Improving Trauma Care in Low Resource Settings

by

Anton Kurdin, MD

A thesis submitted to the

School of Graduate Studies

in partial fulfillment of the requirements for the degree of

Master of Science in Medicine

Clinical Epidemiology

Faculty of Medicine

Memorial University of Newfoundland

May 2018

St. John's, Newfoundland and Labrador

Abstract

Introduction: Caring for traumatic injuries often requires significant resources that may be sparse in certain environments, such as rural communities and Low and Middle Income Countries. To improve trauma care in low resource settings, strategies focusing on education and telemedicine have been proposed. However, such methods have not been thoroughly evaluated and their effectiveness remains unknown.

Objectives: 1) To evaluate the novel use of a Trauma Evaluation and Management course and its effectiveness as a low-cost alternative to ATLS for providing trauma teaching in Low and Middle Income Countries; 2) To assess the effectiveness of telemedicine for providing remote trauma teleconsultations.

Methods: The Trauma Evaluation and Management course was provided to health care professionals in Haiti and Bangladesh. The participants were asked to complete a survey which was analyzed to determine the effectiveness, the potential for modifications and the versatility of the course. To determine the feasibility of remote trauma management, a simulation study was constructed to test the feasibility of providing an accurate representation of an injured patient using telemedicine. Two modes of telemedicine were tested against a control group: a conventional ceiling mounted camera and a handheld device.

Results: Health care professionals in Bangladesh and Haiti provided excellent evaluations of the Trauma Evaluations and Management course. Areas for improvement focused on modifications to reflect the low resource setting and included considerations for lack of specialist referrals, unavailability of patient transfers to high level facilities and a greater role for ancillary and nursing staff. Regarding the use of telemedicine for remote trauma management, Situational Awareness scores did not demonstrate any difference between control and the two intervention groups.

Conclusions: Educational initiatives, such as the Trauma Evaluation and Management course, are an effective method of trauma teaching and are well suited for Low and Middle Income Countries. With the advancements in technology, the use of telemedicine is a viable option for remote trauma management.

Acknowledgements

This work could not have been completed without the help of several groups of individuals.

To the staff and residents of the Division of Orthopaedic Surgery for supporting me during my research. I appreciate the patience in allowing me to pursue this project while attending to resident responsibilities.

To all the participants for taking the time from their busy schedules to contribute to this study.

To Team Broken Earth for their efforts and hard work helping those in need. Your accomplishments are an inspiration.

To my supervisory committee, Dr. Craig Stone, Dr. John Harnett, and Dr. Andrew Furey for their time and continuing support.

To my supervisor, Dr. Andrew Furey, for your guidance throughout residency and this entire project.

Thank you, I am forever in your debt

Dedication

This thesis is dedicated to my wife Nasim and my parents, Anatoliy and Inna and my sister Anna. Your support, patience and understanding laid the foundation for this project.

Table of Contents

List of Tables

List of Figures

Summary of Presentations and Publications

Manuscript 1: Kurdin A, Caines A, Boone D, Furey A. *TEAM: A Low-Cost Alternative to ATLS for Providing Trauma Care Teaching in Haiti*

- Responsible for Literature Search, Study Design, Data Analysis, Data Interpretation and Writing of Manuscript.

- **Published** in Journal of Surgical Education.
    - Kurdin A, Caines A, Boone D, Furey A. *TEAM: A Low-Cost Alternative to ATLS for Providing Trauma Care Teaching in Haiti*. J Surg Educ. 2017 Aug 23.
- **Podium presentation** at Canadian Surgical Forum. *Victoria, BC, September 2017*
- **Poster presentation** at Canadian Orthopaedic Resident Association. *Ottawa, ON, June, 2017*
- **Podium presentation**, MUN Department of Surgery Research day. *St John's, NL, October, 2016*

Manuscript 2: **Kurdin A**, Boone D, Furey A. *Versatility of TEAM for Trauma Teaching in LMIC*

- Responsible for Literature Search, Study Design, Data Analysis, Data Interpretation and Writing of Manuscript.

- **Submitted for publication**
- **Podium presentation**, MUN Department of Surgery Research day. *St John's, NL, October, 2016*

Manuscript 3: Kurdin A, Flynn J, Boone D, Hogan M, Furey A. *The Use of Telemedicine for Remote Trauma Consultations: A Simulation Study.*

- Responsible for Literature Search, Study Design, Collection of Data, Data Analysis, Data Interpretation and Writing of Manuscript.

- **Submitted for publication**
- **Submitted for presentation** to Canadian Orthopaedic Resident Association 2018

Chapter 1: Introduction

1.1 History of Trauma

Injuries from traumatic events have always placed a tremendous burden on societies. Throughout history, recurring conflicts and wars contributed to a significant death toll and severe injury. Despite the horrific consequences of warfare, developments in the field of trauma management have emerged from combat zones.

One of the earliest available confirmations of the extent of injuries sustained during combat came from a mass grave discovered in Egypt (Wilson, 2007). Remains of 60 soldiers dated to 2000BC revealed various penetrating and blunt injuries that soldiers succumbed to. Additionally, the discovery of Edwin Smith Papyrus shed light on some of the treatments those soldiers received. This document contained a description of 48 traumatic cases and depicted the guidelines for diagnosis and management with predictable patient outcomes. It has even described several methods of fracture splinting, not unlike the ones used today.

Rapid recognition and treatment of injuries is also evident in other civilizations. In ancient Greece, the Hippocratic Corpus depicted surgical techniques for the treatment of traumatic brain injuries (Hanson, 1999). The Greeks also developed special barracks (klisiai) that were solely used for the treatment of wounded.

The numerous conflicts during the Roman era resulted in significant contribution to the field of trauma management. Roman surgeons were routinely present at battle sites and provided urgent care such as extraction of arrowheads and even open reduction of fractures (Celsus, 1938).

In China, several accounts of the use of Ma-Huang have been described (Lee, 2011). Ma-Huang contains ephedrine, and it is believed that it was used to treat hemorrhagic shock as a result of bleeding wounds.

In the past 500 years, there has been a significant development in advanced weaponry and subsequently treatment of gunshot wound. Ambrose Pare, a French Surgeon serving under Napoleon, established techniques to manage gunshot wounds with the use of ligature (Drucker, 2008). Another French physician, Dominique-Jean Larrey, developed the concept of a "flying ambulance" in 1792 (Wilkinson, 1993). He described a wagon attached to horses that was used as a swift method to transport the wounded to medical facilities.

Following the advances of anesthesia in 1800s, antiseptic technique in 1848, intravenous antibiotics in 1935 and fluid resuscitation in 1950s, there has been a significant decline in mortality of wounded soldiers (Wilson, 2007). It is estimated that during the American Civil War, 14% of wounded would succumb due to their injuries while 4.5% of injured died in the Second World War (Trunkey, 2008).

