death in San Francisco.(24) This study was the first within the civilian system to demonstrate the importance of specialized, early care of trauma patients at appropriately equipped trauma centers.(1,24) Following the study, Orange County was regionalized in 1980.(1)

Another crucial study from Orange County demonstrated the importance of regionalization. In 1984, Dr Richard Cales conducted a pre-post analysis comparing trauma mortality before and after the implementation of regionalized trauma care in Orange County.(25) In the study, nearly 60 deaths before and after regionalization were compared with potentially preventable death rates dropping from 34% to 15% ($p<0.02$).(1,25) Further, 54% of potentially preventable deaths occurred in non-trauma centers, compared to 4% of patients transported to

trauma centres.(1,25) The mortality rate from motor vehicle incidents dropped from 15.7 per 100,000 to 13.9 per 100,000 ($p<0.03$) in the first year after implementation and to 12.4 per 100,000 in the second year ($p<0.02$) despite the fact that the fact that median Injury Severity Score (ISS) and age were higher in the post-regionalization cohort.(1,25)

Drawing on centuries of military combat experience, the United States in the 1960s and 1970s, laid the foundation of contemporary trauma care. Galvanized by the startling number of trauma-related fatalities, particularly from highway incidents, and spurred by the National Research Council's critiques of the inefficient pre-existing care mechanisms, a structured, regionalized, and tiered trauma care system began to take shape. The research from this period did more than just substantiate the efficacy of these systems within civilian contexts; it underscored the critical role of specialized trauma centers in saving lives, thereby cementing their place in the fabric of modern healthcare.

1.2.10 The Development of the Advanced Trauma Life Support Course

In 1976, an orthopedic surgeon, Dr. James K Styner, was in a tragic plane crash in rural Nebraska resulting in the loss of his wife while he and his children sustained serious injuries.(8) Regarding the care he received, particularly in the context of the rural location of his plane crash, he remarked, “When I can provide better care in the field with limited resources than what my children and I received at the primary care facility, there is something wrong with the system, and the system has to be changed.”(8) The change that this tragic event sparked was the widespread recognition of the necessity of trauma provider training for all physicians providing acute care to patients across the continental United States.

The first ATLS course premiered in 1978 with a series of lectures, lifesaving skill demonstrations, and practical lab experiences with the focus directed towards appropriate and

timely lifesaving care for severely injured patients, particularly those arriving outside a main trauma facility.(8) Today, the ATLS method is accepted as the standard for the first hour of trauma care regardless of the location of the patient's first contact with medical services.

The creation and deployment of the ATLS course is particularly important to the current study as it provides medical professionals with the tools necessary to provide adequate resuscitative care outside of lead trauma centers when resources and appropriate assistance is scarce. This highlights the critical nature of the first hour of care in many rural centers which often lack surgical capabilities. The skills learned in this course are vital for stabilizing patients before they are transferred to a facility with the necessary resources for definitive care.

1.2.11 The Development of Trauma Systems in Canada

The establishment of trauma systems in the United States marked the beginning of a standardized approach to trauma care on a national level, primarily for civilian patients. Canada's development of its own trauma care systems followed closely, drawing significant influence from the advancements made by its southern neighbors.

In his review of Canada's trauma systems development, Dr. David Evans succinctly states, "Trauma care has evolved from primarily dealing with procedures like removing ruptured spleens to now focusing on system-building, performance improvement, research based population-level outcomes, injury prevention, and public advocacy".(26) Although the Canadian system differs from the U.S. in various aspects, it has been shaped with an emphasis on these key elements of trauma care, benefiting from the insight provided by the earlier development of trauma systems in the U.S.

Spearheaded by Manitoban General Surgeon, Dr. Charles Burns, Canada's first developed trauma system was created in 1980 in Winnipeg.(26) In addition, he created the first

ever trauma registry in Canada and served as the first director of the Trauma Association of Canada (TAC), solidifying the group as Canada's version of the American College of Surgeon's Committee on Trauma.(26)

Shortly following this, led by orthopedic surgeon Dr. Robert McMurtry and emergency physician Dr. Peter Lane, Toronto's Sunnybrook Hospital's trauma program was created and is often considered as the country's first fully functional, modern trauma center.(26) Additionally, with their early efforts, they created the first Canadian rendition of aeromedical emergency transport for trauma patients.(26) This has since transformed into the country's largest provincial air ambulance service dubbed Ornge. The creation of this large provincial air medical transport system was and continues to be revolutionary within the Canadian emergency medical system.

Outside of Ontario's capital, other cities were attempting to create trauma systems with a specific focus on the regionalization of trauma care in Canada. One major advance is credited to Dr. Frank Ballie, a Hamilton based surgical intensivist who established Canada's first centralized regional emergency communications network, called CritiCall.(26) This service linked physicians throughout Southwestern Ontario to larger centers to help facilitate urgent care and subsequent transport for acutely ill patients.

Quebec and British Columbia mirrored Ontario in their development of regionalized trauma care. Of note, the British Columbia trauma system was built with a specific focus on the shocking statistic that data from 1985-1987 showed that up to 80% of deaths arising from injury in remote regions of the province occurred in the pre-hospital setting.(26) Since then, the B.C. government has introduced a system of designated trauma hospitals, a high-quality trauma registry, Canada's principal designated military trauma training centre, its own helicopter transport system, and an integrated provincial program providing oversight of trauma care.(26)

Several studies have examined the impact of trauma systems on patient outcomes in Canada. Using a pre-post analysis study design examining the implementation of trauma system designation in Quebec when controlling for age, injury severity, body regions injured, and mechanism of injury, Sampalis et al demonstrated a significantly higher relative risk of mortality in the pre-implementation group when compared with the post-trauma center designation group.(27) Further, using a similar design but comparing their outcomes with designated trauma standards using TRISS-methodology, Charyk-Stewart et al demonstrated significant increases in the probability of survival following trauma center designation in Ontario.(28) These studies demonstrate the need for designated systems of care within the realm of Canadian trauma care and the impact it can have on patient survival.

1.3 Implications for Rural Canadians

1.3.1 Disparities Impacting Rural Trauma Patients in Canada

Despite the advances of these trauma centers and trauma systems in Canada, the country remains plagued by the "tyranny of geography", severely limiting our ability to service rural Canadians.(4) This is different than much of the U.S., and as such, is not nearly as well studied. The gap in trauma care due to the vast distances between patients and trauma centers is particularly evident amongst the Canadian Indigenous populations, who encounter substantial barriers to accessing appropriate healthcare due to a myriad of historical and contemporary factors, as well as the remoteness of many Indigenous communities.(29)

In 2010, Hameed et. al attempted to identify potential barriers to trauma care in Canada with a specific focus on the urban-rural divide impacting access to these services.(2) Utilizing techniques from Geographic Information Sciences (GIS) and conducting a survey to identify all level I and II trauma centers designated by the TAC (Figure 1.6), as well as their equivalents in

areas without completed trauma center designations, Hameed et. al aimed to analyze the accessibility of these centers via ground transportation.(2)

Figure 1.7 demonstrates the geographic locations of Canada's level I and II trauma centers and surrounding 1-hour catchments.(2) This illustrates that overall, 20% of the Canadian population, including 100% of residents residing in the Canadian territories live beyond 1 hour by road travel from definitive trauma care.(2)

In Ontario, 15% of our population lives outside of this 1-hour catchment window. However, there are certain aspects of Ontario's unique geography and population that highlight the importance of this work. Firstly, although Ontario hosts the most level 1 designated trauma centers of all the provinces with five in total, we also have the greatest population with over 15 million people as of 2023 with the population density centered in the Southern parts of the province with Toronto and the Greater Toronto Area in its epicenter. Not surprisingly then, all five designated level 1 trauma facilities are located in these areas to reflect the areas of the highest population density. There remain however, 2.3 million people living outside this catchment in the province.

TABLE 1. Trauma Center Designation

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

Available at: http://www.traumacanada.org/accreditation_committee/Accreditation_Guidelines_Jun_07.pdf.

Figure 1.6: Definitions of Canadian trauma center designation as outlined by the TAC (2)

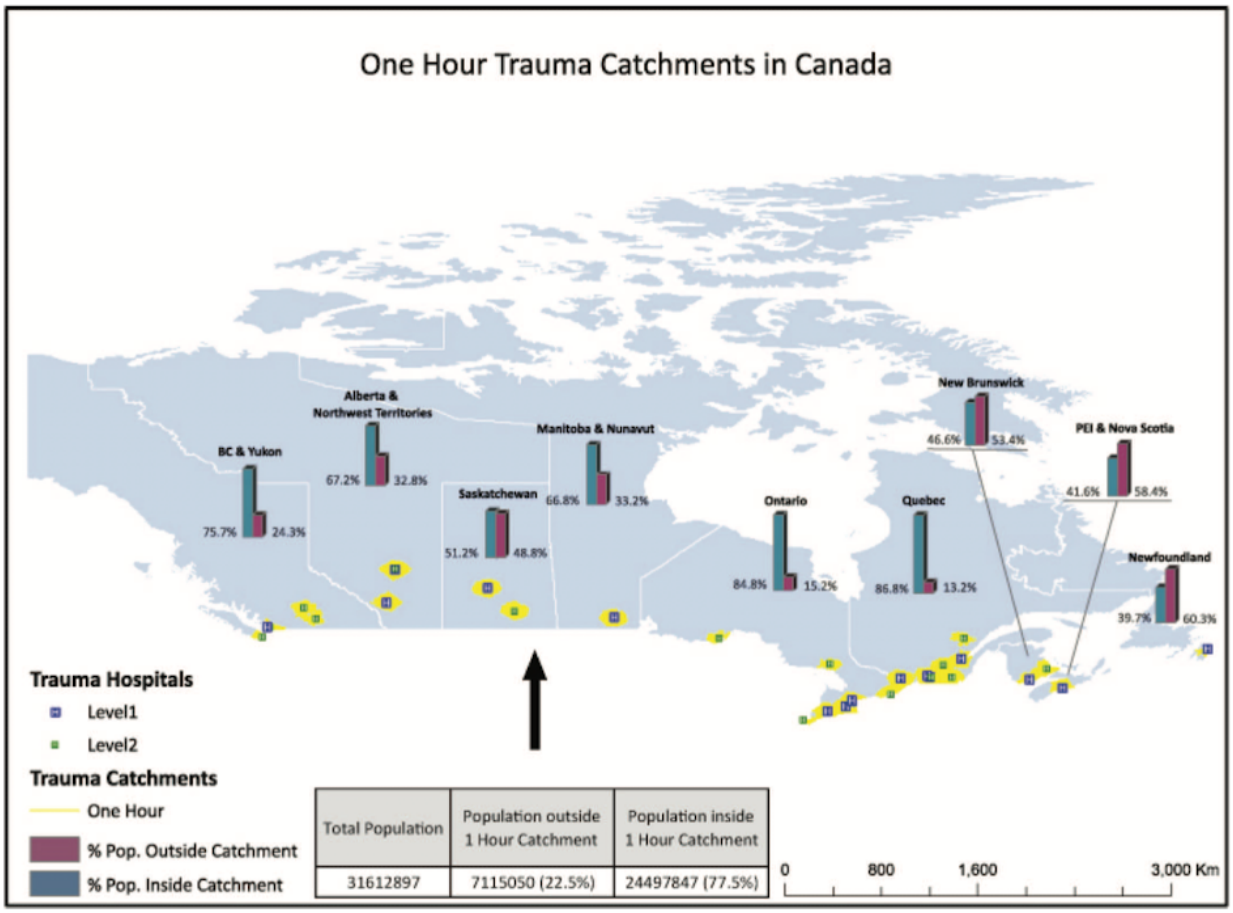

Figure 1.7: Map of Canadian trauma systems outlining one hour trauma catchments (2)

The research by Hameed et. al reveals a major obstacle in achieving an integrated and equitable trauma system in Canada: significant gaps in care for those living in rural and remote communities. This issue is even more pressing for the Canadian Indigenous community, who face additional barriers in accessing healthcare beyond those inherent in the current design of our trauma systems. Illustrating this disparity, Karmali et al demonstrated that age-standardized all-cause mortality of Canadian Indigenous people is twice as high when compared to the whole population of Canada with a major contributor of this death being traumatic injury which accounts for one third of all death in the Canadian Indigenous population.(30) These disparities highlight the urgent need for further research and action to improve access to prompt and

effective care for severely injured trauma patients in rural areas, especially considering the Canadian Health Act's promise of ‘universal healthcare’ and the Truth and Reconciliation Commission's calls to address inequities faced by Indigenous peoples.

1.3.2 Experiencing Trauma in a Rural Center

As outlined above, multiple authors have addressed the issues of access to trauma care for rural and Indigenous communities in Canada and highlighted this as a major fault with the current state of our trauma systems. Despite this, however, there are very few Canadian studies comparing outcomes for patients experiencing trauma in a rural region compared to those injured in an urban region. In fact, to date, the only literature available outlining the urban-rural disparities in injury mortality comes from the U.S. These have shown that over 60% of fatal motor vehicle collisions occur in a rural setting, with these patients facing nearly double the mortality of their urban counterparts.(31)

A 2016 retrospective review of the U.S. Nationwide Emergency Department database attempted to quantify differences in injury mortality between rural and non-rural residents with traumatic injuries.(6) Based on the International Classification of Disease, their study included all emergency department visits with “injury” as the primary or secondary diagnosis, excluding those with superficial injury, foreign body injury, or late effects of injury, as well as those without urban-rural classification.(6) Their primary outcome of interest was defined as mortality following traumatic injury, including death in the emergency department or in the hospital following admission.(6) Overall, rural residents were 14% more likely to die when compared with non-rural residents when controlling for age, sex, ISS, comorbidities, injury type, and trauma center designation ($p<0.001$).(6) Not surprisingly, patients treated at level III and IV trauma centers (as outlined in Figure 1.6) were more likely to experience death when compared

with those treated at level I and II centers ($p<0.001$).(6) When stratified by trauma center designation and controlling for the same variables, rural residents were 20% more likely to die than non-rural residents at level I trauma centers, 34% more likely at level II trauma centers, and 23% more likely at level IV trauma centers ($p<0.001$).(6) These results are concordant with other studies examining outcomes of rural trauma patients reflecting significant differences between groups.(6,32,33)

1.3.3 Damage Control Laparotomy

The concept of DCS and resuscitation, while not new, has become the standard approach for the initial management of severely injured patients by addressing their underlying physiological derangements and controlling major contamination and bleeding before providing definitive injury-directed management. This model is particularly applicable in rural settings, where the aim should conceivably be to provide damage control measures at the nearest care center, even if it is not designated as a dedicated trauma center. While this concept has been widely adopted in the resuscitation sphere – largely thanks to ATLS – in the surgery sphere it has garnered far less attention and adoption.

The concept of DCS is a widely employed term across multiple surgical disciplines. With respect to trauma, its most common use is in the context of damage control laparotomy (DCL) – a technique used to gain rapid control of intra-abdominal hemorrhage and contamination. Initially described in the Annals of Surgery in 1908 by Pringle who used sutures over gauze packing to control portal venous hemorrhage and built upon by Halsted and Stone, DCL is used to manage the onset of major coagulopathy during laparotomy for patients with intra-abdominal injuries.(34) Stone et. al popularized the technique after performing a retrospective analysis of 31 patients who developed major bleeding diatheses during laparotomy describing the situation as

“one of the most frustrating situations ever encountered by the operating surgeon in an open wound is a patient whose blood will not clot and cannot be made to clot.”(35) Fourteen patients were managed with what at the time was considered “standard procedures” directed towards reversal of bleeding and contamination through definitive repair.(35) The other 17 patients had their operation immediately aborted once coagulopathy was noted with abdominal tamponade achieved through packing and contamination managed with bowel resection without anastomosis.(35) These patients underwent abdominal closure under tension and returned to the operating room for re-exploration at 15-69 hours for definitive surgery.(35) Of the 14 patients undergoing definitive surgery, 12 died of hemorrhagic shock.(35) In contrast, of the 17 patients undergoing this early iteration of DCL, only one patient died of continued intra-abdominal hemorrhage.(35) These results reflect the earliest formal description of DCL which has now become the standard for patients with hemodynamic instability in the context of concern for intra-abdominal injury.