In the 1970s, descriptions of statewide trauma systems began to surface in Germany and United States of America (Trunkey, 2008). The most recent significant development to trauma care is the emergence of organized emergency medical services. These response teams consisted of police or fire department vehicles which were used as ambulances capable of rapid transportation and initial resuscitative techniques such as bandaging and artificial respiration.

Trauma care continues to evolve in modern society. The combination of the health care advances with technological innovations could revolutionize the way trauma care is provided.

1.2 Epidemiology of Trauma

Trauma causes injuries through the transfer of energy. For example, when a vehicle is involved in an accident, the rapid deceleration causes the mechanical energy of the vehicle to be transferred to the occupants, resulting in injuries. The transfer of mechanical energy is thought to contribute to 75% of all injuries (Baker, 1992). However, other forms of energy including heat, electricity, radiation and chemical reactions can also result in trauma (Haddon, 1968). Therefore, trauma is classified based on mechanism, intent and location.

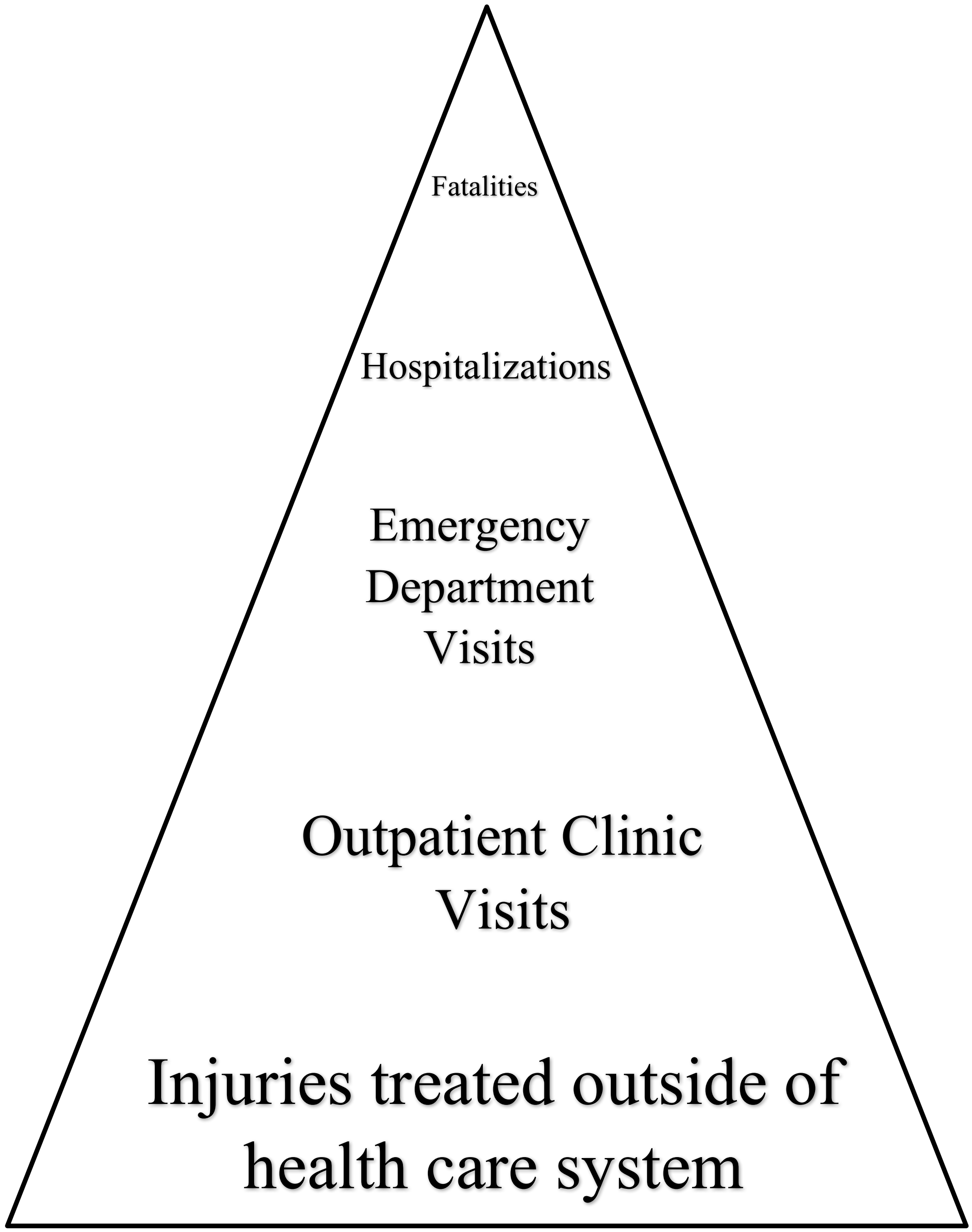
There are numerous mechanisms that cause trauma: motor vehicle accidents, falls, drowning, firearms etc. The two leading causes are road traffic accidents and firearms accounting for 29% and 19%, respectively (Moore, 2008). Falls are the leading cause of non-fatal injuries. Injuries can also be intentional or unintentional. Intentional injuries include those inflicted by others such as assault or homicide versus those inflicted upon oneself as in suicide.

Trauma is one of the leading causes of death. In 2000, there were 5.8 million fatalities globally (WHO: Injury and Violence). In United States, the fourth leading cause of death is because of an injury (Fingerhut, 1997). Non-fatal injures also contribute to significant morbidity in societies. It has been estimated that 13 million nonfatal occupational injuries occur each year just in the United States with 46% of them being disabling (US

Department of Labor; Leight, 1997). However, this in just the tip of the iceberg as the true incidence and the burden of trauma is often underestimated.

One of the challenges of estimating the impact of trauma is due to significant underreporting. In 1931, Heinrich proposed a theory to describe the incidence of injuries in a workplace (The Safety Triangle Explained). He observed a ratio of 29 minor injuries and 300 near misses for every fatality in a workplace. This concept is also applied in trauma as the injury pyramid (Figure 1). For every fatality, there are an exponential number of injuries of lower severity. In United States, each year there are 1.9 million people that are treated as inpatients. However, the majority of injuries are treated as outpatients. It is estimated 29 million injured patients are seen in the emergency departments, which accounts to over one third of all emergency department visits. (Injury Prevention & Control) Furthermore, a large majority of injured patients are treated by general practitioners and some do not even seek medical attention. Finkelstein et al, estimated that almost 100 million visits to a Doctor's Office in the US were for injuries with a significantly higher number not treated by health care professionals. Therefore, the burden of trauma is often underestimated due to lack of data availability.