The bleeding diathesis described by Stone et. al has since been thoroughly explored and now understood to be only one of three major processes that must be reversed following DCS prior to definitive management of injuries. This phenomenon is known as the lethal triad, consisting of major coagulopathy, hypothermia, and metabolic acidosis (Figure 1.8).(23)

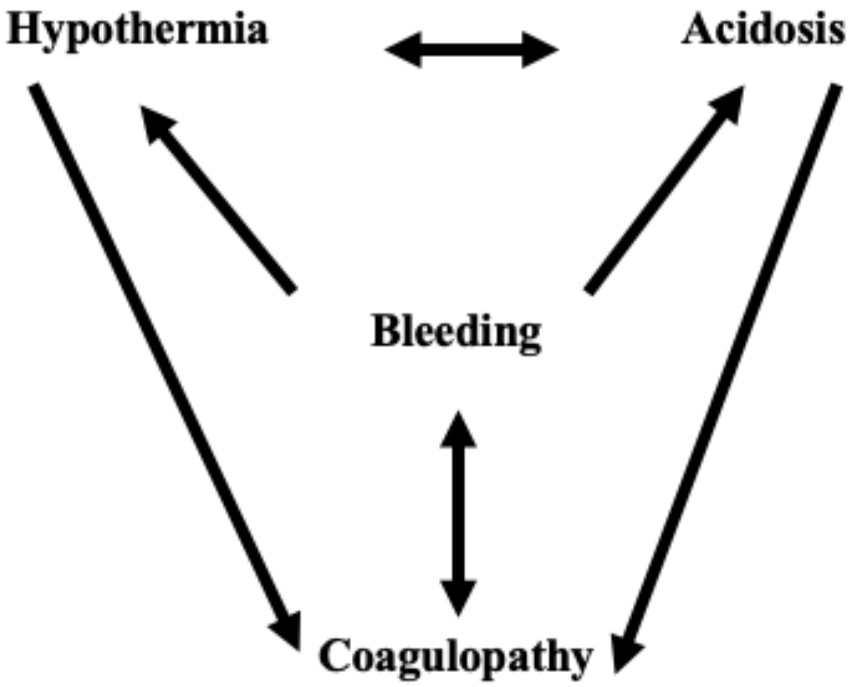

Figure 1.8: The lethal triad

In this context, the lethal triad in trauma patients – hypothermia, coagulopathy, and acidosis – forms a vicious cycle, with each element exacerbating the others. This cycle can result in severe morbidity and eventual mortality if not interrupted, underscoring the critical nature of the triad in trauma care.

The term "damage control laparotomy" was officially coined in 1993 by Rotondo et. al who showed a 77% increase in survival for patients with penetrating abdominal trauma associated with major vascular or visceral organ injury ($p<0.002$).(36) Since that time, the practice has become standard for patients demonstrating any of the three facets of the lethal triad in the context of known or suspected intra-abdominal injury. Although an explanation of the operative approach to DCL is outside the scope of the current review, it is perhaps best

summarized by Scalea who emphasizes that “only blood loss kills early” “and the best place for a sick person is in the ICU” (see Figure 1.9).(37)

Table 1. *Principles of Damage Control*

- Only blood loss kills early.
- GI injuries cause problems much later.
- Everything takes longer than you think.
- It’s easy to miss an injury if you rush.
- Hypothermia, acidosis, and coagulopathy only lead to more of the same.
- The best place for a sick person is in the ICU.

Figure 1.9: Scalea’s principles of damage control(37)

The onset of the lethal triad in the setting of massive hemorrhage occurs almost immediately, thus further reinforcing the crucial importance of the “golden hour” of trauma. In the setting of rural trauma, this concept becomes especially important as transport times to *any* medical facility may be prolonged and access to even basic surgical capabilities may be extremely limited. Several studies from the U.S. have examined the role of rural trauma laparotomy prior to transfer to a definitive trauma center.

1.3.4 Rural Hospital Damage Control Laparotomy

Harwell et. al sought to evaluate the role of DCL as a means of pre-transfer stabilization in a rural setting prior to transfer to a LTH.(31) Over a 6-year period, using their trauma registry, they identified all trauma patients with abdominal injuries who were transferred to their center from a rural facility. Only patients who had laparotomy at the rural facility or at the LTH were included in the study. Patients were then stratified into three groups, (1) those who had DCL

performed at the RH, (2) those who were considered too unstable at the RH and had DCL within 2 hours of transfer to the LTH, and (3) those considered stable at the RH and had DCL between 2 and 12 hours of arrival at the LTH. Here, it is important to note that group 2 is comprised of a group of patients were deemed "too unstable" by the RH surgeon to be operated on outside of a LTH. As acknowledged by the authors, this is not a reflection of appropriate care, but rather an unwillingness by those RH surgeons to proceed with DCL in the context of a severely injured patient requiring urgent operative intervention. A total of 45 patients were identified and after stratification, each group had 7, 30, and 8 patients, respectively. Notably, there was a statistically significant difference in mortality between the three groups. Only one of the seven patients who had DCL at a RH died. This is in contrast to the patients deemed too unstable but who had DCL early on arrival to a LTH, who experienced a 75% mortality rate. These findings are consistent with the premise that severely injured trauma patients require timely intervention, especially within the rural setting where transfer to a dedicated LTH significantly delays this time and, at least in this study, was associated with an increased rate of mortality.

In the context of the previously described concerns with access to care in the Canadian context – as well as the inherent differences between Canadian and American trauma systems as outlined – the need for Canadian-specific studies to explore trauma patient outcomes in rural versus urban settings is clear. The established efficacy of DCL as an emergency intervention underscores the potential adaptability of trauma care protocols to the needs of rural environments.

1.3.5 Advanced Notification of the Trauma Team Leader

Patients injured in rural areas may face unavoidable barriers to emergency care due to the limitations of the RHs to which they present. These include but are not limited to, lack of

surgical capabilities, limited blood products, lack of support staff, and lack of ICU-level care supports, as well as vast distance to the next closest medical facility. As a result, these patients should be transported swiftly to the nearest capable hospital, usually a LTH with a trauma team led by a designated individuals known as the Trauma Team Leader (TTL).

In Ontario, the TTL is generally a general surgeon or emergency medicine physician with additional training in trauma care that is responsible for leading the team providing immediate care for a trauma patient as they arrive at the LTH. In other words, they lead the initial trauma resuscitation ensuring that each patient receives both standard and patient specific care in the time immediately following arrival to the LTH prior to transfer to the next phase of care such as the CT scanner, operating room, or ICU. In addition to leading this process of care, TTLs are also responsible for communication with RHs as they assess and treat trauma patients. In the context of our current studies, the TTL is the delegate at the LTH responsible for assessing a situation whereby a patient would benefit from intervention at a RH and collaborating with the physicians at this RH to advocate for said intervention.

Central to the effectiveness of the process of transferring critically ill or injured patients from one facility to another is communication. In the area of stroke and acute coronary syndrome, this has been well demonstrated in numerous studies, where outcomes are improved when there was advanced notification of the receiving facility prior to patient arrival. To date, there is limited evidence examining the impact of advanced trauma team notification prior to patient arrival on outcomes. Synnot et. al performed a systematic review examining experimental and observational studies of pre-hospital notification compared with no notification in major trauma patients requiring emergency transport.(38) They included three observational studies of over 70,000 major trauma patients. Unfortunately, the quality of the evidence was rated as very

low and no definitive conclusions could be drawn from the study. The most robust study included in their review however did demonstrate an overall reduction in mortality when comparing patients whose care was associated with advanced trauma team notification compared with those who did not (adjusted odds ratio [OR] 0.61, 95% confidence interval [CI] 0.39-0.94, 72,073 participants).(38)

It is logical that early involvement of the trauma team – where an experienced trauma provider can advocate for any further intervention in the rural setting prior to transfer and/or prepare with as much notice as possible for the arrival of the potentially unstable patients – has the potential to be associated with improved patient outcomes.

1.4 Thesis Aims and Outline

This thesis encompasses three distinct projects, each aimed at contributing to the literature on the disparities in trauma care access in Canada, with a particular focus on the rural population.

The first project involves a retrospective, matched cohort study comparing outcomes amongst patients who undergo DCL at a RH prior to transfer to a LTH with those who are directly cared for at a LTH. Our primary outcome of interest is abdominal-injury specific complications. We hypothesize that patients who undergo DCL prior to transfer to a LTH will have similar outcomes to those undergoing DCL after initial arrival to a LTH, and will provide the first Canadian data on these outcomes.

The second project aims to evaluate the impact of the recent policy changes in Ontario that mandate advanced TTL notification for incoming hemodynamically unstable patients. Before this policy change, TTLs were only notified after the patient was en route to the LTH; however, with the new policy change, they must be informed prior to departure. By examining

patient presentations at our LTH before and after this policy change, we hypothesize we will demonstrate that earlier notification can reduce the time to critical intervention on arrival to LTH and improve patient outcomes.

The final project involves a two-pronged survey targeting trauma medical directors and general surgeons in community hospitals across Ontario. The survey seeks to evaluate their current understanding of the recent policy changes affecting the transfer of rural trauma patients, as well as to identify barriers to delivering trauma care, including emergency surgical care in rural and remote hospitals prior to transfer to a LTH.

These interconnected projects seek to shed light on the difficulties and enhance trauma care for one of Canada's most underserviced groups. Considering the previously mentioned issues with healthcare access in Canada and the distinct differences between Canadian and American trauma systems, it is evident that there is a need for studies focused on Canadian trauma patient outcomes in rural versus urban settings. Through tackling these vital concerns, our research aims to provide crucial insights and drive advancements in trauma care across various regions of Canada.

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Chapter 2

Reinforcing the Role of Rural Trauma Laparotomy

Chapter 2. Reinforcing the Role of Rural Trauma Laparotomy

2.1 Background

It has been established that experiencing trauma in a rural setting and receiving initial treatment at a rural hospital (RH) is associated with higher rates of morbidity and mortality.(1–5) For example, 25% of all motor vehicle collisions occur in a rural setting, yet they account for nearly two-thirds of all trauma related deaths.(3) Studies clearly show that for patients sustaining major trauma, treatment at a designated lead-trauma hospital (LTH), is associated with improved outcomes – both with respect to morbidity and mortality.

For severely injured trauma patients with intra-abdominal injury however, it has also been shown that damage control laparotomy (DCL) to gain rapid control of hemorrhage should be completed as soon as possible with delay to DCL being associated with increases in morbidity and mortality.(3,8,9) Considering the critical role of timely intervention in the treatment of severely injured trauma patients, prioritizing DCL at the nearest possible site – even if that site is not a LTH – needs to be considered.

Given the contemporary data supporting the regionalization of trauma care, and advocacy surrounding early transfer to a LTH, there remains a paucity of data around the role of DCL in RHs. To date, research examining the role of RH-DCL has been exclusively conducted in the United States, with a notable absence of Canadian studies. We are aware however, that in some Canadian jurisdictions, RH-DCL is advocated for by LTHs in communication with RH physicians for patients in extremis with presumed abdominal hemorrhage. We undertook this study to evaluate the outcomes of patients who receive RH-DCL in comparison to patients who arrive directly to a LTH and receive DCL. We hypothesize that patients who undergo RH-DCL and are subsequently transferred to our LTH for definitive care will have similar abdominal-

injury specific outcomes to patients who undergo DCL after presenting directly to a LTH without transfer from another facility.

2.2 Methods

Within Southwestern Ontario, London Health Sciences Center (LHSC) is the LTH in a hub and spoke model of regional trauma care serving over 1.6 million people. Advocating for RH-DCL is a practice that has been supported within this region due to the vast catchment area and therefore significant transport times involved in getting patients to the LTH. This matched retrospective cohort study evaluated all patients who sustained trauma and underwent what was planned to be a DCL at a referring (non-LHSC/LTH) hospital prior to transfer to our LTH at LHSC over a 15-year period between 2007 and 2022.

Following institutional research ethics board approval, patients 18 years or older and receiving RH-DCL with subsequent transfer to LHSC for definitive trauma care were identified from our prospectively collected institutional trauma registry. These patients were then matched 1:1 with patients presenting directly to LHSC with mandatory matching criteria of age (± 10 years), year of arrival to LHSC (± 2 years), and severity of abdominal injury (MAIS). Additional secondary criteria for matching, included sex, pre-existing health conditions, Charleston-comorbidity index (CCI), initial measures of physiology including heart rate, systolic blood pressure (SBP), and Glasgow Coma Scale (GCS), and type of abdominal injury (solid organ vs. hollow viscus vs. mixed type). Secondary criteria had more liberal matching windows, and medical record review was utilized to confirm the best possible match for each patient who received RH-DCL with a hierarchy of secondary criteria as follows: type of abdominal injury > initial measures of physiology > pre-existing health conditions > sex.

Data were collected using the LHSC trauma registry and was augmented with a retrospective review of LTH medical records. Data collected included patient demographic information including age, sex, and comorbidities (CCI); injury data including mechanism, specific injuries sustained, and injury severity score (ISS); time data including time of call to LTH, time of arrival to LTH, and transport times; operative data including details of initial and subsequent trauma laparotomies; and outcome data including course in hospital, abdominal specific complications, other complications during hospital stay or in clinic follow-up, and discharge disposition. We categorized the types of abdominal injury into solid organ, hollow viscus, mixed (solid organ and hollow viscus), abdominal wall (including diaphragm), and vascular (including retroperitoneal hematoma). Patients were followed for the duration of their primary hospital stay following trauma.

The primary outcome of interest was a composite of abdominal-injury specific complications including surgical site infection (SSI), anastomotic complications, fistula formation, unplanned return to the operating room for abdominal concern, and wound dehiscence. SSI was defined using the CDC criteria as infection occurring in the first 30 post-operative days with at least one of the following: (1) purulent drainage from the incision, (2) organisms isolated from aseptically obtained culture of fluid or tissue from the incision, (3) at least one of pain, localized swelling, redness, or heat as a presenting sign/symptom of infection, and (4) diagnosis of SSI by the surgeon or attending physician.(10) Information about this was obtained from daily progress notes, discharge summaries, nursing notes, and clinic follow-up notes in the patient's electronic health record. Anastomotic complications were determined based on imaging reported by an attending radiologist or documented anastomotic leak at the time of OR by the attending surgeon. Fistula formation was defined as any formation of enterocutaneous

fistula as documented by the attending surgeon or based on imaging reported by an attending radiologist. Wound dehiscence was defined as any separation of the abdominal fascia following definitive closure during the patient's hospital stay as documented by the attending surgeon. Secondary outcomes included overall mortality, abdominal-specific mortality, duration of open abdomen, length of ICU stay, length of overall hospital stay, and discharge destination.

No formal sample size calculation was completed, but rather, in line with data captured within our trauma registry, we used a convenience sample of 15 years. Data analysis was conducted with IBM SPSS Statistics for Mac (IBM Corp., Armonk, NY., Version 29.0). Given an anticipated small sample size (and subsequent lack of power for multivariable analysis), we restricted our analyses to univariate comparisons between groups. Continuous normally distributed data were compared using Student's t-test, continuous non-normally distributed data were compared using non-parametric tests, and categorical data were compared using the chi-square or Fischer's Exact Test, where appropriate.

2.3 Results

A total of 21 patients received RH-DCL at 10 different regional hospitals and were transferred to our facility over the 15-year study period. These patients were matched to 21 similar patients who presented directly to our LTH and underwent DCL. Therefore, the total number of patients included was 42.

Overall, the majority of patients were young, healthy males who experienced severe trauma (Table 2.1). Fourteen of 21 patients from each group were male (66.7%). Mean age in the RH-DCL group was 42.5 (16.7) and 43.1 (16.1) in the LTH-DCL group ($p = 0.89$). Median CCI in both groups was 0. In the RH-DCL group, median ISS was 34 [IQR 27, 45] and 41 in the LTH-DCL group [IQR 31, 50] ($p = 0.37$).

	RH-DCL	LTH-DCL	p-value
Demographics			
Number	21	21	N/A
Male sex, N (%)	14 (66.7%)	14 (66.7%)	1.00
Mean age in years (SD)	42.48 (16.7)	43.14 (16.0)	0.89
Median CCI, [IQR]	0 [0,0]	0 [0,0]	0.15
Median ISS, [IQR]	34 [27,45]	41 [31, 50]	0.37
Baseline Physiology			
Median Heart Rate, [IQR]	122 [95.5, 140]	115 [103, 134]	0.39
Median SBP, [IQR]	100 [77.5, 138.5]	119 [93.5, 159]	0.55
Median GCS, [IQR]	14 [7.75, 15]	14 [8, 15]	1.00
Mechanism			
Blunt, N (%)	17 (80.9%)	16 (76.2%)	0.71
Type of Injury, N (%)			
Solid Organ	9 (42.9%)	7 (33.3%)	0.53
Hollow Viscus	1 (4.76%)	1 (4.76%)	1.00
Mixed	9 (42.9%)	9 (42.9%)	1.00
Abdominal wall (including diaphragm)	2 (9.52%)	1 (4.76%)	0.55
Vascular (including retroperitoneal hematoma)	0 (0%)	3 (14.3%)	0.15

N = number; SD = Standard Deviation; IQR = Interquartile Range; CCI = Charlson Comorbidity Index; ISS = Injury Severity Score; SBP = systolic blood pressure; GCS = Glasgow Coma Scale

Table 2.1: Demographic and injury summary of patients in RH-DCL and LTH-DCL groups

With respect to baseline physiology at the site of initial primary survey, there was no significant difference between groups for initial heart rate, SBP and GCS (Table 2.1).

The majority of patients had a blunt mechanism of injury with 17 in the RH-DCL group and 16 in the LTH-DCL group (p=0.71). The majority (55%), suffered motor vehicle collisions with other blunt injury mechanisms a result of recreational vehicle trauma (11.9%) and falls (11.9%). There was a total of 9 penetrating injuries with 5 in the LTH-DCL group and 4 in the RH-DCL group (p=0.71).

A total of 9 patients from each group (42.9%) had a mixed type of injury (Table 2.1). Seven patients (33.3%) from the LTH-DCL group had isolated solid organ injuries with 9 (42.9%) in the RH-DCL group (p=0.53). One patient from each group had an isolated hollow viscus injury (4.8%). Two patients (9.5%) from the RH-DCL group had abdominal wall injuries compared with one patient (4.8%) from the LTH-DCL group (p=0.55). Three patients (14.2%) had vascular injuries in the LTH-DCL group, with none from the RH-DCL group (p=0.15).

With respect to our primary outcome of abdominal injury specific complications, we found these to be relatively common with over a fifth (21.4%) of all patients regardless of location of DCL experiencing some type of complication. Of these patients, multiple patients had more than one complication. There was no statistically significant difference when comparing groups (p=0.08). There was a total of 6 patients (28.6%) representing 9 total complications in the RH-DCL group and 3 (14.3%) representing 4 total complications in the LTH-DCL group (p=0.26).

The most encountered abdominal specific complication was intra-abdominal abscess formation and need for reoperation (excluding second-look laparotomy and/or fascial closure operations). There was a total of 4 patients (19%) with intra-abdominal abscess formation in the RH-DCL group and 2 (9.5%) in the LTH-DCL group (p=0.38). Four patients (19%) in the RH-

DCL group required reoperation related to their abdominal injury and 1 (4.8%) in the LTH-DCL group (p=0.29).

Similarly, there was no statistically significant difference noted between groups for all secondary outcomes analyzed (Table 2.2). Median duration of open abdomen (days) in the RH-DCL group was 1.0 and 0 in the LTH-DCL (p=0.25). Nearly all patients had an ICU stay with 20 (95.2%) in the RH-DCL group and 17 (81.0%) in the LTH-DCL group (p=0.15). Median length of ICU stay in days was 8.5 in the RH-DCL group and 3.0 in the LTH-DCL (p=0.44). Median length of total hospital stay in days following DCL was 16.0 in the RH-DCL group and 17.0 in the LTH-DCL group (p=0.48). There was also no statistically significant difference in overall mortality with only 3 (14.3%) patient deaths in the RH-DCL group and 6 (28.6%) in the LTH-DCL group (p=0.26). Of the mortalities noted, there were only two that were a direct result of abdominal injuries with both coming from the LTH-DCL group. Both patients had severe pelvic fractures and solid-organ injury resulting in ongoing hemorrhage in the ICU despite operative intervention including pre-peritoneal packing and external fixation at their index operation and interventional procedures for one of the patients. They both developed severe coagulopathy and eventually died in the ICU following withdrawal of life support.

	RH-DCL	LTH-DCL	p-value
Median duration of open abdomen (days) [IQR]	1.0 [0.0, 2.0]	0 [0.0, 1.0]	0.25
N requiring ICU stay (%)	20 (95.2%)	17 (81.0%)	0.15
Median Length of ICU stay (days) [IQR]	8.50 [1.25, 13.5]	3.0 [1.0, 11.5]	0.44
Median length of hospital stay (days) [IQR]	16.0 [5.5, 24.5]	17 [1.5, 29.5]	0.48
Mortality, N (%)	3 (14.3%)	6 (28.6%)	0.26

Table 2.2: Secondary outcomes

2.4 Discussion

Overall, our Canadian-first data examining the role of the RH-DCL prior to transfer to a LTH demonstrates no statistical difference between the two groups analyzed in the study with respect to all primary and secondary outcomes defined. When considering the time sensitive nature of severe traumatic intra-abdominal injuries and the need for urgent control of hemorrhage and contamination, the present study along with previously established work from the U.S. suggests a non-inferior role of RH-DCL when compared with those patients treated directly at a LTH. In other words, it appears that by performing RH-DCL, practitioners are not causing any harm to patients when compared to LTH-DCL.

Although no formal definition of "rural trauma" exists, Ball et. al offer perhaps the most comprehensive description, defining it as "a scenario in which the optimal care of an injured patient is delayed or limited by geography, weather, distance, resources, or lack of experience."(11) The authors recognize the contentiousness surrounding this definition,

particularly the concept of "optimal care." It is inferred that this term likely refers to the standard of care typically provided at designated level I trauma facilities, which are usually located in urban areas. This definition then, creates a very clear divide between the quality of care received by patients injured in an urban area with proximity to one of these facilities and those injured in a rural area. For the purposes of the present study, our RHs were those within the catchment area of our LTH who do not have LTH designation and regularly transfer patients to our tertiary care center.

Though surprising given our vast geography, there is a sparsity of Canadian data that exists illustrating this urban-rural disparity in trauma outcomes, although work from the U.S. shows that outcomes for patients injured in a rural environment are significantly worse when compared with their urban counterparts. Further, utilizing data from the Nationwide Emergency Department database, Jarman et. al demonstrated that rural residents experiencing trauma were 14% more likely to die when compared to non-rural residents ($p<0.001$).(5)

Although exact outcomes of rural trauma in Canada have yet to be published, a number of authors have demonstrated major issues with access to trauma in Canada for individuals living in rural areas. Hameed et. al used techniques from Geographic Information Sciences (GIS) to show that 20% of the Canadian population and 100% of those living in the Canadian territories live beyond 1-hour by road travel from level I and II trauma centers. When considering already marginalized communities such as Indigenous populations in Canada, addressing these inequities impacting access to trauma care becomes even more pressing. In their attempt to outline these inequities and propose potential solutions, Zakrison et. al refer to this urban-rural disparity as the “tyranny of geography” that plagues Canadian rural trauma patients.

DCL is not a new concept with Stone et al. studying and popularizing the technique in 1983.(9) Since then, its effectiveness for the unstable trauma patient with suspected intra-abdominal injury has been demonstrated in numerous studies.(8,12) Notably, its main purpose is to interrupt the "lethal triad" and allow the patient to be transferred to an intensive care setting to have their metabolic derangements – acidosis, hypothermia and coagulopathy – corrected prior to returning to the operating room for definitive repair.(12) In fact, Aoki et al. in their retrospective review of 68 patients who underwent DCL, showed a 66.2% mortality rate in those patients who did not have normalization of their acidosis, coagulopathy and hypothermia prior to returning to the operating room for definitive repair.(12)

The problem with the aforementioned data (and most existing data) highlighting the benefits of DCL, is that it exclusively investigates DCL within the context of a LTH. Further, the data that does exist examining the role of RH-DCL is minimal and only from the U.S. trauma system. Extrapolating from this data however, it makes logical sense that the priority for severely injured rural trauma patients with suspected intra-abdominal hemorrhage or contamination may be to have them assessed and treated with DCL at their nearest hospital – regardless of trauma center designation.

Three studies to date have examined the role of rural trauma laparotomy in the United States, and are in line with our findings.(1–3) Harwell et al conducted a 7-year retrospective review of 47 trauma patients who underwent DCL with one group having their intervention prior to transfer and the other at the LTH.(2) Perhaps the starkest finding of their work was that for the patients who received RH-DCL mortality rate was 14.3% whereas for those patients who were deemed hemodynamically unstable but received LTH-DCL (i.e., after transfer from the rural area), mortality was 75.0% ($p<0.001$).(2)

Veenema et al performed a retrospective review of 50 trauma transfers from level III hospitals and mortality associated with these trauma patients.(1) Using the Major Trauma Outcome Study as their comparator and Trauma and Injury Severity Score (TRISS) methodology to predict outcomes for patients, they showed that triage and stabilization of severely injured rural trauma victims at level III hospitals before transfer to a level I trauma facility provides outcomes similar to national results.(1,13)

Finally, in a third study examining 56 patients who underwent trauma laparotomy, those who underwent laparotomy at rural or remote facilities before transfer to definitive care had outcomes similar to those patients injured in an urban setting and were taken directly to a regional trauma center.(5) Their comparisons were also made using TRISS methodology and comparison against expected outcomes.

The current study is limited by its retrospective nature and the challenges associated with such data collection. Additionally, the small sample size reduces the statistical power of the study. Importantly, we cannot account for patients who died prior to arrival at our LTH following RH-DCL. Although exact data on this patient population is not available, information from our regional trauma network indicates that this number is very low.

2.5 Conclusions

This Canadian-first study provides insights into the role and outcomes of DCL performed in RHs prior to patient transfer to a designated LTH. Despite the geographical and logistical challenges inherent to rural trauma care, our findings demonstrate that RH-DCL does not appear to be associated with inferior abdominal-specific or other patient outcomes when compared with patients treated initially at a LTH. This supports surgical intervention, in the form of laparotomy, being performed as soon as feasibly possible, and highlights the potential for RH-DCL to serve

as a viable and effective component of a broader trauma care strategy. Additionally, given the small number of patients in this study, continued surveillance of this practice is warranted.

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Chapter 3

Evaluating the Impact of Advanced Trauma-Team Leader Notification

Chapter 3. Evaluating the Impact of Advanced Trauma-Team Leader Notification

3.1 Background

Regional trauma systems rely on the seamless integration of pre-hospital, referring hospital, and lead-trauma hospital (LTH) personnel and infrastructure to optimize outcomes after severe injury. In Ontario, trauma systems rely on leadership from level 1 equivalent trauma centers to aid and advise in caring for critically injured patients; especially those injured in a rural or remote setting where resources and experience with trauma are limited. In caring for the rurally injured trauma patient, there is a delicate balance between providing timely emergent care at rural hospitals (RH) and transferring the patient to a LTH for definitive, specialized care. Achieving this balance hinges on effective communication between all care providers involved including RH and LTH physicians and those responsible for executing and providing care during the transport between the two sites. In Ontario, this entity is the Ornge air ambulance service which includes specialized paramedics and physicians responsible for transporting and caring for these patients during transport from the scene of injury or between facilities.

Advanced notice of impending arrival of a critically injured trauma patient has been hypothesized to be associated with more efficient processes of patient care that ultimately lead to improved patient outcomes. (1–4) Data further supports that, when opportunities for specific surgical intervention exist prior to transfer to a LTH, such interventions may confer patient morbidity and mortality benefits. (5–7) Previous work completed by our group has shown that damage control laparotomy (DCL) prior to transfer for a hemodynamically unstable patient with suspected intra-abdominal injury does not result in worse outcomes when performed at a RH when directly compared with outcomes from those patients who receive DCL at a LTH. This

work has prompted increased recognition of the potential role for advanced intervention in referring hospitals and has been part of the impetus for policy changes within Ornge that govern the practices surrounding communication and transport of severely injured trauma patients.

Prior to this policy change, patients being transported from a RH via a "modified scene" response, were identified through a pre-arrival notification to the trauma-team leader (TTL) only once the patient was in transit to the LTH. A modified scene response occurs when Ornge has been dispatched to the scene of injury, but the local ambulance has already initiated transport to the nearest hospital. In this case, Ornge will route to meet the patient at this hospital and transfer the patient to definitive care at a trauma designated facility – with or without the patient engaging in medical care at the referring facility.

Historically, the policy associated with modified scene responses created situations where the opportunity for early intervention in a RH may have never been afforded to critically injured patients. Further, in Southwestern Ontario, many patients have short flight times, and as such the TTL (who covers their call duties from home) is often not notified in sufficient time to be in hospital when the patient arrives.

The revised policy, put into effect in July 2023, requires direct communication between Ornge paramedics and the TTL at the accepting LTH prior to beginning transport in a patient who has had any episode of hypotension defined as a systolic blood pressure (SBP) < 90 mmHg after injury. This policy impacts both "modified scene" responses, and responses where Ornge can transport the patient directly from the scene of injury.

The overall aim of this policy change is twofold: 1) to provide an opportunity for the TTL to advocate for any indicated, and potentially lifesaving intervention at a RH prior to departure for transfer and 2) to allow maximal pre-hospital notification of a critically injured patient

arriving at the LTH, which we hypothesize will allow for early mobilization of the trauma team and advanced preparation of necessary resources and personnel to provide definitive care to these patients as early as possible after arrival.

The primary objective of the present study is to evaluate the impact of this policy change with respect to processes of care and patient outcomes. Specifically, we wish to evaluate, amongst trauma patients with at least one episode of pre-hospital hypotension being transported directly to London Health Sciences Center (LHSC) via scene and modified-scene calls, if advanced TTL notification is associated with a decrease in time to critical intervention or decreased overall time spent in the emergency department (ED). As this is a province-wide policy change, this single centre review was designed to serve as a pilot to inform data collection provincially.

3.2 Methods

As a pilot to a larger province-wide study, we conducted a retrospective pre-post analysis comparing patients at a single LTH (LHSC) since implementation of the new policy on July 1, 2023, through to Dec. 1, 2023, to similar patients arriving during the same time-period one year prior (July 1 – Dec. 1, 2022). Following full institutional research ethics board approval and establishing appropriate data sharing agreements, patients were included if they sustained traumatic injury and had any documented episodes of hypotension as recorded by Ornge (SBP < 90 mmHg) prior to arrival at LHSC from a scene or modified scene response.

The remainder of the data were obtained from the prospectively collected and maintained Ornge database and LHSC trauma registry and supplemented with electronic medical record review where required. Data collected included: patient demographic data (age, sex, comorbidities); timing of all notifications and communications prior to arrival to LHSC;

presence of TTL on patient arrival; injury details including mechanism, injury severity score (ISS), and injuries sustained; all interventions received in the pre- and post-arrival phases of care; time from arrival in the trauma bay to critical interventions or departure time from the ED and outcomes including length of hospital stay and mortality. Critical interventions were defined as: transfusion of any blood components, chest tube insertion, critical fracture reduction, emergent operative intervention and emergent angioembolization in interventional radiology.

The composite primary outcome of interest was defined as time to critical intervention or time to departure from the ED to the next phase of care. This acknowledges that, while critical interventions in the trauma bay are likely to be the most impacted by advanced notification, some patients do not receive these interventions – either because they are not indicated, or because they may be better performed in an alternate location (i.e. the OR). Secondary outcomes include frequency of advanced notification (policy compliance); time of advanced notification in relation to time of leaving scene/referring hospital as well as in relation to time of arrival at LTH; TTL presence upon patient arrival to the LTH; and morbidity and mortality. Policy compliance was defined as the number of patients whose injury occurred after the policy change who had documentation of the conversation between Ornge personnel and the TTL (as mandated by Ornge charting standards). Additionally, the policy states, where reasonably possible, there should be notification prior to departure from the scene or modified scene response. Therefore, for modified scene responses, the addition of pre-departure notification was used as a second measure of policy compliance.