Figure 1. Injury Pyramid



Trauma is not a random process. It is a disease entity with risk factors, prognostic outcomes and preventable measures. It is important to understand these factors as they can shed light on ways to improve trauma care and prevent injuries. These factors include certain predispositions for age, gender, socioeconomic status, occupation, and geographic location (Moore, 2008).

Trauma has been shown to primarily affect the young. When adjusted by age, injuries are the number one cause of mortality in the 5-44-year-old group. (Naghavi, 2009). Certain age groups are also associated with specific injuries (Moore, 2008). Infants less than one year of age are affected with unintentional injuries which contribute to the seventh cause of death. These unintentional injuries include falls and suffocation. Children aged 1 to 14 years have the highest rates of drowning and being struck by vehicles. Young adults aged 15 to 24 years have the highest rates of motor vehicle accidents because of risk taking behavior and lack of driving experience. Intention injuries such as homicide and suicide are associated with the adolescent age group. With advancing age, road traffic accidents start to decline and falls and suicide become prevalent as the leading causes of death from an injury. Interestingly, the highest rate of injury fatality was noted in the people over 75 years, 179 per 100,000 (Finkelstein, 2006).

Gender also plays a role (Wilson, 2007). Males are at higher risk of injury from motor vehicle accidents, falls and homicide. Females are more susceptible to suicide, assault and murder by intimate partner. Overall, males are 2.4 times more likely to be injured than females (Finkelstein, 2006).

There are also geographic variations for injury predisposition. These variations are both regional and global. For example, Hong Kong has the lowest mortality from injuries (25/100,000) while Russia is the highest (195/100,000) (Murray Christopher, 2003). This is in comparison to the United States where the mortality rate from injury is 54.5/100,000. For the most part, motor vehicle accidents have been the leading cause of injuries in each country except many African nations where war is the number one cause (Wilson, 2007). There are also regional variations in injury patters. Unintentional injuries are highest in rural areas while intentional injuries have been associated with urban communities.

Other factors include lower socioeconomic status and certain occupations. Lower socioeconomic status is associated with assault and homicide (National Center for Health Statistic, 2001). Occupations including fishers, timber cutters and truck drivers are associated with fatal injuries while people employed at nursing and personal care homes have the highest incidence of non-fatal injuries (US Department of Labor).

Understanding these risk factors is imperative to developing strategies in injury prevention.

1.3 Trauma Network

A trauma system is defined as an "organized approach to acutely injured patient in a defined geographical area" (Moore, 2008). This network encompasses various medical services from pre-hospital care to rehabilitation (West, 1988). Besides direct patient care, a trauma system must enhance community heath through identifying risk factors, decreasing the impact of injury and improving patient outcomes. There are several components of a trauma system: access to care, pre-hospital care, hospital care, rehabilitation, prevention, disaster medical planning, patient education, research and rational financial planning. Having a regionalized trauma system can reduce the potentially preventable death due to trauma (West, 1983; Shackford, 1986; Mackenzie, 2006)

Hospitals vary in their access to health care resources and are categorized by levels (ACSCT, 2006). A Level 1 trauma centre is usually an academic institution. It is a regional facility that provides comprehensive care to even the most complex injuries. They are equipped with a standardized trauma response team with around the clock, in-house coverage by general surgeons and availability of various surgical subspecialties including orthopedic surgery, neurosurgery and anesthesiology. These centres serve as regional referral centre for several communities and are continually involved with research and education. A Level 2 trauma centre also has the capabilities to manage most complex cases. They have constant coverage by a general surgeon with availability of some subspecialties. They often receive referrals from other centres and share the overflow from Level 1 facilities. A Level 3 trauma centre is crucial to the care of patients in rural settings. They have the capability to promptly assess, resuscitate and stabilize an injured patient. Most Level 3 facilities are covered by an emergency physician with availability of a general surgeon if needed. There is usually a lack of surgical subspecialties such as neurosurgery, cardiothoracic surgery and interventional radiology or advanced imaging such as Magnetic Resonance Imaging. They receive referrals from Level 4 trauma centres and will usually transfer trauma patients for definitive management to higher level centres once initial stabilization is completed. A Level 4 trauma centre may or may not have a staffed emergency department. They can provide initial resuscitation but are often limited by their resources and lack of operating capabilities. Some areas also include a Level 5 designation which does not have any emergency services and may only include an ambulatory clinic.

Having health care facilities with various resources poses a challenge to determine where each patient should be treated. The concept of triage describes a process of initial evaluation of the patient to determine the priority and the level of care that is required (Moore, 2008). This method allows for allocation of limited resources to those that need it most. Although certain major injuries require treatment at a trauma centre, most injuries can be treated at community hospitals (Shackford, 1986). Only 7-15% of injured patients require services that are only offered at a major trauma centre (Moore, 2008).

The process of triage starts once the emergency services have been notified and is constantly occurring throughout the treatment of the injured patient. Paramedics, rural physicians and specialist are constantly evaluating the injured patient and assessing the need for transfer to a higher level facility. To aid with this decision there are several criteria which includes physiologic and anatomical parameters, mechanism of injury, and numerous triage scoring systems.

A patient's physiologic status is often defined by vital signs. These include blood pressure, heart rate, respiratory rate, temperature and level of consciousness. They represent a snap shot of one's well-being (Champion, 1986). These parameters are quantifiable and are easily assessable. Greater deviations from normal have also been associated with the severity of an injury (Kirkpatrick, 1971; Baxt, 1989; Guzzo, 2005). However, these parameters only represent a single glimpse of the patient's status which can result in the undertriage of patients who decompensate. Therefore, it is important to constantly obtain new measurements.

Anatomic parameters can also indicate the severity of an injury. These usually encompass only the visible injuries. They include obvious fractures, penetrating injuries and significant burns. Although they can provide insight to the patients' condition, absence of gross anatomical abnormalities does not equate to hemodynamic stability or rule out any less obvious injuries. There are many injuries that do not have any obvious signs. These include significant chest and intra-abdominal injuries from blunt trauma and spine injuries (Mackenzie, 1989; Landercasper, 1990; Rizoli, 1994).

The mechanism of trauma can help estimate the force that was transferred to the patient and therefore the potential need for a higher level trauma centre (Grande, 1990). Examples of injuries that can have devastating injuries include falls from fifteen feet, motor vehicle accidents associated with on scene fatalities, passenger ejections and prolonged extraction times, pedestrian stuck by vehicles and penetrating injuries.

Other factors that have been related with the severity of the injury include age and medical comorbidities. Increasing age is related to an increase in morbidity and mortality (Knudson, 1988). Chronic diseases have also been associated with poor patient outcomes, independent of age (Milzman, 1992).