Definitions of time to critical intervention or time to departure from the ED were determined prior to data collection to ensure consistency amongst individual patients. All times were calculated from the documented arrival time of the Ornge helicopter at LHSC. In the

absence of chart-documented times, time of first transfusion of blood components was defined as the recorded time the blood bank dispensed the first unit plus 15 minutes (to account for portering time and transfusion prep time). This methodology was adopted from the FiiRST trial which utilized similar time additions to account for time to reconstitute fibrinogen concentrate.(8) Time of chest tube insertion was defined as the time of chest x-ray to confirm chest tube placement minus 15 minutes (accounting for time of arrival of the x-ray technologist to the trauma bay to obtain imaging). Similarly, critical fracture reduction was defined as the time of post-reduction portable x-ray minus 15 minutes. In the absence of exact charting of times of intervention (blood product administration, chest tube placement, fracture reduction) in our paper or electronic health records, we estimated that the 15-minute timeframe would best reflect the true time of intervention. Time of routine chest and pelvic x-rays were obtained from our imaging platform utilizing the time stamp on the radiographs. Time of advanced imaging, namely routine CT scans for trauma patients, were obtained using the time stamp on the images. Arrival to the operating room and interventional radiology suite was routinely recorded in the patient's electronic health record as a part of the operating room/IR nurse's record. Arrival to the intensive care unit (ICU) or inpatient trauma ward was defined as the first set of recorded vital signs in the patient chart as it is standard practice to obtain a set of vitals upon patient arrival to the unit.

No formal sample size calculation was completed given our reliance on a convenience sample of all patients eligible for this policy since its inception compared to all eligible patients in a similar timeframe before policy implementation. Given known volumes of scene/modified scene responses to our LTH, we anticipated relatively small sample sizes, and a priori determined this work to be pilot work towards a similar provincial study.

Descriptive analyses were completed with means (standard deviations) and medians [interquartile ranges] calculated for continuous variables where appropriate, and frequencies (percentages) calculated for categorical variables. Data were compared between groups (pre- and post-implementation). Independent samples t-test were used to compare normally distributed continuous variables, Mann-Whitney-U tests were used for the comparison of non-normally distributed continuous variables, and chi-square and Fischer's exact test for categorical variables, as appropriate.

3.3 Results

A total of 29 patients were included in the study with 12 in the before policy change (BPC) group and 17 in the after policy change (APC) group. Of these, in the BPC group, there were 10 (83%) modified scene responses and 2 (17%) scene responses. In the APC group, there were 14 (82%) modified scene responses and 3 (18%) scene responses. Of the 17 patients that were transferred to LHSC by Ornge following policy change, there was documented discussion between Ornge paramedics and the receiving TTL for 100% of patients.

Overall, our patients were relatively young, mostly male, with few existing comorbidities and had sustained serious injuries (Table 3.1). Half of the patients in the BPC group and 70% of the patients in the APC group were male ($p = 0.44$). The mean age in the BPC group was 49 (17.4) years compared to 49 (17.4) years in the APC group ($p = 0.94$). Median Charleston Comorbidity Index (CCI) was 0.5 [IQR 0, 2.8] in the BPC group and 0 [IQR 0, 3] in the APC group ($p = 0.95$). In the BPC group, median ISS was 26 [IQR 19, 50] compared to 20 [IQR 14, 31] in the APC group ($p = 0.26$).

With respect to physiology, we compared initial measures between groups that were recorded by Ornge (transport vitals) and those captured during the primary survey at the LTH

(Table 3.1). There were no statistically significant differences noted between transport vitals or LTH vitals when comparing measured heart rate, SBP, and Glasgow Coma Scale (GCS) (Table 3.1). First documented hypotension by Ornge revealed a median first SBP in the BPC group of 82 mmHg [IQR 74.6, 85.6] and 86 mmHg [IQR 75, 88] in the APC group ($p = 0.27$). Unfortunately, this is only the first documented hypotensive blood pressure measurement and the median transport SBP differs from this as illustrated in table 3.1.

All patients in both groups had a blunt mechanism of injury. The majority were motor vehicle collisions with 8 (66.7%) in the BPC group and 12 (70.6%) in the APC group ($p = 0.32$). The remainder were primarily falls (3 in the BPC group vs. 1 in the APC group) or recreational vehicle incidents with 1 in the APC group. Within the 'other' category, injury mechanisms included contact with agricultural machinery and one incident of being struck by a horse.

	Before	After	p-value
Demographics			
Number	12	17	N/A
Male sex, N (%)	6 (50%)	12 (71%)	0.44
Median age in years (SD)	49.2 (17.4)	48.7 (17.4)	0.94
Median CCI [IQR]	0.5 [0, 2.8]	0 [0, 3.0]	0.95
Median ISS [IQR]	26 [19,50]	20 [14, 31]	0.26
Physiology			
Median initial transport heart rate [IQR]	94 [68.3, 127.8]	89 [64, 112.5]	0.62
Median initial transport SBP [IQR]	95 [85, 101]	117 [99.5, 126.5]	0.02
Median initial transport GCS [IQR]	12 [4.5, 15]	11 [4, 14]	0.72
Median initial LTH heart rate [IQR]	118 [70, 120]	95 [74, 121.5]	0.93
Median initial LTH SBP [IQR]	110 [93, 135]	102 [89.5, 114.5]	0.35
Median initial LTH GCS [IQR]	15 [14, 15]	14 [14, 15]	0.69
Mechanism, N (%)			
Blunt	12 (100%)	17 (100%)	0.32
Fall	3 (25)	1 (5.9%)	
MVC	8 (67%)	12 (71%)	
Recreational Vehicle	0 (0%)	1 (5.9%)	
Other	1 (8.3%)	3 (18%)	
Type of Response, N (%)			0.005
Scene	2 (17%)	3 (18%)	
Modified Scene	10 (83%)	14 (82%)	
Location of Injury, N (%)			0.62
Street/Highway	8 (67%)	12 (71%)	
Home	2 (17%)	1 (5.9%)	
Farm	2 (17%)	4 24%)	

N = number; SD = Standard Deviation; IQR = Interquartile Range; CCI = Charlson Comorbidity Index; ISS = Injury Severity Score; SBP = systolic blood pressure; GCS = Glasgow Coma Scale

Table 3.1: Demographic and injury summary of patients in BPC and APC groups

For patients managed using a modified scene protocol, the median ground transport time from the scene to the nearest hospital prior to Ornge arrival was 12.5 [IQR 11.5, 21] minutes in the BPC group and 16.5 [IQR 11, 38] minutes in the APC group (p = 0.43). The median amount of time spent at the first hospital was 68 [IQR 43.5, 87.5] minutes in the BPC group and 84 [IQR 51, 115] minutes in the APC group (p = 0.39). The median transport time from the first hospital to the LTH was 51 [IQR 27, 60] minutes in the BPC group and 48 [IQR 30, 57] minutes in the APC group (p = 0.60). No patients underwent critical intervention at a RH prior to transport at the recommendation of the TTL during the advanced notification discussion.

With respect to our primary outcome of interest, we found no statistically significant difference between the two groups. The median time to critical intervention or departure from the trauma bay was 17 [IQR 8, 35] minutes in the BPC group and 29 [13.5, 51.5] minutes in the APC group (p = 0.21). For patients who had a critical intervention in the trauma bay (7 in the BPC group and 9 in the APC group), the median time to first critical intervention was 14 [5, 17] minutes in the BPC group and 15 [8, 20] minutes in the APC group (p = 0.61). Sensitivity analysis, excluding patients whose first critical intervention was blood transfusion compared 3 patients in the BPC group to 6 patients in the APC group. Median time to critical intervention in this analysis was 48 minutes in the BPC group and 19 [11.5, 54.5] minutes in the APC group (p = 0.26). The median time between arrival and departure from the ED in the BPC group was 45 [IQR 35, 55] minutes and 49 [IQR 43.5, 62] in the APC group (p = 0.26).

The most frequent destination of post-trauma bay phase of care was the CT-scanner with 8 (67%) of patients in the BPC group and 12 (71%) of patients in the APC being brought to CT directly from the trauma bay. In the BPC group, the median time from arrival to the CT-scanner was 40 [IQR 32.8, 45] minutes and 49 [IQR 40, 59] minutes in the APC group (p = 0.057). Three

(25%) of patients in the BPC group went directly to the OR with a median time in the trauma bay of 71 minutes and 3 (25%) patients in the APC group went directly to the OR with a median time in the trauma bay of 61 minutes [IQR 45.3, 82.5] (p = 0.321). All the patients who went directly to the operating room underwent time sensitive operations in the form of trauma laparotomy for intra-abdominal hemorrhage (n = 2), exploratory thoracotomy (n = 1), pelvic external fixation for pelvic hemorrhage (n = 3) or open reduction and internal fixation of significant open fractures (n = 5). One patient in the APC group went directly to the ICU following their trauma resuscitation with an arrival time of 58 minutes.

With respect to specific interventions, results can be found in Table 3.2. The median time from arrival to chest tube placement was 48 minutes in the BPC group and 13 minutes in the APC group. There were no patients in the BPC group who required critical fracture reduction, however, the median time from arrival to critical fracture reduction in the APC group was 15 minutes. Median time from arrival to trauma bay chest x-ray in the BPC group was 11 [IQR 6, 30] minutes and 14 [IQR 10, 23] minutes in the APC group (p = 0.54). Median time from arrival to pelvic x-ray was 13 [IQR 9.3, 20.8] minutes in the BPC group and 13 [IQR 11, 23.3] minutes in the APC group (p = 0.48). Lastly, median time from arrival to the time the patient began receiving their first unit of packed red blood cells (PRBCs), was 8 [IQR 3, 17] minutes in the BPC group and 15 [IQR 4.5, 40] in the APC group (p = 0.34).

Median time from arrival in minutes to:	Before	n	After	n	p-value
Critical intervention/post-trauma bay phase of care [IQR]	17 [8, 35]	12	29 [13.5, 21.5]	17	0.21
CT-Scan [IQR]	39.5 [32.8,45]	8	48.5 [40,59]	12	0.057
Operating room [IQR]	71	3	60.5 [45.3,82.5]	3	0.321
ICU	N/A	0	58	1	N/A
Chest tube	48	3	13	2	0.20
Critical fracture reduction	N/A	0	14.5	2	N/A
Chest x-ray [IQR]	11 [6,30]	11	14 [10,23]	15	0.54
Pelvic x-ray [IQR]	12.5 [9.3,20.8]	8	13 [11,23.3]	14	0.48
First unit of PRBCs [IQR]	8 [3, 17]	7	15 [4.5,40]	8	0.34

Table 3.2: Time from arrival to critical intervention or ED departure

With respect to policy compliance, there was documentation of discussion between the Ornge paramedics and the receiving TTL in all cases (100% compliance). For the 14 modified scene responses, advanced notification occurred to the TTL in nine cases prior to leaving the RH, and in the remaining 5 cases, conversations did not occur until after leaving the RH. When specifically reviewing modified scene response cases from hospitals with surgeons (n = 8), the TTL was given advanced notification in 6 cases prior to Ornge leaving the RH. For all modified scene responses, the median time from advanced TTL notification and departure from the RH was 27 [IQR 12.3, 40.8] minutes. The median time from TTL notification to arrival time at the LTH was 52 minutes [IQR 24.5, 67].

In the BPC group, the TTL was documented to be present on arrival of the patient for 10/12 (83%) cases and in the APC group, the TTL was documented to be present for 9/17 (53%) with 4 cases of no record of the TTL being present (i.e., it is unknown if they were present at the time of patient arrival) ($p = 0.14$).

With respect to patient outcomes, the median length of hospital stay was 15 [IQR 6, 21.5] days in the BPC group and 8 [IQR 2.5, 27] days in the APC group ($p = 0.71$). There was no statistically significant difference in mortality between the two groups with 4 (33%) patients in the BPC group and 2 (12%) in the APC group dying in hospital after their injuries ($p = 0.198$).

3.4 Discussion

Our study, aimed at evaluating a new practice in Ontario's trauma system pertaining to transport of severely injured patients, demonstrates that advanced-TTL notification reveals no statistically significant impact on time to trauma bay therapeutics or advanced imaging, critical intervention, or the next phase of trauma care (time in the ED), however forms the basis for a larger provincial study aimed at evaluating these differences with an adequately powered sample size.

This policy was implemented in response to other work completed by our group that demonstrated that severely injured patients requiring trauma laparotomy had similar outcomes when undergoing laparotomy at a RH when compared with a LTH. The goal of the policy was therefore two-fold: mandatory communication between rural physicians, Ornge personnel and the TTL to provide the opportunity to advocate and discuss potential intervention prior to transport; and provide advanced notice of the impending arrival of severely injured patients. We hypothesized that advanced notification of the receiving trauma team at the LTH would be associated with shorter delays to time sensitive care. Although we were unable to demonstrate

this in a statistically significant manner, the present study was limited in its ability to evaluate the other intended purpose of this policy change: to facilitate mandatory discussion between TTL and RH physicians to potentially change the course of care these patients receive. Without access to the transcripts of the conversations that occurred, we are unable to measure how often, after discussion with the TTL, did patients receive RH intervention that otherwise would not have occurred.

Although we were unable to demonstrate statistical significance in this small pilot series, there are two critical interventions that appeared to occur earlier after policy implementation. The largest difference was made in the time to chest tube placement with the median time to chest tube in the BPC group being 48 minutes and only 13 minutes in the APC group. Similarly, although not as large a difference, the median time to the patient arriving in the operating room in the BPC group was 71 minutes compared to 61 minutes in the APC group. When considering these operations and the severity of the injuries, a delay of even a few minutes in the pre-operating room phase of care can make a significant impact on patient outcomes.

There exists limited current literature exploring the concept of pre-hospital notification for major trauma patients requiring emergency transport. In a 2017 systematic review, Synnot et al were able to analyze the impact of pre-hospital notification in three observational studies including over 70,000 trauma patients with the central variables analyzed being mortality, time to intervention, length of hospital stay, and length of ICU stay.(2) The only variable that showed any benefit of pre-hospital notification for major trauma was mortality with the caveat that they were unable to make firm conclusions as they could not pool the data due to different study methods used.(2) This remains a provocative finding despite the caveats raised. Of the two

studies in their review that did analyze mortality as an outcome, they interestingly both showed reduced mortality with adjusted odds ratios of 0.61 (95% CI; 0.39 – 0.94).(2,9,10)

Ahmed et al conducted a study examining the impact of pre-arrival notification for pediatric trauma on Advanced Trauma Life Support (ATLS) protocols utilizing video review of trauma team response compared against ATLS expert models based on ATLS fitness scores (i.e., how well the average ATLS team are expected to perform).(11) The ATLS fitness score ranged from "0" (non-compliant) to "100" (completely compliant).(11) They found that the average overall fitness was 89 with longer pre-arrival notification times being associated with improved completion of pre-arrival tasks, overall resuscitation performance, and secondary survey performance.(11)

Although the concept of pre-arrival notification remains under studied and in its relative infancy within the realm of trauma care, it has been well established in other fields that provide time sensitive care, namely in stroke and myocardial infarction (MI) pathways.(12,13) For example, much like in trauma, when a patient is faced with MI, time to intervention is of utmost importance. Savage et al define this time to critical intervention as "door to balloon" (DTB) time and showed that in patients where pre-arrival notification occurred, there was a 47.8% shorter DTB time ($p < 0.001$). Moreover, in stroke patients, Lin et al demonstrated in over 370,000 patients, there was a significantly shorter time to critical intervention, defined as tissue plasminogen activator administration for those patients where pre-arrival notification occurred.