There are also triage scoring methods that provide guidance on patient triage (Emerman, 1991; Ornato, 1985). They incorporate various criteria including patient parameters and injury circumstances. Examples include the Trauma Index, Glasgow Coma Scale, Revised Trauma Score, Injury Severity Score and the American College of Surgeons Field Triage System.

1.4 Socioeconomic Impact of Trauma

Trauma has a significant burden on society. The socioeconomic effects of injuries are seen globally and are detrimental to each society. To understand the true cost of trauma, it is important to consider the estimated costs of direct medical care and the costs associated with loss of productivity.

Direct medical costs are expenses used for the care of injured patients. The costs are acquired due to fatalities at the scene of the accident and the health care setting, and nonfatal injuries that resulted in hospital admission, discharge and outpatient medical treatment. In United States, direct medical costs total around $80 billion each year. Fatalities account for around 1%, hospitalizations for 42%, while the majority of 57% is attributed to outpatient treatment (Finklestein, 2006).

Loss of productivity because of an injury is also a large contributor to the total costs of caring for trauma patients. This is mainly due to the temporary and permanent disability which results in inability to maintain a job and incapacity to perform household responsibilities. The costs associated with lack of productivity and inability to produce goods and services are endured by society.

One of the reasons that trauma has been a significant cause of loss of productivity compared to other diseases and illnesses is due to its predilection for the young. One way to quantify the effect on society is by calculating the years of potential life lost because of premature death and disability. For example, using the economic productivity cutoff of 75 years as set out by Center of Disease Control, an individual dying at 25 years will have a loss of 50 years of potential life. Years of potential life lost due to injuries is estimated to exceed years of potential life lost due cerebrovascular disease by a factor of 22, despite cerebrovascular disease contributing to more deaths overall. The outcome of loss of productivity is a predicted cost of $326 billion just in United States in one year (Finkelstein, 2006).

Therefore, in United States, the calculated total cost of injuries is over $400 billion per year. Such a tremendous economic expense coupled with an increasing incidence of injuries makes trauma a significant burden on any society and highlights the importance of improvements to trauma care and injury prevention.

Chapter 2: Trauma in Low Resource Settings

As outlined in Chapter 1, trauma has a significant burden on society. Unfortunately, due to lack of resources certain communities are unable to care for the injured. This is particularly evident in developing nations and rural settings.

2.1 Trauma in Low and Middle Income Countries

There is a significant epidemic of injuries in Low and Middle Income Countries (LMIC). Each day around 15,000 people die because of an injury with 90% of fatalities occurring just in LMIC (Murray, 1996). This is more than HIV/AIDS, malaria and tuberculosis combined.

It is important to consider some of the epidemiological disparities between High Income Countries (HIC) and LMIC. A study by Mock et al, demonstrated the influence of the economic environment on mortality rates of injures patients (Mock, 1998). In HIC the authors noted a mortality rate of 35%. This is in contrast to 55% and 63%, found in middle and low income countries, respectively. Isolating for the mortality rates of injured patients that eventually presented at a health care facility, Mock et al also exhibited a six-fold increase in mortality rates between HIC and LMIC (Mock, 1993).

Disabilities from injuries have also shown disparities based on economic region. Around 250 million people are disabled because of an injury in LMIC (Debas, 2006). In HIC, the main causes of disabilities were head and spinal cord injuries while in LMIC the majority resulted from extremity injuries (Mock, 1993; MacKenzie, 2006). This brings up an important point as most head and spinal cord injuries are difficult to recover from while extremity injuries can be significantly improved through inexpensive orthopaedic and rehabilitative services.

To further characterize the trauma inequality between HIC and LMIC, it is important to consider road traffic accidents as an example. In 2013, there were an estimated 1.25 million death from traffic accidents globally (Global status report on road safety 2015). Ninety percent of deaths due to road traffic accidents occurred in LMIC (Peden, 2002). This is quite alarming considering that LMIC only account for 54% of world's registered vehicles. Another way of describing the difference between the economic environment is by evaluating the mortality rates from road traffic accidents. The death rate from a road traffic accident in low income country is 24.1 deaths per 100,000 accidents. The rate in HIC is 9.2 per 100,000 and the global average is 17.4 death per 100,000 accidents (Global status report on road safety 2015).

It is also important to consider the future trends of road traffic accidents. Since 2007, mortality rates from traffic injuries have slowly plateaued due to improved infrastructure, vehicle safety features and stronger law enforcement. However, these improvements have only been instituted in HIC (Jacobs, 2000; Dahdah, 2008). For example, in 2010, 68 countries have seen a rise in road traffic deaths while 79 saw a decrease (Global status report on road safety 2015). Of the countries that experienced a rise, 84% where characterized as LMIC. With the increasing rates of industrialization of LMIC, the number of vehicles is expected to increase further contributing to the surge of road traffic accidents and subsequent injuries.

There are several characteristics of LMIC that can explain the disparities discussed above. Lack of infrastructure, medical supplies and staff with appropriate training all have resulted in poor outcomes seen in injured patient in LMIC.

Infrastructure plays a tremendous role in caring for the injured which is often underappreciated in HIC. A staffed centralized emergency response system in HIC can provide medical assistance within minutes of an accident. However, many of such services are often unavailable in LMIC. The shortage of emergency vehicles, causing emergency services to be provided by bystanders with little training, results in significantly prolonged arrival times to hospitals (Mowafi, 2016; Botchey, 2017). Furthermore, lack of infrastructure has also been seen within health care facilities. For example, in an urban teaching centre in Ghana, an average delay from arriving to the hospital ward and start of emergency treatment has been estimated to be 12 hours (London, 2001).

Vital medical equipment is also absent in LMIC. For example, chest tubes are frequently used in trauma patients particularly those with chest injuries. They are inexpensive and are considered life saving. In a study from Ghana, out of 11 hospitals located on major roads, none had any chest tubes and only four hospitals had any emergency airway equipment (Quansah, 2001). There is also a significant lack of advanced imaging equipment that is considered the standard of care in many HIC to treat injured patients. For example, Computed Tomography (CT) scans have been used to diagnosed internal injuries such as spine, chest, abdomen and pelvic injuries. In many trauma centres CT scans have become the standard of care and has largely replaced the use of X-rays. Besides the high initial cost there is a constant need for maintenance which unfortunately is not always feasible in LMIC (Arreola-Risa, 1999).

There is also a lack of medical staff in health care facilities found in LMIC, particularly those with trauma training (Mock, 2003; Joshipura, 2003; Quansah, 2001). For example, once an injured patient is brought to an urban tertiary care centre in a developed country, a myriad of health care professions are involved to provide care in a systemic manner. This team of trauma providers includes specialized emergency physicians, trauma surgeons, anesthesiologist and numerous ancillary staff including nurses and respiratory and radiology technicians. However, in LMIC the injured patients are typically assessed by a single physician with little trauma training, usually a learner or a general practitioner. Additionally, it has been estimated that almost 30% of the general practitioners that are involved in the care of injured patients in LMIC, have not had any surgical rotations during their training (Quansah, 2008). Due to the lack of appropriate training, one of the recommendations by the World Health Organization is to implement trauma courses to health care providers in LMIC.

Although the detrimental effects of trauma have been clearly demonstrated in LMIC, little support has been offered by the global health community (Guidelines for essential trauma care; Ostlin, 2005). For example, the estimated yearly global cost for road traffic injuries is $518 billion (Global status report on road safety 2015). The clear majority, 86% was spent in HIC, while only 65 million was spent in all LIC despite containing over 80% of world's population.

There is also a significant lack of research that is focused on trauma care in LMIC (Hofman, 2005). Research is a vital component of every health care system as it can provide future guidance and improve the care of patients. However, there is a consistent paucity of data available on injuries in In Low and Middle Income Countries. Without such data, the public officials are unable to recognize the impact of certain injuries and are unable to focus their efforts.

There are several reasons attributed to lack of research in Low and Middle Income Countries. Clinicians practicing in low resource settings are unable to focus their time on research as they are overwhelmed by the burden of illnesses and the struggle to provide appropriate care in a setting that lacks basic equipment and supplies.

Another reason is lack of funding. A global average of 3-4% of all health care costs is estimated to go towards research and development. However, this is not the case in LMIC. A study by Bishai et al. estimated that per capita yearly expenditure on road safety are US$0.07 and US$0.09 in Pakistan and Uganda, respectively, which is a fraction of funds used in HIC (Bashai, 2003).

With the increasing burden of injuries in LMIC, it is the role of the global health community to provide support to improve trauma care for those that desperately require it.

2.2 Trauma in Rural Communities

Challenges with low resources and caring for injured patients in not exclusive to LMIC. There are numerous rural communities in developed regions where lack of resources prohibits the appropriate care (Marcin, 2016).

It is difficult to define a rural community. According the US Census Bureau, an urban community is defined as greater than 50,000 people and a population density of greater than 1,000 people per square mile (Moore, 2008). Communities that do not fulfill the urban definition are considered rural. With respect to trauma care: "Trauma is deemed as rural when optimal care of the injured patient is delayed or limited by geography, weather, distance, resources, or lack of experience" (Moore, 2008). These areas are usually sparsely populated with a lack of heath care resources, particularly physicians. Only one third of physicians practice in a rural setting (Rogers, 1999). This is quite alarming considering the population that is affected by the shortage of care.

Around 70% of the US population lives in urban environments while 30% resides in a rural setting. However, 70% of trauma fatalities occur in rural settings (Rogers, 1999). Another concerning finding is that the consequences of sustaining an injury in a rural area are far greater than the urban counterparts (Muelleman, 1993). For example, the relative risk of dying from a motor vehicle accident in a rural community is fifteen times greater compared to an urban setting (Maio, 1992). This is quite disturbing considering that around 20-30% of death that occur in rural communities are thought to be preventable (Esposito, 1995).

There are several reasons for the disparities between urban and rural counterparts when it comes to caring for injured patients. Perhaps these disparities are best illustrated with a hypothetical scenario.

“While traveling on a single lane country road during a snow blizzard, a 65-year old male lost control of his vehicle. He was unable to regain control and swerved off the road. After striking the lane boundary, the vehicle rolled over into the ditch. Patient is unconscious and there are no bystanders around to help or call emergency response services.”

This scenario describes a very frequent occurrence of an accident in a rural environment. One of the biggest issues with obtaining prompt health care is lack of discovery. Rural areas are characterized by a low population density. There are certain areas, even roads that do not have any traffic for several days. This results in significant delays in discovery of injured patients and a delay in hospital presentation of hours and even days (Rogers, 1999; Rogers, 2001).

There are also certain patient characteristics that are associated with accidents in rural areas that pose a challenge to their care. Patients are usually unaccompanied. They tend to be older with significant medical co-morbidities and a higher incidence of alcohol use compared to a typical trauma patient in an urban area (Resources for Optimal Care of the Injured Patient 2014). Most of the trauma is blunt from motor vehicle accidents, suicides, homicides and falls. Coupled together, these factors can contribute to poorer outcomes after sustaining a severe injury.

Once the patient is discovered, there is often difficulty obtaining the necessary medical response teams to the patient. In urban environments, notification of the centralized emergency response systems is possible through multiple bystanders and abundance of telephones. However, in a rural setting requesting medical assistance is often difficult. Certain rural areas do not have any telephone or cellular service. There are also locations where 911 services are simply unavailable. It has been estimated that the average local ambulance is unavailable 15% of the time in rural communities (Rogers, 1999).

Transportation is also a challenge. Accidents can occur in remote environments with no road access. Often there are no street addresses which make it difficult to dispatch emergency services. Furthermore, once the patient has been located, transferring the patient back to the hospital may be difficult due to lack of infrastructure. Therefore, there has been an increased use of off road vehicles, snowmobiles, marine vehicles and air ambulances which lack the capability for appropriate trauma care such as cervical spine immobilization and concurrent resuscitative efforts. As the treatment of injuries is most successful within the first hour of trauma, difficulty with transport can result in significant delays of getting the patients the appropriate care. It has been estimated that in rural areas the time from an accident to the arrival to the hospital is more than an hour in

30% of cases versus 7% in urban systems (Champion, 1999). This results in the golden hour being spent on the road and not in the emergency room.

As trauma patients often have serious life threatening injuries they are often taken to the closest hospital for initial resuscitation. In a rural community, this is usually a Level 4 or 5 centre with limited capabilities. Many of such health care facilities do not have a standardized approach to trauma and patients may not even be seen by a physician upon arrival and may even wait in triage.

Lack of trauma-trained physicians is another concern. Without a standardized approach, rural physicians can be distracted by extremity injuries, while ignoring life threatening internal injuries. This is of concern as availability of trauma trained physicians has been associated with improved outcomes and lower mortality rates (Rutledge, 1994). Low volumes of specific injuries also result in lack of subspecialists due to struggle to maintain practice (Sanders, 2016). Furthermore, there is difficulty of maintaining skills due to low volumes. Severe trauma represents less than 5% of the practice of most rural surgeons which results in loss of skill over time (Moore, 2008).

Once the patient is in the emergency room, the rural physician has a significant responsibility. They must determine if the patient is stable and whether the sustained injuries require a transfer to a higher level facility. This is a very time sensitive task as outcomes worsen as time progresses.