It is conceivable then, that for trauma patients who regularly require timely intervention, that pre-arrival notification would be of significant benefit although no study to date has been able to demonstrate this convincingly. This is likely, in part, due to the heterogeneity of injury patterns and interventions, making direct comparisons between patients challenging.

The main differentiator between the studies that have been completed in the world of MI and stroke with trauma is the size of the studies conducted which is the main limiting factor of the present study. The current study is certainly underpowered to evaluate the primary outcomes as identified. The value of this pilot study lies in our improved understanding of the process of data collection and variable standardization, which will allow us to move forward confidently with an adequately powered provincial study addressing the impact of this new policy.

Other limiting factors of this study include the presence of confounders. For example, in the BPC group, there was a concurrent quality improvement initiative and analysis at our center whereby for all trauma patients, prior to arrival there were two units of uncrossmatched PRBCs released from the blood bank. This makes measuring time to first unit difficult as this time would have been significantly shortened within this group of patients. Further, our analysis of pre-hospital physiology and the impact of response is limited by the fact that the recorded vital signs within both the Ornge and our trauma database does not include every set of vitals taken.

Additionally, we are limited by the fact that not all trauma patients require critical intervention necessitating co-primary outcomes of critical intervention and time to post-trauma phase of care. Given that this study is largely pilot work to assess ongoing changes in the processes for severely injured trauma patients, we chose these co-primary outcomes as a means to measure the effect of advanced-TTL notification on time to intervention or further care. Despite this choice, the small number of patients limit our conclusions.

Future directions of this research aim to continue to prospectively collect this data in the hope that as time progresses and further education and training for RH physicians, Ornge personnel and TTLs is completed, that these processes will continue to improve. Further, we will be collaborating with other level I equivalent trauma centers in Ontario to include the full

spectrum of patients in the province who had the opportunity for advanced-TTL notification under this new policy. We also aim to potentially address and quantify the impact of this policy as it relates to pre-transport discussion between Ornge and the LTH. This may be able to be accomplished through further collaboration with Ornge to record the cases of unstable trauma patients where pre-departure mandatory calls between paramedics and TTLs has changed the trajectory of care for these patients (namely in the form of RH intervention).

3.5 Conclusions

This study aimed to provide pilot data to evaluate the impact of a new policy mandating advanced TTL notification for critically injured patients being transported to a LTH in Ontario. While our findings did not demonstrate a statistically significant reduction in time to critical interventions or transition to the time of departure from the ED, several key insights were gained. There were promising trends observed in the reduction of time to critical interventions such as chest tube placement and operating room arrival in the APC group compared to the BPC group. However, we acknowledge that despite this, overall time to critical intervention was actually longer in the APC group with no statistical significance. These trends suggest potential benefits of early TTL notification that warrant further investigation.

Importantly, our study continues to attempt to address the necessity of seamless communication and coordination among pre-hospital, referring hospital, and LTH personnel to optimize trauma care outcomes. The observed improvements in time to intervention, even if modest, highlight the potential of such policies to enhance trauma system performance. These trends and identified areas for improvement provide a foundation for further research and refinement of trauma care protocols. Continued efforts to enhance pre-hospital communication

and timely interventions remain vital in improving the care and outcomes of severely injured patients in Ontario and beyond.

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Chapter 4

Evaluating Perspectives of Ontario Surgeons and Trauma Directors on Intervention and Transfer Processes for Hemodynamically Unstable Trauma Patients

Chapter 4. Evaluating Perspectives of Ontario Surgeons and Trauma Directors on Intervention and Transfer Processes for Hemodynamically Unstable Trauma Patients

4.1 Background

Recent analyses of rural trauma laparotomies in Ontario, and the communication protocols with trauma-team leaders (TTL) at lead trauma hospitals (LTH), have prompted procedural updates amongst stakeholders in trauma care. Most notably, this has resulted in a new policy requiring the provincial air ambulance service (Ornge) to alert TTLs in advance of transporting critically unstable patients, including those being transferred from a rural or regional hospital (RH). This ensures early communication and provides an opportunity for collaboration between LTHs and RHs in an effort to both advocate for potentially lifesaving intervention (including surgery) at a RH, and to prepare the LTH for the impending arrival of a patient who may need rapid intervention.

The practice of advanced intervention in the form of surgery or other critical intervention such as chest tube placement, pelvic external fixation, or critical fracture reduction for trauma at RHs however, is believed to differ widely across the province, and no data currently exists on capacity or desire to perform these interventions at the provincial RHs. Similarly, there has been no systematic evaluation of the perspectives of the LTHs on this practice, with our current knowledge base derived only from anecdotal evidence.

Developing and implementing a policy is merely one step towards improving patient outcomes. With respect to advanced intervention at RHs for severely injured patients, an understanding of the perspectives of the LTH and the RH are key to ensuring successful integration of any policy change. The identification of potential barriers within institutions and

trauma systems both from the perspective of general surgeons and trauma medical directors (TMDs) surrounding the initial management of hemodynamically unstable trauma patients are vital. To that end, the primary objective of the present study is to evaluate perspectives of non-trauma center general surgeons and TMDs in Ontario surrounding current practices in management and transfer of hemodynamically unstable trauma patients from RHs to LTHs.

4.2 Methods

To further elucidate understanding around the system of care for unstable trauma patients in rural and remote environments, we developed and conducted two separate surveys. The first survey aimed to evaluate perspectives of general surgeons who are not currently working in a LTH. The second was designed to gain an understanding of the LTH perspective, as perceived by the TMDs of the level 1 trauma center equivalent hospitals.

Following Western University Research Ethics Board approval, we developed an 8-item questionnaire that was piloted with community general surgeons prior to administration with feedback regarding content and structure incorporated into the final survey for distribution. Secondly, we developed an 11-item survey that was piloted with the previous TMD at our center. Much like the first survey, feedback and suggestions were incorporated fully into the final survey. Each survey consisted of multiple choice and free-text question formats. The surveys were developed and completed by respondents using RedCap online software through Lawson Health Research Institute.

For the community surgeons, survey items included the nature of respondents current practice (i.e., large community with academic affiliation, large community without academic affiliation, or small/rural community), years of practice experience, sub-specialty training, the nature of trauma care at their institution (i.e., presence of a formal trauma team), current comfort

levels in performing trauma laparotomy for unstable trauma patients at their institution, and barriers to performing trauma laparotomy for unstable trauma patients both at an institutional and systems level (see Appendix V).

There were no formal constraints placed on respondents with regards to how to classify their community hospital (small/rural vs. large community) and discretion was left up to the individual respondent as to how they would classify their own practice setting. However, large community focused hospitals with academic involvement were defined as those where community surgeons, despite working outside of a formal academic institution or hospital, still have the regular presence of learners such as medical students or residents.

For the TMDs, survey items included the nature of standardized protocols for advising RHs in dealing with unstable trauma patients both in terms of Advanced Trauma Life Support (ATLS) protocols and operative intervention, the perceived differences in comfort level in advising community surgeons to proceed with operation based on TTL training pathway (emergency medicine or surgery), barriers to performing exploratory laparotomy in a RH at a trauma system level, levels of engagement between TTLs and Ornge, and space for prose on their current opinions surrounding this topic (see Appendix VI). Both surveys questioned respondents' current knowledge surrounding new policy change facilitating the transfer processes for these patients.

The community general surgeon survey was distributed to Ontario Association of General Surgeons (OAGS) members through an online posting to their official webpage and social media reminders through the association. Results were anonymously collected between February and June 2024. TMDs in Ontario's 5 level 1 equivalent trauma centres (The Ottawa Hospital, Sunnybrook Health Sciences Centre, Unity Health - St. Michael's Hospital, Hamilton

General Hospital, and London Health Sciences Centre) were contacted directly through email via known existing relationships, and sent reminders at 2-week intervals until responses from all level 1 equivalent LTHs in Ontario were obtained. A full explanation of the purpose and nature of all procedures was provided along with a formal copy of the new policy. Electronic consent was obtained from each participant before they were able to proceed with the survey.

No formal sample size was completed but based on a convenience sample of the current practicing general surgeons in Ontario and potential response rate, we anticipated a total of 30 respondents for the general surgeon survey. Due to the nature of direct communication in requesting participation of the TMDs, we anticipated a 100% response rate.

All data collected in this study is descriptive and therefore was reported using frequencies and percentages for categorical data, and medians with interquartile ranges for continuous data. Purely descriptive questions with narrative responses were compiled and analyzed by all authors individually to identify key themes and terms in responses. These key terms and themes were analyzed amongst all groups using frequencies and percentages.

4.3 Results

4.3.1 Community General Surgeon Survey

Of the 151 community-based surgeons in Ontario who are currently OAGS members, we received a total of 10 responses for a response rate of 6.6%. Amongst these, 5 (50%) reported that they currently practice in a small community or rural hospital, 3 (30%) reported that they work in a large community focused hospital with some academic involvement, and 2 (20%) responded that they work in a large community focused hospital with no academic involvement.

The median length of time practicing community general surgery was 17.5 years [IQR 9–29]. The majority of respondents (80%) had no formal fellowship training prior to entering

community general surgery practice. Of the two respondents who did have formal fellowship training prior to entering practice, one surgeon obtained critical care training and the other practices both community general and thoracic surgery. All general surgeons who responded said that their institution does not currently have a designated trauma team.

When asked about their level of comfort performing a trauma laparotomy on an unstable patient with an indication to do so (i.e., positive FAST exam), most respondents (70%) said they would be "very comfortable" in performing this operation. The remaining 30% of respondents all said they would be "comfortable, but only in certain circumstances (i.e., there is a second surgeon to assist, there was ample access to blood products, anesthesia support, etc.). No respondents said they would be "uncomfortable and would prefer to transfer patients to a LTH with fellowship trained trauma surgeons."

Amongst the 70% of respondents who felt barriers exist to performing trauma laparotomy for hemodynamically unstable patients within their institution, the most commonly cited barriers were "availability of suitable surgical assistants" (50%) and "lack of nursing experience" (30%) (Figure 4.1). Of note, no respondents reported that suitable anesthesia support was a barrier to performing these operations, though as described below, this does seem to be a potential barrier.

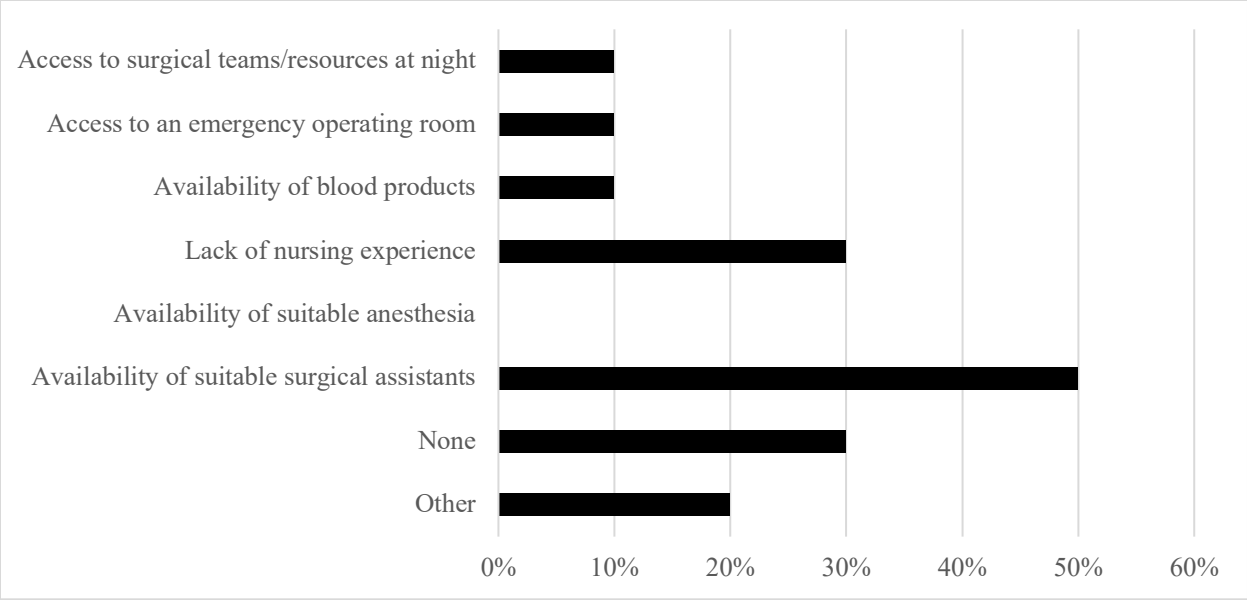

Figure 4.1: Community general surgeon's perceived barriers to exploratory laparotomy in their center

Two community general surgeons selected "other", and one provided narrative responses describing their reasons for not choosing one of the provided responses:

> *"The principles of damage-control surgery are fairly straightforward. I feel adequately supported by CritiCall and our regional trauma center to get the patient out for post-operative care in a formal ICU, if needed."*

Three respondents provided additional prose surrounding their perceived barriers to performing trauma laparotomy on hemodynamically unstable patients in their community center:

> *"We don't have much exposure to head-injured patients, and I think our anesthetists would struggle a bit to feel they were providing optimal care. I think it would be so valuable to have systems in place that made it easier for family medicine anesthesia providers to get tertiary care anesthesia support on the go."*

> *"Only barrier is volume. Only do 1 maybe 2 per year. Additionally, good anaesthesia, likely a colleague to assist, it could only get worse in the chopper."*

> *"[Our] ER team arranges transfer before consulting General Surgery, non-FRCPC anesthesia that are not comfortable with unstable patients."*

When asked about current barriers within trauma systems related to performing a trauma laparotomy for a hemodynamically unstable patient, 50% of respondents felt that there were "none" (Figure 4.2). Amongst those who did identify barriers, the most commonly cited were: "lack of timely transport available to a trauma center" (40%) and "limited access to reliable transport to a trauma center" (30%). One surgeon provided additional narrative response when asked about further barriers to caring for hemodynamically unstable trauma patients within trauma systems in Ontario, with feedback that they felt that "'*other services' have been difficult to reach at night, but that there was always ample support from trauma teams and TTLs"*. The term "other services", however, was not defined in the response.

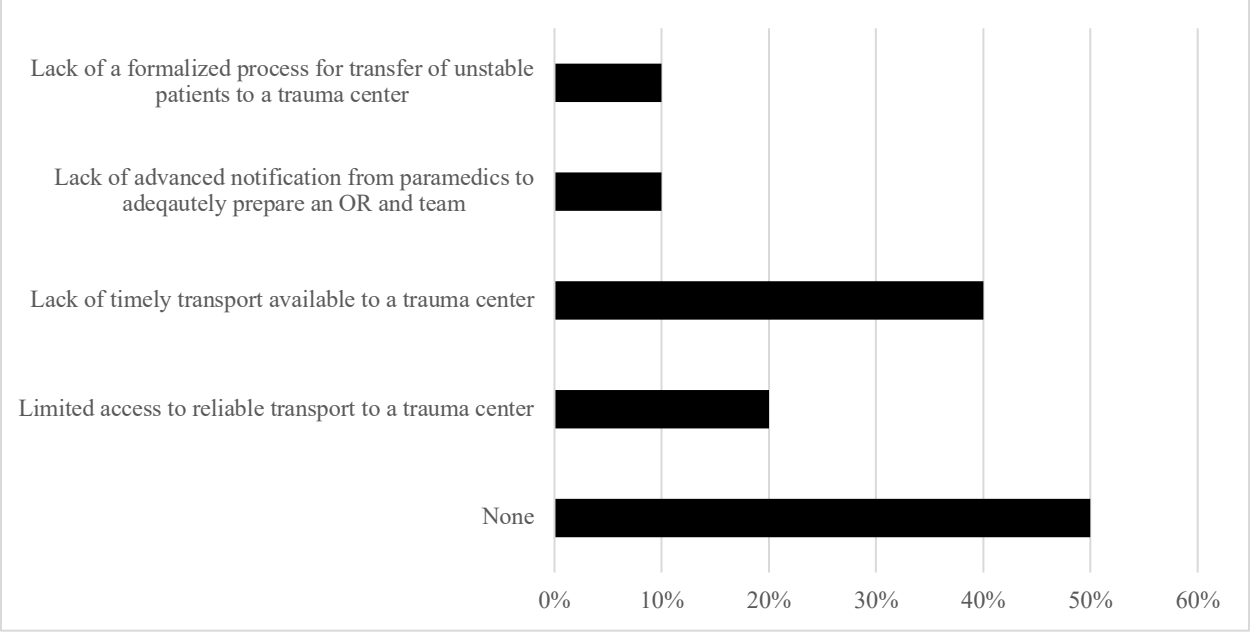

Figure 4.2: Community general surgeons perceived barriers to exploratory laparotomy within trauma centers in Ontario

4.3.2 Trauma Medical Director Survey

Survey responses were received from all five TMDs (or delegate) from each of the LTHs contacted.