Not all injured patients require transfer to higher level facilities. Certain injuries can be definitively treated at rural centres. This has several advantages including convenience for the patient and family members and easier reintegration into community with rehabilitation. The risks associated with transfer and inability to manage the patient while in transfer is eliminated. There are also significant potential cost savings and reduction in the burden on regional trauma centres (Richardson, 1997).

However, if the patient is unstable, the rural physician must be able to provide initial treatment to stabilize the patient which often involves surgical care in a form of damage control surgery. For example, a patient with pelvic injury that is bleeding into the intrapelvic cavity is likely to be hemodynamically unstable and should not be transferred due to possibility of decompensation while in transfer. A more appropriate stabilization would include intraabdominal packing with external fixation of the pelvis. This will decrease the hemorrhage and allow for proper resuscitation. Once the patient is stabilized, he or she can be transferred for definitive care to a tertiary centre. The rural physician should not be tempted to perform additional diagnostic and therapeutic procedures as they will result in a delay to definitive treatment (Stabilization and Transport, ATLS, 1997).

The result of all the issues seen when caring for injured patients in a rural setting is poorer patient outcomes, including a higher risk of mortality (Baker, 1987; Cales, 1985; Certo, 1983) Although this is partly due to the unique challenges associated with a rural environment, there are contributions from the quality of care that is provided to injured patients in rural communities. As demonstrated by Houtchens et al., there was a significant departure from standard care protocols seen in rural hospital (Houtchens, 1977). This finding was also confirmed by Hicks et al. (Hicks, 1982). The authors analyzed the care that patients received at a rural hospital prior to the arrival to a tertiary care centre. They studied neurological, chest, abdominal and orthopedic injuries and noted major departures from the accepted standards of care in more than 70% of the patients. A study by Martin et al. found that these deviations from the standard care protocols were classified as life threatening in 5% and capable of causing serious harm in 80% (Martin, 1990).

Clearly, caring for injured patients remains a challenge in a rural environment. To improve patient outcomes, numerous strategies to improve trauma care in rural communities should be initiated.

Chapter 3: Improving Trauma Care

3.1 General Considerations

In 1960s, William Haddon created the Haddon matrix to attempt to define the cause of injuries and isolate the areas for potential improvements (Haddon, 1980). He defined three phases of trauma: pre-event, event and post-event. These phases are influenced by three factors: the host, the vector and the environment.

The pre-event phase encompasses the elements that lead to an accident. The event phase focuses on the factors that caused the injury once the occurrence or the accident has already occurred. The post-event covers the factors that determine the severity of the injury and the factors that contribute to the outcome.

Each of the phases is influenced by the three different factors. The host is the individual that is involved in an accident and sustains an injury. The vector is the source of the energy that was transferred to the host to cause an injury. Most common examples of vectors are vehicles and weapons. Finally, the injuries are influenced by the environment which includes physical and social factors. Road conditions, availability of emergency response teams and distance from the health care facility are just some of the characteristic of the environment that can place a great influence on injuries.

Table 1: Haddon Matrix Example of a Road Traffic Accident

	Host, i.e. Driver	Vector, i.e. Vehicle	Environment, i.e. Roads
Pre-event What leads to an accident?	• Skill of the driver • Driving under influence • Distraction	• Vehicle condition • Collision avoidance systems	• Appropriate speed limits • Weather conditions
Event Once the accident has occurred, what causes the injury?	• Use of seatbelts • Personal protective equipment	• Airbags • Crumple zones	• Road side features • Guardrails
Post-event What determines the severity and the outcome of an injury?	• Age • Medical Co-morbidities	• Integrity of fuel tank	• Trauma systems • Availability of Emergency Response System

One of the examples to consider is a road traffic accident (Table 1). A motor vehicle accident contains the driver as the host, the vehicle as the vector and the road as the environment. The host can influence the pre-event phase by use of alcohol, the event phase with use of seatbelts and the post-event phase with presence of medical comorbidities. The vehicle as the vector can influence the pre-event phase due to the condition of brakes and tires. The use of airbags can influence the event phase and the integrity of the fuel tank can impact the post-event phase. Speed limits are an example of an environmental characteristic that impacts the pre-event phase. Protective guard rails can influence the event phase and rapid presentation to a trauma centre can certainly affect the outcome of patients as the post-event phase.

The majority of the factors discussed can be modifiable. To reduce the impact of injuries and improve the care of injured patient each of the factors can be isolated and targeted. It is important to discuss each phase separately to demonstrate some of the strategies that are currently utilized or are anticipated to play a large role in the future.

The focus of pre-event interventions is primarily through prevention. Since the accident and the resulting injuries could be eliminated through prevention there has been a significant emphasis on pre-event strategies. Some of the recent areas of attention have been on creating safer roads and reducing vehicular speeds and impaired driving.

In a growing society, transportation plays an important role. With increasing distances for daily travel, there has been a steady increase in traffic speeds. However, increased traffic speeds have been associated with increased incidence of accidents and greater risk of death (Elvik, 2009; Rosen, 2011). A solution is to appropriately place speed limits that fit the environment and the condition of the road. For example, urban areas with high pedestrian traffic require a reduced speed limit. An adult pedestrian has an 80% survival rate if struck by a vehicle travelling less than 50 km/h while only a 40% survival rate if the speed is 80 km/h (Rosen, 2011). Therefore, one of the effective strategies to prevent injury would be to focus on speed limits particularly in highly dense areas.

Another focus of attention has been on impaired drivers. Operating a vehicle requires focus and attention. Consumption of alcohol or recreational drugs increases the chances of an accident and results in serious injury (Elvik, 2009). Blood alcohol content between 0.02 g/dL and 0.05 g/dL is associated with three times the risk of dying from an accident. This risk exponentially increases with levels above 0.08 g/dL (Killoran, 2010). Another recent phenomenon that has become prevalent in a modern society is the use of mobile devices while operating a vehicle. Handheld devices have been shown to be a visual, auditory, manual and cognitive distraction (Mobile Phone Use, 2011; Redelmeier, 1997; Dragutinovic, 2005). The use of a mobile device while operating a vehicle results in longer reaction times, inability to stay in correct lanes or keep appropriate distances between vehicles, and a fourfold increased risk of being involved in an accident. It is not surprising that reducing the use of mobile devices has been one of the most targeted interventions.

Creation of safer roads is another trend in the recent decade. With the increasing cost of purchasing and operating a vehicle and the detrimental environmental effects associated with emissions, an emergence of use of alternative transportation methods has been noted. The increase has been seen in the use of motorcycles and bicycles, and the overall number of pedestrians on the roads. To improve road safety, there needs to be a separation of non-motorized methods. This strategy has already been implemented in several locations and has shown success. For example, the use of bicycle-only lanes reduced the fatalities amongst cyclist by 35% (Peden, 2004).