When questioned about existing formal policy advising rural and remote physicians in the management of unstable trauma patients, 80% of respondents did not have formal or informal policy around advising on standard ATLS interventions and 60% had no form of policy around operative intervention. On advising standard ATLS interventions, 20% of respondents had a formal policy and 40% had an informal policy in advising operative intervention for these patients. One TMD provided a narrative response outlining their informal policy surrounding operative care:

> "*For operative intervention, our TTLs are instructed to advocate for this in the referring facility (with the assistance of the [LTH] surgeon if there is a non-surgeon TTL) if the referring facility has a surgeon available and the patient is unstable with a clear indication for an operation (i.e., positive FAST examination with hemodynamic instability).*"

When questioned about comfort level in advocating for RH-DCL in the hemodynamically unstable patient with a clear indication for surgery to RH surgeons, 100% of respondents noted that their TTLs would feel comfortable doing this, but only in certain circumstances such as when there is a second community surgeon to assist, there is access to anesthesia care, and/or the RH has ample access to necessary blood products. When differentiating comfort level between emergency medicine trained TTLs and surgeon trained TTLs in advising a RH surgeon to proceed with exploratory laparotomy, 80% of respondents felt there was a difference in the comfort level between the two groups. Of those that responded that there was a difference, 100% felt that surgeons would be more comfortable than emergency medicine trained TTLs in advising a RH surgeon to proceed with operative intervention.

When questioned about the perceived barriers to performing exploratory laparotomy for hemodynamically unstable patients with a positive FAST in a community center, 100% of TMDs responded that "perceived community hospital surgeon comfort" is a barrier (Figure 4.3). The second most common responses were, "availability of blood products" (80%), "time of arrival at the LTH"(60%), "availability of anesthesia" (60%), and "availability of suitable surgical assistants" (60%).

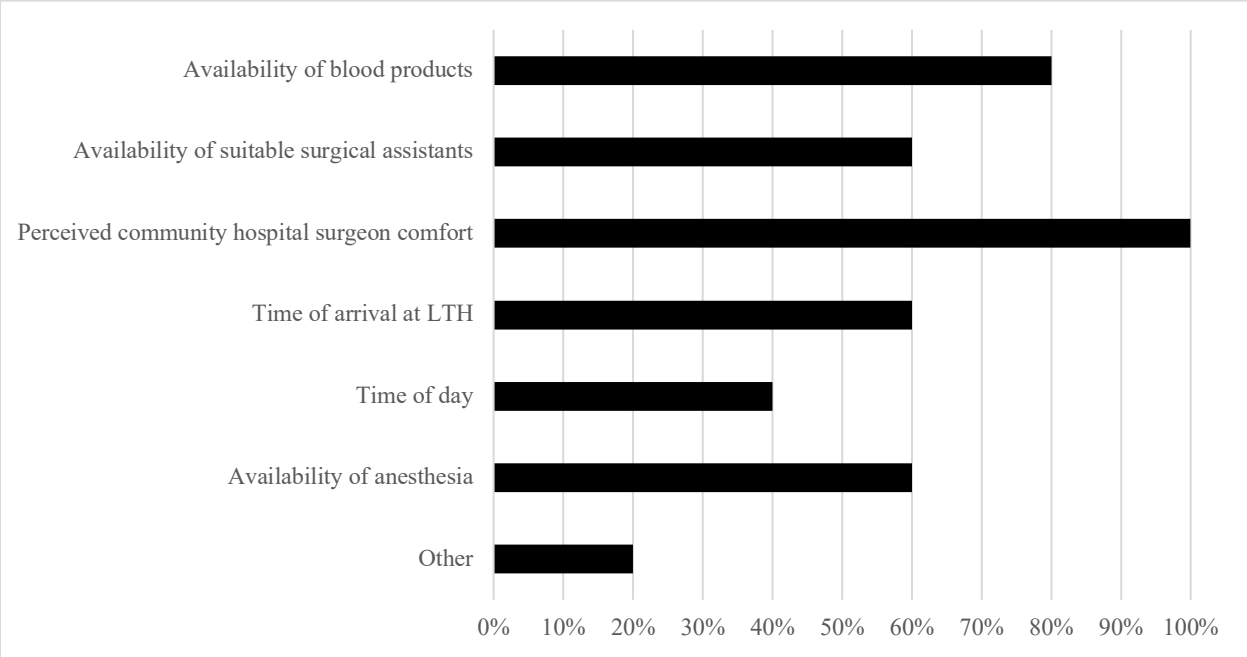

Figure 4.3: Trauma medical director's perceived barriers to exploratory laparotomy in a community center

One respondent chose "other" as an option and provided the following narrative response:

> *"The general surgeons at these hospitals do not want to do it, refuse to do it, and decline to be involved in the care of trauma patients in their emergency departments."*

Regarding the level of communication with Ornge paramedics amongst their TTLs, 60% of respondents say their TTLs do not routinely engage with Ornge to gain a better understanding

of availability and timing of transport. One TMD chose that their TTLs contact Ornge through direct formal contact with the on-shift transport medicine physician, and also through informal contact with another Ornge physician on or off shift. Another TMD chose that their TTLs engage with Ornge through direct formal contact with the on-shift transport medicine physician and through direct formal contact with Ornge operations.

With regards to the new policy change directing the protocols surrounding transport of hemodynamically unstable trauma patients within Ornge (enacted 6 months prior to this survey being completed), 40% of respondents reported not being aware of this change.

When prompted, three TMDs provided prose regarding their attitudes surrounding advanced-TTL notification, recent changes to Ornge policy, or other comments:

> *"We believe advanced notification is essential to 1) provide opportunity to our TTLs to advocate for intervention prior to transport, and 2) to allow time for preparation at the LTH to receive unstable patients."*
>
> *"The system should be created so that it does not require heavy use of individual decisions to get patients where they belong. People's roles and expectations should be set a priori, and then they should be expected to fulfill them."*
>
> *"Advance notice is only needed in my view, to an extent that prepares the receiving team to be ready with the necessary equipment to provide the needed care. At a LTH, the team should always be ready and the TTL requires 20 minute heads up."*

4.4 Discussion

This survey of Ontario community general surgeons and TMDs regarding the operative management of hemodynamically unstable trauma patients is the first to attempt to garner the outlook and perspectives of key stakeholders in providing care to those injured in the rural and remote setting who may benefit from advanced intervention prior to transfer to a LTH. Further, it acts as a small step toward improving trauma systems in Ontario to provide timely, critical intervention to patients who face inherent health disparities based solely on their location.

Although literature originating in the Canadian trauma systems examining outcomes of rural trauma patients is sparse, extrapolating from the United States, there is little debate that those patients injured in the rural and remote setting face worse outcomes when compared to their urban counterparts. Improving care for these patients requires a multi-faceted approach addressing issues within both rural and remote facilities acting as the initial point of contact for these patients as well as the trauma systems that patients and practitioners must navigate to receive and provide timely and quality care. However, before we can begin to tackle these issues and barriers to care, they must first be addressed by examining what is known about the current practices in place and the perceived barriers inhibiting this care.

When examining the results of the community surgeon survey, we are limited by the lack of responses and acknowledge this is unlikely to be a representative sample of currently practicing community general surgeons in Ontario. However, the sample we do have, with a median practice length of 17.5 years and being primarily from small/rural communities with no formal fellowship training, reflects extensive experience serving small and rural communities in their responses. The caveat to this relative experience, however, is that we are questioning a group of experienced surgeons about their level of comfort in performing an operation on a hemodynamically unstable patient, which is a rare event in a small hospital today. Changes in trauma management protocols and transportation however, mean that when these surgeons trained (over 15 years ago), these operations were far more common, and we therefore hypothesize that the group of surgeons who responded are doing so with a lens of more experience than their younger counterparts. We have very little knowledge on comfort levels of recent graduates currently in the early phases of community practice.

To further accentuate this point, there appears to be discordance in the surveyed community general surgeons' level of comfort performing trauma laparotomy on a hemodynamically unstable patient in their small/rural hospitals and the perceived comfort of these surgeons amongst TMDs in the province. For example, 70% of community general surgeon respondents say they are "very comfortable" performing this operation, along with 50% of community general surgeon respondents saying that they feel there are currently no barriers to performing this operation currently within trauma systems in Ontario and 30% responding that they feel there are no barriers to performing this operation within their current institution. In contrast to this, 100% of TMDs felt that "perceived community hospital surgeon comfort" was the biggest barrier to hemodynamically unstable trauma patients with suspected intra-abdominal injury receiving DCL prior to transfer. Speculating on this discordance, one plausible explanation is that given our significant risk of sampling bias with a very low number of community surgeon respondents, the remaining surgeons who did not respond to this survey may represent the sample of community surgeons that the TMDs are basing their responses on. The less experienced (and possibly less comfortable surgeons) are not adequately captured in this small sample. Another possibility is that on an individual level, community general surgeons *are* more comfortable performing these operations than hypothesized and reflected by the TMD responses, but system level barriers are preventing them from performing this operation. However, contradictory to this hypothesis, 50% of general surgeon respondents did not feel there are any current barriers within trauma systems in Ontario preventing them from performing this operation for hemodynamically unstable trauma patients.

An additional explanation for this discordance is that we have anecdotal evidence that there are RHs whereby the emergency room physicians contact the LTH and Ornge for transport

prior to involving the community general surgeon at all. These results tell us that although at LTHs we perceive this as a lack of willingness of RH surgeons to be involved in the care of seriously injured trauma patients, it may just be that they were never contacted in the first place. This indicates the potential need for significant cultural shift and integration of RH surgeons into the fabric of trauma care in their communities.

The importance of the recently graduated general surgeon, not well-represented in our sample, is underscored by work completed by Engels et al in 2024. This multi-center retrospective review of operative and non-operative trauma teaching in Canada over a 10-year period concluded that general surgery residents across the country receive variable and limited exposure to both operative and non-operative trauma throughout their training.(1) They found that graduating Canadian general surgical residents over the last 10 years are present for only an average of only 4 index trauma laparotomies with the average procedural experience being 2 bowel resections and 1 trauma splenectomy. When adding this lack of exposure to the ongoing movement away from predominantly operative intervention to non-operative management (i.e., interventional radiology for splenic artery embolization or observation alone for stable patients), resident exposure to index trauma operations becomes a scarce learning opportunity. Additionally, and as Engels et al outline, as with much of general surgery, there has been increased recognition of the role of sub-specialization, including trauma surgery. It is possible then, that graduating general surgery residents who choose to work in these RHs may not fully appreciate their role in the broader system of trauma care.

With respect to the level of knowledge surrounding recent changes to processes of communication and transfer of hemodynamically unstable trauma patients, nearly half of all TMDs in the province were not aware of the recent policy change. This policy change was

instituted as an attempt to improve communication between RHs, LTHs and Ornge and to advocate for potentially lifesaving intervention at RHs prior to transfer, as well as to prepare LTHs for impending arrival of severely injured patients. However, with this lack of knowledge regarding these new processes amongst the individuals responsible for trauma care at LTHs, we must re-visit how these changes are communicated to our TMDs and indirectly, to TTLs and RH general surgeons across the province. As it stands, Ornge is responsible for enacting this policy change, however, without knowledge amongst all caregivers in these circumstances, there is unfortunate opportunity for miscommunication, delays, and frustration surrounding transfer potentially leading to adverse outcomes for our patients.

The biggest limitation of the present study is the poor response from community general surgeons. Additionally, although we were able to obtain a 100% response rate from TMDs, this still represents a small sample size with only five in the entire province. All of our answers are only reflective of trauma care in Ontario and are not generalizable to the remainder of the country where access to rural trauma care remains a substantial issue.

The next step of the present work is to establish a larger representative sample of community general surgeons throughout Ontario as we work collaboratively with them to improve the care for patients injured in their communities. We intend to conduct a qualitative study, using focus group methodology and recruiting more directly from communities across Ontario as an attempt to garner a representative sample. Further, we plan to present this data (in addition to our other work surrounding RH-DCL and advanced-TTL notification) at the upcoming OAGS meeting in an attempt to draw attention to our work and prompt participation in our upcoming studies to gain a more in-depth understanding of the barriers potentially preventing community general surgeons in performing this operation. Lastly, given the current

knowledge surrounding recent policy change, we will meet with the Ornge administration again to discuss a strategy for educating key stakeholders in trauma care across Ontario regarding the current, as well as future, policy changes impacting the care of trauma patients.

4.5 Conclusions

This study presents a critical examination of the current practices and perceptions of community general surgeons and TMDs in Ontario regarding the management of hemodynamically unstable trauma patients. The findings highlight significant discrepancies between the reported comfort levels of community surgeons performing trauma laparotomies and the perceived comfort levels of these surgeons held by TMDs. This discordance suggests that there are underlying factors, possibly related to training and systemic barriers, that need to be addressed to improve trauma care in rural and remote settings.

Despite the low response rate from community surgeons, the insights provided by experienced practitioners offer valuable perspectives on the existing barriers to effective trauma care. The study emphasizes the necessity of standardized protocols and enhanced communication channels between rural hospitals, trauma centers, and Ornge to ensure timely and efficient patient management. The lack of awareness among TMDs about recent policy changes further underscores the need for comprehensive education and dissemination of new protocols.

References

1. Engels PT, Shi Q, Coates A, Allen L, Priestap F, Moffat BS, et al. Trauma Resident Exposure in Canada and Pperative Numbers (TraumaRECON): A National Multicentre Retrospective Review of Operative and Nonoperative Trauma Teaching. CJS. 2024 Mar 7;67(2):E99–107.

Chapter 5

Summary of Results and Discussion

Chapter 5. Summary of Results and Discussion

5.1 Clinical Importance

The advent of modern trauma systems found its roots in wartime medicine and has since been molded to suit the needs of modern society. The initial catalyst for this ongoing transformation stems from the National Committee on Shock and Trauma in the United States when they labelled accidental death as a "neglected disease of modern society."(1) Since that time, impressive strides have been made in both the U.S. and Canada to establish refined systems to care for severely injured patients.

The earliest trauma systems were developed as a response to reduce unnecessary morbidity and mortality from violence and injury, and all subsequent advancements have built upon this foundational goal. The current stimulus challenging our modern systems, especially in Canada, is the rurally injured patient. Outcomes for these patients are significantly worse when compared with their urban counterparts and these outcomes are amplified when considering the magnitude of patients in Canada who reside outside the usual catchment area of designated trauma centers in our country.

The common thread linking the studies in this thesis is the overarching goal of critically examining our current trauma systems and addressing the disparities that continue to affect patients in rural and remote areas. This thesis represents one of the first bodies of work in Canada to address this pressing issue, and we hope it will set the stage for further research in this important area.

Our first study critically examines current practices and outcomes for those patients injured in the rural setting and require damage control laparotomy (DCL) to address life-threatening intra-abdominal injury. While this only represents one facet of the care required for

these patients, DCL is a lifesaving operation that could be readily accessible in most community hospitals (provided a general surgeon is available) that can temporize severe injury and allow appropriate transfer to a lead trauma hospital (LTH) for definitive care. While this practice has been studied in the U.S. (albeit in a limited nature), this is the first study within the Canadian trauma ecosystem to examine this patient population.

When advanced intervention is not indicated or undertaken in a community hospital, or when a patient is transported directly from the scene of injury, advanced notification of their impending arrival to a trauma center is important. Our second study aimed to examine a new practice in Ontario trauma systems whereby trauma-team leaders (TTL) are notified of impending arrival of hemodynamically unstable trauma patients with the goal of advocating for critical intervention prior to departure from a community hospital and/or preparing for the arrival of that patient. We aimed to show that through advanced notification, severely injured patients experience a shorter time to critical intervention or post-trauma bay phase of care with the overarching goal of improving overall outcomes for these patients.

Related to the outcomes associated with DCL, from a health services perspective, key stakeholders providing care to trauma patients in our country have unique insight into the barriers and facilitators to providing advanced trauma intervention in a community hospital. Notably, for the rurally injured patient, community hospital general surgeons are often the first point of contact in providing time sensitive operative care for these patients (mainly in the form of DCL). Further, the appropriate and timely transfer of these patients relies on efficient and meaningful communication between rural trauma providers and TTLs at LTHs. Therefore, we designed a survey to assess current perspectives on the state of systems designed to provide care for these patients and identify barriers preventing this care directed towards both community

general surgeons and trauma medical directors in Ontario. In addition to evaluating our systems as they currently exist, we also aimed to use the responses to identify further areas of study and learn how to integrate our findings across both community and LTHs across Ontario to improve patient outcomes.

Overall, our research highlights the urgent need to address the disparities in trauma care for rural and remote patients in Canada. By critically examining current practices and outcomes, we shed light on the unique challenges faced by these patients and the healthcare providers who serve them. Our studies on DCL and advanced notification systems underscore the potential for improved outcomes through timely and appropriate interventions. Additionally, our survey of key stakeholders provides invaluable insights into the barriers and opportunities for enhancing trauma care. This thesis not only represents a pioneering effort in the Canadian trauma landscape but also sets the stage for ongoing research and systemic improvements aimed at ensuring equitable and effective care for all trauma patients, regardless of their geographic location. Through continued collaboration and innovation, we can build a more responsive and inclusive trauma care system that meets the needs of every patient.

5.2 Summary of Results

Our Canadian-first study examining the role of rural DCL examined outcomes of patients who received rural-hospital DCL (RH-DCL) and compared these with those patients who presented directly to the LTH and received LTH-DCL. We did not detect a meaningful difference in abdominal-specific outcomes when comparing RH-DCL to LTH-DCL. Further, we noted no significant difference in all secondary outcomes including length of intensive care unit stay, length of hospital stay, duration of open abdomen, and mortality.

Our pre-post analysis of recent policy change mandating advanced-TTL notification for impending hemodynamically unstable trauma patients demonstrated that despite advanced notification, there was no statistically significant difference in overall time to critical intervention or time in the emergency department (ED). However, despite our limited sample size, we were able to demonstrate in a number of important interventions, namely chest tube placement and time to the operating room, there was a decrease in the time from arrival to intervention after implementation of this policy. Further, for those patients where advanced notification was deemed to be reasonable and could make a significant difference to care, we demonstrated a near 100% rate of policy compliance amongst care providers. We hypothesize that, as the number of patients effected by this policy increases, we may be able to show a significant relationship between advanced notification and time to intervention or further care.

Lastly, our surveys illuminated important insights into the current attitudes and perceptions of trauma systems and care for severely injured patients from both community hospital general surgeons and trauma medical directors (TMDs). Notably, there was significant discordance between the comfort level of community general surgeons in performing trauma laparotomy (with most stating they would be comfortable performing the operation), and the perceived comfort of these surgeons from the TMDs across Ontario. This suggests that there may be underlying factors impacting the ability of community surgeons to provide this necessary care for trauma patients which is manifesting as a perceived discomfort. These factors may include training and systemic barriers that need to be addressed to continue to improve trauma care in rural and remote settings.

The present work provides a foundation to begin addressing the disparities impacting rural Canadians who experience significant trauma. While we are limited by our mainly

retrospective approach and small sample sizes, it is our hope that the present work can be expanded upon to both strengthen our conclusions and identify further areas of improvement and study within Canadian trauma systems.

5.3 Future Directions

To make firm conclusions regarding the role of RH-DCL and advanced-TTL notification, there is a significant need to increase our sample size. We hypothesize that through expansion of the present work, we may be able to show an equivalence or even superior role of RH-DCL when compared with LTH-DCL and that the improved times to critical intervention may become statistically significant. As a response to this need, our center has already begun prospectively identifying the patients who meet our study criteria to expand our study population. Further, for both studies, we hope to foster future collaboration with the four other level I equivalent trauma centers across Ontario to expand the work to a provincial scale.

The next step to garner further perspectives of trauma providers in Ontario is to establish a larger representative sample of community general surgeons throughout Ontario. Therefore, we aim to evaluate perspectives of key informants using focus groups of representative samples from communities across Ontario. Further, we plan to present this data at the upcoming Ontario Association of General Surgeons (OAGS) meeting in an attempt to draw attention to our work and prompt participation in our upcoming studies to gain a more in-depth understanding of the barriers potentially preventing community general surgeons from performing lifesaving intervention.

References

1. Liberman M, Mulder DS, Sampalis JS. The History of Trauma Care Systems From Homer to Telemedicine. MJM [Internet]. 2020 Dec 1 [cited 2023 Nov 13];7(2). Available from: https://mjm.mcgill.ca/article/view/785

Appendices

APPENDIX I. Chapter 2 Research Ethics Board Approval

Western Research

Date: 20 February 2024

To: Dr. Kelly Vogt

Project ID: 122203

Review Reference: 2024-122203-89545

Study Title: Reassessing the role of trauma laparotomy prior to transfer to a dedicated trauma centre

Application Type: Continuing Ethics Review (CER) Form

Review Type: Delegated

Date Approval Issued: 20/Feb/2024 14:51

REB Approval Expiry Date: 16/Feb/2025

Ethics Lapse: 16/Feb/2024 - 20/Feb/2024

Dear Dr. Kelly Vogt,

The Western University Research Ethics Board has reviewed the application. This study, including all currently approved documents, has been re-approved until the expiry date noted above.

REB members involved in the research project do not participate in the review, discussion or decision.

Western University REB operates in compliance with, and is constituted in accordance with, the requirements of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2); the International Conference on Harmonisation Good Clinical Practice Consolidated Guideline (ICH GCP); Part C, Division 5 of the Food and Drug Regulations; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. The REB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Please do not hesitate to contact us if you have any questions.

Electronically signed by:

Mr. Joshua Hatherley, Ethics Coordinator on behalf of Dr. N. Poonai, HSREB Chair 20/Feb/2024 14:51

Reason: I am approving this document

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

APPENDIX II. Chapter 3 Research Ethics Board Approval

Western Research

Date: 26 February 2024

To: Dr. Kelly Vogt

Project ID: 124355

Review Reference: 2024-124355-89299

Study Title: Advanced Notification of Trauma Team Leaders: A Retrospective Evaluation of Recent Policy Change

Application Type: HSREB Initial Application

Review Type: Delegated

Date Approval Issued: 26/Feb/2024 14:48

REB Approval Expiry Date: 26/Feb/2025

Dear Dr. Kelly Vogt

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above mentioned study as described in the WREM application form, as of the HSREB Initial Approval Date noted above. This research study is to be conducted by the investigator noted above. **All other required institutional approvals and mandated training must also be obtained prior to the conduct of the study**.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Research Protocol (02_12 ver.2)	Protocol	12/Feb/2024	2
Advanced TTL Data Collection Sheet (02_12 ver.2)	Other Data Collection Instruments	12/Feb/2024	2

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
Study Budget (25:11 ver.1)	Study budget	25/Nov/2023	1

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University HSREB operates in compliance with, and is constituted in accordance with, the requirements of the TriCouncil Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2); the International Conference on Harmonisation Good Clinical Practice Consolidated Guideline (ICH GCP); Part C, Division 5 of the Food and Drug Regulations; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Please do not hesitate to contact us if you have any questions.

Electronically signed by:

Mr Joshua Hatherley , Ethics Officer on behalf of Dr. Naveen Poonai, HSREB Chair, 26/Feb/2024 14:48

Reason: I am approving this document

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations, See Electronic System Compliance Review)

APPENDIX III. Chapter 4 Research Ethics Board Approval

Western Research

Date: 9 January 2024

To: Dr. Kelly Vogt

Project ID: 124308

Review Reference: 2024-124308-87779

Study Title: Evaluating Perspectives of Ontario Surgeons and Trauma Directors on Intervention and Transfer Processes of Hemodynamically Unstable Trauma Patients

Application Type: HSREB Initial Application

Review Type: Delegated

Date Approval Issued: 09/Jan/2024 08:33

REB Approval Expiry Date: 09/Jan/2025

Dear Dr. Kelly Vogt

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above mentioned study as described in the WREM application form, as of the HSREB Initial Approval Date noted above. This research study is to be conducted by the investigator noted above. **All other required institutional approvals and mandated training must also be obtained prior to the conduct of the study**.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Trauma Survey Protocol (20:11 ver. 1)	Protocol	20/Nov/2023	1
Trauma Program Director Survey (20:11 ver. 1)	Online Survey	20/Nov/2023	1
General Surgeon Survey (20:11 ver.1)	Online Survey	20/Nov/2023	1
Trauma Program Director Email (20:11 Ver. 1)	Email Script	20/Nov/2023	1
General Surgeon Email (29_12 Ver. 1)	Email Script	29/Dec/2023	1
Education Document(01:05 Ver. 2)	REB Response Letter	05/Jan/2024	2
Letter of Information and Consent (01:05 Ver. 4)	Written Consent/Assent	05/Jan/2024	4

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University HSREB operates in compliance with, and is constituted in accordance with, the requirements of the TriCouncil Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2); the International Conference on Harmonisation Good Clinical Practice Consolidated Guideline (ICH GCP); Part C, Division 5 of the Food and Drug Regulations; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Please do not hesitate to contact us if you have any questions.

Electronically signed by:

Melanie Munroe, Ethics Officer on behalf of Dr. Naveen Poonai, HSREB Chair, 09/Jan/2024 08:33

Reason: I am approving this document

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations, See Electronic System Compliance Review)

APPENDIX IV. Letter of Information for Surveys

Western

Office of Research Ethics

Letter of Information and Consent

Title: Evaluating Perspectives of Ontario Surgeons and Trauma Directors on Intervention and Transfer Processes of Hemodynamically Unstable Trauma Patients

Principal Investigator: Dr. Kelly Vogt

Co-Investigators: Dr. Cohen Chaulk and Ms. Laura Allen

Dear Ontario Trauma Program Directors and General Surgeons,

You are invited to participate in a research study evaluating current knowledge and practices surrounding management and transfer of hemodynamically unstable trauma patients initially presenting to non-lead trauma hospitals.

Literature suggests that time to intervention is crucial in the treatment of hemodynamically unstable trauma patents. Additionally, recent work by our group has shown that there is no difference in outcomes between patients receiving a laparotomy at a rural center compared to a dedicated trauma facility.

There have been recent policy changes within Ontario's provincial air ambulance service (Ornge) whereby all trauma-team leaders must be notified prior to take-off of a hemodynamically unstable trauma patient being transferred to their center from a "scene" or "modified-scene." The goal of this policy change is for trauma-team leaders to have the opportunity to advocate for potentially crucial intervention at the non-lead trauma hospital and should a decision for transfer arise, prepare resources (OR, interventional radiology, ICU, etc.) prior to arrival.

Given this new policy change dictating processes of care for hemodynamically unstable trauma patients, our group is particularly interested in assessing current knowledge of practitioners outside of lead-trauma hospitals caring for these patients as well as trauma program directors in the province. Our goal is to assess for the need of further education of the current, and potentially future, policies surrounding this care.

Additionally, and perhaps more importantly, we are interested in surveying both non-lead trauma hospital general surgeons and trauma program directors regarding current barriers they face at both an institutional and trauma systems level. We hope to be able to identify these issues and as we move forward with our work in improving the care provided to rural and remote trauma patients, integrate these barriers.

Methodology:

This survey-based investigation will be distributed to all current members of the Ontario Association of General Surgeons through their email notification system. Recipients are asked to participate if they are currently practicing General Surgery in Ontario and not currently working at a lead-trauma hospital. A separate, but similar survey will also be sent to all trauma program directors within the province. We anticipate a total of 65 participants based on a convenience sample of currently practicing community general surgeons and trauma directors in Ontario.

This survey will take approximately 10-20 minutes complete. There are no known or anticipated risks or discomforts associated with completion of this survey.

When published, this data will reflect patterns within regional and rural trauma care in Ontario and the barriers that impact this care and not that of you as an individual. Your personal information will not be collected and if this investigation is published, no identifiable information will be made public. Responses will be aggregated before analysis and therefore individual responses will not be evaluated.

A follow-up email will be sent 3 weeks after the initial contact email.

Participation:

You may refuse to participate or withdraw at any point in the study prior to survey submission. The survey is secured through the RedCap survey platform, hosted by Lawson Research Institute. Data collected is stored within a firewall protected, secure data center hosted by Lawson Research Informatics. This data server is in Canada. Data collected is confidential and available only to members of the research team. No identifiable personal information will be collected. Data will be securely stored in accordance with university policy. While REDCap hosted by Lawson has been tested and proven to be a safe, protected method of storing information, nothing is ever 100% safe when stored on the internet. There are always small risks that data stored within the online platform becomes susceptible to access from non-research personnel. However, all measures as outlined by Lawson and

Your participation in this survey is voluntary. You may decide not to be in this study. Even if you consent to participate, you have the right to not answer individual questions or to withdraw from the study at any time. Representative from Western University's Health Science Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of research. Representatives from Lawson Quality Assurance Education Program may look at study data for quality assurance purposes.

If you choose not to participate or to leave the study at any time it will have no effect on your employment or academic status. There is no compensation for you participation in this study. You do not waive any legal right by signing this consent form.

If you have any questions about this investigation, please do not hesitate to contact: Dr. Kelly Vogt [redacted], Dr. Cohen Chaulk [redacted] or Laura Allen [redacted]

Additionally, if you have any further questions about your rights as a research participant or the conduct of the study, you may contact the Patient Relations Office at LHSC at [redacted]

I have read the Letter of Information and I agree to participate. Completion of this survey is indication of your consent to participate.

Sincerely,

Dr. Kelly Vogt
Dr. Cohen Chaulk
Ms. Laura Allen

APPENDIX V. Community General Surgeon Survey

Form 1

The following survey is designed to gain a further understanding of current practices in Ontario community hospitals surrounding hemodynamically unstable trauma patients and any barriers that prevent definitive care of these patients within community hospitals.

We kindly ask that you answer the following questions as representative of your practice. Your responses to this survey are extremely valuable and we thank you for your participation!

This survey has been created as a part of the Master of Science in Surgery degree for Cohen Chaulk, General Surgery resident at Western.