Event phase strategies focus on reducing the potential injuries during the accident. To reduce the extent of the injury, an emphasis on personal protection has been seen in many societies. For example, the use of seatbelts has been shown to reduce the risk of death by up to 50% (Dept of Transportation, 2008). Furthermore, with the increasing use of motorcycles particularly in LMIC, appropriate use of helmets can reduce the risk of death by 40% and risk of injury by 70% (Global status report on road safety 2015).

Another focus of event phase improvement is in vehicle safety. Technological advances such as Anti-lock Braking Systems, airbags, crumple zones and electronic stability control have been shown to be an effective way to protect occupants from possible injuries (Global status report on road safety 2015; Lie, 2006; Erke, 2008). Vehicle safety features have also been extended to the pedestrians. Use of softer bumpers and improved hood clearances are more “forgiving” for pedestrians during a collision.

Although efforts on pre-event and event phase interventions have significant potential to reduce the impact of trauma, there are challenges that should be considered. To implement a successful injury prevention program, it is necessary to have appropriate legislation and enforcement, continuing education and behavior change, and encouragement for engineering and technological advances. A successful injury prevention program often requires the collaboration amongst several representatives including government agencies, health departments, school boards etc. The involvement of numerous agencies certainly can have practical and logistical issues.

Another barrier that hinders the success of pre-event and event phase interventions is compliance. Preventions can be active or passive. Active preventions are those that require the public to initiate themselves. For example, vehicle drivers must put on a seat belt when operating a vehicle. Although a simple task with tremendous benefits, use of seatbelts has been plagued by low compliance. According to the World Health Organization, 161 countries have implemented seat belt laws, yet global compliance still remains low, especially with child restraints (Global status report on road safety 2015).

Passive preventions, on the other hand, are more effective in terms of compliance (Moellee, 1992). An example of an effective passive prevention is use of airbags during a collision. However, even passive preventions encounter challenges. Although it has been estimated that 20,000 lives per year are saved because of the Federal Motor Vehicle Safety Standards, there continues to be lobbying from the automotive industry due to extra expenses associated with demanding safety standards (Christoffel, 1999; Nader, 1965).

There are also ethical considerations. Although some situations such as driving under the influence have a clear answer due to the potential risks to the public, certain situation where there is no risk to the public are less clear. For example, there have been many arguments against the use of helmets by the motorcycle community. One of the points proposed by the motorcycle drivers is that helmets reduce the visibility and can result in an accident. The choice not to wear a helmet also does not have any potential risks to the public. However, it is necessary to consider the significant economic costs that the public incurs when treating an individual with a traumatic brain injury because of not wearing a helmet (Mcswain, 1990).

Despite these issues, the importance the above interventions cannot be overstated. However, even if effectively implemented, these types of interventions will not completely abolish injuries. Therefore, it is important to continue to implement post-event strategies. Post-event interventions encompass those that focus on treating the already sustained injuries. This involves health care services that are offered by society and includes various components of a trauma network. As outlined in Chapter 2, injuries carry a large impact on low resource areas such as rural communities and LMIC. Therefore, some of the emerging strategies to improve trauma care via post-event interventions have been focused on low resource settings.

3.2 Education

In 1976, Dr. James Styner, an Orthopaedic surgeon, along with his family was involved in a plane crash in a rural Nebraska. His wife was killed and his children sustained critical injuries. Dr. Styner witnessed the unfamiliarity of local physicians to treating injured patients and developed the Advance Trauma Life Support (ATLS) program.

ATLS provides physicians with a systematic way to approach various injuries while managing the extreme pressure and anxiety associated with a trauma patient. It was primarily designed for health care providers that did not frequently encounter major trauma. The ATLS course spans over two days. It consists of a series of lectures, interactive didactic sessions, simulated case scenarios with hands-on training and numerous group discussions. Since its introduction in 1980, it has shown immediate success and has grown to become the accepted method of initial trauma resuscitation (Baker, 1994; vanOlden, 2004). There have been over 1.5 million participants and more than 75,000 courses around the world.

In addition, there has also been a significant amount of evidence to support the use of ATLS course. Numerous studies demonstrated significant improvements in cognitive knowledge and clinical skills pertaining to trauma care. (Aprahamian, 1984; Girdley, 1993; Ali, 1994; Ali, 1995; Miller, 1995; Ali, 1996; Ali, 1998; Ben, 1999). There is also some evidence to suggest that the ATLS can improve patient outcomes (Driousis, 2011; vanOlden, 2004; Vestrup, 1988; Ariyanayagam, 1992; Olson, 2001; Wang, 2010).

However, the majority of these studies were retrospective. The influence of ATLS training on clinical outcomes has also been studied in LMIC. Ali et al. demonstrated that there was a reduced mortality in only the severely injured patients, those with ISS scores greater than 16 (Ali, 1994). In contrast, a study by Driousis showed on the contrary that mortality rates were increased in the ATLS trained group in Greece (Driousis, 2011).

Although there is still some uncertainty if the use of ATLS improves patient outcomes, the lack of evidence does not necessarily mean that ATLS is ineffective. It is difficult to implement a prospective, well-designed study exploring the patient outcomes. A recent meta-analysis by Jayaraman et al. attempted to search for high level evidence to explore the effects of ATLS on clinical outcomes (Jayaraman, 2009). After using strict inclusion criteria isolating for only prospective and Randomized Control Trials, the authors failed to identify any investigations. One of the explanations that the authors provided for the lack of evidence is the logistical difficulty in designing a well thought-out study. Firstly, ATLS is designed to improve a single individual's knowledge and skills and as physicians change their practice location, it is difficult to isolate the effect to a single population. Additionally, there are many communities, particularly LMIC, that do not have accurate databases to allow for such an investigation. The authors again cautioned that: "no evidence of effect does not equal evidence of no effect", and encouraged continued research focused on ATLS and patient outcomes.

Moreover, the success of ATLS is not easily reproduced in environments with low resources, particularly LMIC. The ATLS course was initially intended for the use in developed regions. It references the use of advanced technologies, sophisticated imaging modalities and availability of subspecialists. Some of these aspects are not appropriate for a LMIC due to lack of resources. Additionally, ATLS content is strictly regulated by the American College of Surgeons and does not allow for any modifications to suit a specific region.

In addition, there is a significant logistical concern with ATLS in LMIC. Advanced Trauma Life Support is an intensive, hands-on and specialist-driven course with a mandatory one to four instructor to student ratio (Mock, 2005). It has been estimated that the average start-up cost to providing an ATLS course is $80,000 USD (Quansah, 2008). It is not surprising that attempting to provide ATLS teaching in LMIC has been difficult.