How would you classify the hospital where you primarily practice General Surgery?	◯ Academic ◯ Large community, academic ◯ Large community, non-academic ◯ Small community/rural
How many years have you been practicing General Surgery?	_____
Do you have sub-specialty fellowship training?	◯ Yes ◯ No
Please indicate which sub-specialty fellowship(s) you completed. Choose all that apply.	☐ Acute Care Emergency Surgery ☐ Bariatric Surgery ☐ Breast Surgery ☐ Colorectal Surgery ☐ Critical Care/Intensive Care ☐ Endocrine Surgery ☐ Advanced Endoscopy ☐ Head and Neck Surgical Oncology ☐ Hepatopancreaticobiliary (HPB) ☐ Minimally Invasive Surgery ☐ Pediatric Surgery ☐ Surgical Oncology ☐ Thoracic Surgery ☐ Transplant Surgery ☐ Trauma Surgery ☐ Vascular Surgery ☐ Other(s), please specify below
Please indicate any sub-specialty fellowship training that you have completed that is not included in the above question.	_____
Does your hospital have a designated trauma team?	◯ Yes ◯ No
Are the general surgeons at your center a part of the trauma team?	◯ Yes ◯ No

How would you describe your level of comfort performing an exploratory trauma laparotomy on an unstable patient with a positive FAST examination?	◯ Very comfortable ◯ Comfortable, but only in certain circumstances (i.e, there is a second surgeon to assist, my center has access to ample blood products for resuscitation, anesthesia support, etc.) ◯ Uncomfortable and would prefer to transfer patients to a lead-trauma hospital with fellowship trained trauma surgeons
Please outline what you feel could improve your level of comfort performing a trauma laparotomy on a hemodynamically unstable patient with an indication to do.	_____
Please select all options that you perceive as barriers at your insitution that decrease your level of comfort in performing a trauma laparotomy on unstable patients.	☐ I do not perceive there to be any barriers ☐ Limited, or no, availability of experienced surgical assistants ☐ Limited, or no, availability of anesthesia ☐ Lack of nursing experience in dealing with hemodynamically unstable trauma patients ☐ Limited availability of blood products at our institution ☐ Access to an emergency operating room ☐ Inability to prepare an emergency operating room ☐ Issues with obtaining access to surgical teams and resources at night (if applicable) ☐ Other(s), please list below
You have selected that you do not perceive there to be any barriers at your institution that decrease your level of comfort in performing a trauma laparotomy on hemodynamically unstable patients. Please indicate why in the space provided.	_____
Please list any other barriers at your institution that decrease your level of comfort in performing a trauma laparotomy on hemodynamically unstable patients.	_____
Please select all options that you perceive as barriers within trauma systems in Ontario that decrease your level of comfort in performing a trauma laparotomy on unstable patients.	☐ I do not perceive there to be any barriers within trauma systems in Ontario ☐ Limitations in post-operative transport to a critical care center ☐ There is no trauma system close enough to our center to allow safe post-operative transport of trauma patients in a timely fashion ☐ Lack of advanced notification from paramedics (Ornge or otherwise) to adequately prepare an operating room and team ☐ Other, please specify
You have selected that you do not perceive there to be any barriers within trauma systems in Ontario that decrease your level of comfort in performing a trauma laparotomy on hemodynamically unstable patients. Please indicate why in the space provided.	_____

Please list any other barriers within trauma systems in Ontario that decrease your level of comfort in performing a trauma laparotomy on hemodynamically unstable patients.	_____

APPENDIX VI. Trauma Medical Director Survey

Trauma Program Director Survey

The following survey is focused on the responses of trauma programs to community hospitals and surgeons who are treating hemodynamically unstable trauma patients in their centers without full trauma teams or Level 1 trauma designation.

We kindly ask that you answer the following questions as a representative of the clinical practices or policies (formal or informal) in your center that are currently in place.

Your responses to this survey are extremely valuable and we thank you for your participation!

This survey has been created as a part of the Master of Science in Surgery degree for Cohen Chaulk, General Surgery resident at Western.

Which trauma center in Ontario do you represent?	_____
Does your center have a policy outlining trauma-team leader response to community hospitals in advising standard ATLS interventions (i.e., chest tube insertion, blood product transfusion, pelvic binder placement, etc.) prior to transferring a hemodynamically unstable patient to your center?	◯ Yes, a formal policy ◯ Yes, an informal policy ◯ No
Does your center have a policy outlining trauma-team leader response to community hospitals in advising operative intervention (i.e., laparotomy, pelvic external fixation, etc.) prior to transferring a hemodynamically unstable patient to your center?	◯ Yes, a formal policy ◯ Yes, an informal policy ◯ No
Please outline your policy here. If this is an informal policy, please describe the current practices guiding trauma-team leader response at your center in this situation. If you have a formal written policy and wish to share, please write N/A as your response to this question and upload the formal policy in the space below.	_____
If a formalized policy exists, please upload it here.	
In general, how would you rate the comfort level of your trauma-team leaders in advising a community general surgeon to proceed with exploratory laparotomy for a hemodynamically unstable trauma patient with a definitive indication to do so (i.e., positive FAST)?	◯ Very comfortable ◯ Comfortable, but only in certain circumstances (i.e., there is a second community surgeon to assist, the community center has ample access to blood products, etc.) ◯ Uncomfortable and would actively advocate for patients to be transferred to our lead-trauma hospital for their trauma laparotomy by the quickest means possible

Do you perceive there to be a difference between your emergency medicine trained trauma-team leaders and your surgery trained trauma-team leaders with respect to their comfort level in advising a community general surgeon to proceed with exploratory laparotomy for a hemodynamically unstable trauma patient with a definitive indication to do so?	◯ Yes ◯ No
Which of the following applies to your perceived differences between emergency medicine physician and surgeon trauma-team leaders with respect to their level of comfort in advising a community general surgeon to proceed with exploratory laparotomy?	◯ Surgeons are more comfortable ◯ Emergency medicine physicians are more comfortable
What do you see as potential barriers to performing an exploratory laparotomy for hemodynamically unstable patients with a positive FAST in a community center? Choose all the apply.	☐ Availability of blood products ☐ Availability of suitable surgical assistants ☐ Perceived community hospital surgeon comfort ☐ Time of arrival at lead-trauma hospital ☐ Time of day ☐ Availability of anesthesia ☐ Other, please specify below
Please list any other potential barriers to performing an exploratory laparotomy for hemodynamically unstable patients with a positive FAST in a community center that you perceive to exist	_____
Do your trauma-team leaders routinely engage with Ornge for a better understanding of availability of and timing of transport?	◯ Yes ◯ No ◯ Unknown
In what way do your trauma-team leaders engage with Ornge for a better understanding of availability and timing of transport?	☐ Direct contact with Ornge transport medicine physician on shift ☐ Direct contact with Ornge operations ☐ Direct informal contact with other Onrge physician on or off shift ☐ Other, please specify below
Please describe any other ways in which your trauma-team leaders engage with Ornge for a better understanding of availability and timing of transport.	_____
Are you aware of the recent policy change by Ornge surrounding advanced notification of trauma-team leaders of unstable patients assessed outside of a lead-trauma hospital by Ornge?	◯ Yes ◯ No

Since you selected no to the previous question, we have provided the updated policy surrounding advanced notification of trauma-team leaders of hemodynamically unstable patients by Ornge.

Prior to this policy change, patients being transported from a trauma scene or referring hospital via a "modified scene" response, were identified via pre-arrival notification to the trauma team leader only once the patient was in transit to the Lead Trauma Hospital. This created situations where the opportunity for early intervention in a referring hospital was never afforded to critically injured patients. Further, in Ontario, many patients have short flight times, and as such the trauma-team leader (who sometimes covers call from home) is often not notified in sufficient time to be in hospital when the patient arrives.

The revised policy now requires direct communication between the Ornge paramedics and trauma-team leader prior to beginning transport for a patient who has had any episode of hypotension (systolic blood pressure < 90 mmHg).

R. Cohen Chaulk

Education

General Surgery Residency – Western University	2022 – Present
Master of Science in Surgery (M.Sc.) – Western University	2023-2024
Doctor of Medicine (M.D.) – University of Saskatchewan	2018 – 2022
Master of Arts in Music Theory (M.A.) – Western University	2017, 2021
Bachelor of Music (Honors) in Piano Performance (B.Mus.) – Memorial University	2013 – 2017

Research

Current Activity

Reinforcing the role of rural trauma laparotomy *Study in progress*	2022 – Present
Evaluating the impact of advanced trauma-team leader notification *Study in progress*	2023 – Present
A brief history of trauma systems and their integration into Canada *Study in progress*	2023 – Present
Fatal de novo antibody mediated rejection after SARS-CoV-2 mRNA vaccination in liver transplantation *Study in progress*	2022 - Present
Improving perioperative outcomes after adrenalectomy for pheochromocytoma: an international multi-centre study *Study in progress*	2023 - Present
A novel same day discharge program after pulmonary wedge resection: A prospective clinical controlled trial *Submitted for publication*	2023 - Present
Same day discharge after pulmonary wedge resection: a cost-utility analysis *Study in progress*	2024 - Present
Approaches to thymectomy in the minimally invasive era: a narrative review *Submitted for publication*	2024 – Present
Etiology, diagnosis, and management of descending necrotizing mediastinitis:	2024 - Present

R. Cohen Chaulk

a narrative review
Submitted for publication

Publications

Qu, L., Istl, A., Tang, E., **Chaulk, R.C.**, Gray, D. Variability in the perioperative management of pheochromocytoma in Canada. CUAJ. 2024 May;18(9).

Pirpiris, A., Chan, G., **Chaulk, R.C**., Tran, H., Liu, M. An update on urethral diverticula: Result from a large case series. CUAJ. 2022 March;16(8):443-7.

Chan, E., **Chaulk, R.C.,** Cheng, Y., Shin, J. No decrease in incidence of arthroscopic meniscectomy in a Canadian province. Knee Surg Sports Traumatol Arthrosc. 2021 Dec;29(12):4223-31.

Research Awards

Trauma Association of Canada: Best Trainee Research Presentation	2024
Western University Department of Surgery Resident Research Grant ($5000)	2023
Western University Resident Travel Award ($750)	2023
Ontario Graduate Scholarship ($15,000)	2023
Western University Graduate Research Scholarship ($3000)	2023
Western University Department of Surgery Resident Research Grant ($2500)	2022
American Association of Thoracic Surgeons Summer Intern Scholarship	2021
American Association of Thoracic Surgeons Member for a Day Scholarship	2021
University of Saskatchewan Department of Medicine Research Day: First Place Poster Presentation	2019
Social Sciences and Humanities Research Council Grant ($18,000)	2018
Ontario Graduate Scholarship ($15,000)	2018
Ontario Graduate Scholarship ($15,000)	2017
Western University Graduate Research Scholarship ($12,000)	2017

Research Presentations

Canadian Association of Thoracic Surgeons: Canadian Surgical Forum 2024
Same day discharge after pulmonary wedge resection: a cost-utility analysis - Podium

Trauma Association of Canada Conference 2024
Reinforcing the role of rural trauma laparotomy - Podium

Committee on Trauma: Resident Research Competition 2023
Reinforcing the role of rural trauma laparotomy – Podium

Western University Department of Surgery Robert Zhong Research Day 2023
Reinforcing the role of rural trauma laparotomy – Poster

Western University Department of General Surgery Research Day 2023
Reinforcing the role of rural trauma laparotomy – Podium

Notable Research Contributions

Jamieson, W.E.J., Ely, J., Brink, J., Pennel, T, et al. PROSE: Prospective randomized trial of the On-X mechanical prosthesis and the St. Jude mechanical prosthesis. 2021
Assisted in data collection at Groote Schuur Hospital in Cape Town, South Africa.

De Souza, J., Roy, A., and Goldman, A. "Classical Rondos and Sonatas as Stylistic Categories" *Music Perception* 37 (Iss. 5): 373 – 391. 2020
Designed computer program for experiment and assisted in data collection. Acknowledged as contributor with special thanks in publication.

De Souza, J., and Lokan, D. 2020. "Hypermetrical Irregularity in Sonata Form: A Corpus Study." *Empirical Musicology Review* 14 (July): 138. 2020
Assisted in data collection and extensive musical analysis. Acknowledged as contributor with special thanks in publication.

Other Research and Scholarly Activity

Western University Trauma Manual and App 2023
Lead author for trauma manual and led team in developing app based on trauma manual for Western University and London Health Science Center's Trauma Program

Canadian Association of General Surgeons: Resident Research Retreat 2023
Nominated and chosen to attend CAGS resident research retreat to aid in the development of early career surgical researchers.

Cardiothoracic Surgery Research Externship – University of Cape Town 2016
Responsible for collecting retrospective data for multi-center study comparing

various types of mechanical heart valves.

Select Academic Awards and Scholarships

University of Saskatchewan Professor's Prize in Surgery	2022
University of Saskatchewan Professor Popkin Prize in Obstetrics and Gynecology	2022
University of Saskatchewan College of Medicine Student Award	2021
Indspire Academic Scholarship	2021
University of Saskatchewan College of Medicine Student Award	2020
Nasser Scholarship for Academic Achievement in Medicine	2020
Health Canada MD Student Bursary	2019
PEERSiM Mentee of the Year Award	2018
Norah and Leo Healey Award in Music	2017
Memorial University School of Music: Dean's List	2017
The Mrs. H.B. Young Memorial Scholarship in Music	2017
Memorial University School of Music: Dean's List	2016
Norah and Leo Healey Award in Music	2016
The Andreas Barban Scholarship in Piano	2016
Memorial University School of Music: Dean's List	2015
The Dennis G. Browne Memorial Scholarship in Music	2015
Memorial University School of Music: Dean's List	2014

Work Experience

Advanced Trauma Life Support Instructor 2024 – Present

Graduate Research Assistant: Western University, Department of Music 2017 – 2018
Assisted with research for the Music Cognition and the Brain and Musical Learning Across the Lifespan initiatives.

Beach Volleyball Coach: Beach Volleyball Academy, London, Ontario 2017 – 2018

Teaching Assistant: Memorial University, Department of Music 2014 – 2017
Assisted with music theory classroom teaching, grading and tutorials.

Laborer: Deer Lake Power 2014 – 2015

Leadership and Teaching

Cadaver Lab Dissection: Surgical Foundations 2024
Led anatomy teaching sessions for first year surgical residents

Western University Trauma Grand Rounds: Pancreatic Trauma 2023

Western University General Surgery: Resident Program Committee 2022-Present
Representative for PGY year on residency program committee.

Undergraduate Surgery Journal Club: University of Saskatchewan, College of Medicine 2021 - 2022
Created academic surgery journal club for medical students

University of Saskatchewan Student Surgical Society

Third-Year Representative 2020 – 2021

Vice-President 2019 – 2020

Treasurer 2018 – 2019

University of Saskatchewan Diagnostic Imaging Group, 2018 – 2019
First-Year Representative

Memorial University of Newfoundland Student Music Society, *President* 2015 – 2017

Volunteer Experience

College of Medicine Mentoring Program 2019 - 2021

College of Medicine Body Bequeathal Ceremony: *Performed in and* 2018 - 2021
Organized recital for families of those who donated their body to the Anatomy department at the College of Medicine at the University of Saskatchewan

Better Breathing Choir: *Helped develop and run choir dedicated to individuals* 2016 - 2018
With pulmonary conditions.

Lauda Choir for Neurodiversity: *Rehearsal pianist for choir dedicated to* 2017

neurodivergent children

Indigenous Beach Volleyball Coach: *Trained and coached indigenous athletes at the Newfoundland and Labrador Summer Games.* 2017

Athletic Accomplishments

Canadian Interuniversity Sport Academic All Canadian: *Awarded to student athletes who achieve academic excellence throughout their season.* 2014

Memorial University Men's Volleyball: *Member of Memorial University's Men's Volleyball Team.* 2013 - 2014

Newfoundland and Labrador Canada Summer Games
Men's Volleyball, Team Captain 2013

Newfoundland and Labrador Volleyball Association Athlete of the Year 2012

Premier's Athletic Award: *Awarded to top athletes in Newfoundland and Labrador.* 2011 - 2013

Newfoundland and Labrador Provincial Volleyball Team 2008 – 2013

Conferences

Trauma Association of Canada: Annual Conference 2024

Canadian Association of Thoracic Surgeons: Annual Conference 2024

Canadian Association of General Surgeons: Canadian Surgery Forum 2024

Canadian Association of General Surgeons: Canadian Surgery Forum 2023

Canadian Association of General Surgeons: Canadian Surgery Forum 2021

American Association of Thoracic Surgeons Annual Symposium 2021

Professional Memberships

- Canadian Association of General Surgeons (CAGS)
- Canadian Association of Thoracic Surgeons (CATS)
- Society of American Gastrointestinal and Endoscopic Surgeons (SAGES)
- American Association of Thoracic Surgeons (AATS)

Certifications

R. Cohen Chaulk

- Standard First Aid and CPR/AED Level HCP
- Basic Life Saving (BLS)
- Advanced Cardiac Life Support (ACLS)
- Advanced Trauma Life Support: Provider
- Advanced Trauma Life Support: Instructor

Professional Courses

Western University Endoscopy Bootcamp 2023

Hobbies and Interests

- Volleyball – Play weekly competitive indoor and beach volleyball throughout Southwestern Ontario
- Music – Continue to maintain daily piano practice, collaborate with other musicians and learning guitar
- Camping
- Hiking
- Fishing
- Weightlifting
- Fitness classes