One of the proposed solutions to improving trauma care through education is to create low-cost alternatives that could be modified to suit a particular region. There have been several examples of such focused trauma courses provided to LMIC. They have shown improvements in cognitive and hands-on skills. There have also been promising results regarding improved patient outcomes (Petroze, 2015).

The issues with implementing the ATLS course have also been noted in several rural communities. One of the challenges is inability to maintain the skills learned from ATLS in a rural practice setting due to lack of volume. (Ali, 1996; Ali, 2001; Ali, 2004; Blumenfeld, 1998; Azcona, 2002). The knowledge gained starts to decline at 6 months and plateaus at 2 years, although the organizational and priority skills are maintained for up to 8 years. A study by Ali et al. also provided evidence that patient volumes influence skill retention (Ali, 2002). The authors demonstrated that greater than 50 trauma patients per year resulted in a significantly higher trauma knowledge two years following the completion of ATLS. This poses a challenge to rural physicians where there is a lack of high volume of trauma cases resulting in higher attrition rates of trauma knowledge.

Unfortunately, lack of resources results in an inability to transport injured patients to trauma centres. Another strategy to improve rural trauma care is by bringing the trauma centre to the patient. With the advancing technology, this may become the solution to the perplexing issue of rural trauma care.

3.3 Telemedicine

Telemedicine is defined as the use of technology to communicate amongst health care providers that are separated by great distance. One of the first examples of use of telemedicine was done by Einthoven. In 1905, he used a telephone to transmit an electrocardiogram and a phonocardiogram from the Academic Hospital of Leyden to his laboratory (Hjelm, 2005). In 1968, Dr. Bird was the first to coin the term telemedicine. He developed a two-way video connection between Massachusetts General Hospital and a medical clinic at Logan Airport (Bird, 1975). In the late 20th century, rapid technological advances propelled telemedicine to new heights with availability of internet and wireless communication. There has been a tremendous increase in various uses of telemedicine and numerous articles and publications.

One of the promising uses of telemedicine is in emergency care and trauma. Managing injured patients requires rapid and precise care with a need for major resources and expertise. Often such resources are not available in many health care settings. Telemedicine could create an instant link between trauma experts and rural physicians, providing necessary assistance and teleconsultations for dealing with major injuries.

One of such systems was implemented at Longyearbyen Hospital Spitsbergen and a University Hospital of North Norway 1,000 km away (Lafiti, 2010). The trauma room in Spitsbergen contained an oversight camera which provided real time video to trauma surgeons at the University hospital. The trauma surgeons could follow the trauma resuscitation and provide assistance and guidance to rural physicians.

Pilot programs such as the one described in Norway have been implemented in numerous communities throughout the world. Some of the benefits of a telepresence program are improved patient care and significant cost savings. For example, as shown by Duchesne et al., 2008, use of telemedicine allows for a faster identification of severely injured patients and allowed for a quicker transfer. They also noted a drastic decrease in hospital care costs by over $6 million.

However, there are still several issues with telemedicine. It is still a new technology with unproven methods. One of the questions that remain to be answered is if virtual representation of patients relays the necessary information to the treating physicians. This particularly applies to trauma as there are a multitude of situational cues present in the trauma bay that stimulate all five senses to provide clinical information to the surgeon. Reproducing such an intricate environment may not be possible through virtual technology.

Additionally, there are several legislative concerns that have lagged behind the expanding field of telemedicine. Some of the issues that have been brought up are patient privacy, physician liability and unavailability of specialized governing agencies. There are also concerns as there is a lack of evidence analyzing patient outcomes and telemedicine with only retrospective data available.

Clearly, telemedicine is a promising concept for health care. However, more research is necessary to determine its effectiveness.

Chapter 4: Use of Trauma Evaluation and Management in Low and Middle Income Countries

4.1 Introduction

Trauma education is a promising solution to improving trauma care in Low and Middle Income Countries (LMIC). Although the Advanced Trauma Life Support (ATLS) program has been at the forefront of trauma education, there are certain challenges to providing ATLS in LMIC. These challenges include significant start-up costs and inability to modify the curriculum to apply to a specific region (Quansah, 2008). An alternative is to use a course that allows for flexible modifications and is affordable in LMIC.

To address the issues with ATLS in LMIC, there have been several low-cost alternatives. National Trauma Management course has been developed in India and has been used since 2000 (Guidelines for essential trauma care). It is a two-day course that focuses on initial management of injured patients. It does not have any significant start-up costs and has been used to train over 1,500 physicians in India.

Another course developed by the Canadian Network for International Surgery is the Trauma Team Training (Bergman, 2008). This course is provided over 3 days and focuses on the team aspect of providing trauma care. It has been significantly used in Uganda and has trained over 200 health care providers.

Another potential alternative is Trauma Evaluation and Management (TEAM) course. It has several advantages over the currently utilized low-cost trauma courses. The TEAM was developed by the American College of Surgeons (ACS) and is based on the principles of ATLS (ACS). Additionally, there are no regulations imposed by the American College of Surgeons allowing the instructors to make necessary changes to suit the needs of a particular region. This course is free and has already been demonstrated to be an effective teaching tool for medical trainees (Ali, 2008; Li, 2006). However, its utilization in LMIC has yet to be described.

The objective of this study was to evaluate the TEAM course as a low-cost alternative to ATLS for providing trauma care teaching in LMIC. To answer this question two studies were designed with the following intents:

1) Evaluate TEAM course and determine the need for any modifications
2) Assess the versatility of TEAM for general use in Low and Middle Income Countries

The TEAM course was provided in Port-au-Prince, Haiti and Dhaka, Bangladesh. Both regions are densely populated and have publicly funded health care systems. Unfortunately, there is significant underfunding by the public sector creating large out-of-pocket expenses for the patients. For example, only 3% of the Gross Domestic Product is spent on the health care system in Bangladesh while 11.5% is spent in Canada (Islam, 2014; Health Spending, 2017). This scarcity of funding ultimately results is poor patient outcomes, particularly in Haiti where the health spending is among the lowest in the world (WHO, 2017). The life expectancy in Haiti is only 65 years and the mortality among children is more than double compared to Dominican Republic (WHO, 2017). The lack of financial support by the public sector also takes a toll on the training of health care professionals. For every 3,000 people, there is only a single nurse or a physician in Haiti (WHO, 2017). Therefore, these regions may benefit from additional educational initiatives that could potentially improve patient care.

4.2 Methodological Considerations

4.2.1 Study Design

Certain considerations were given when selecting an appropriate study to evaluate the use of TEAM for trauma teaching in LMIC. During this selection, levels of evidence of each study type were contemplated.

In 1979, the Canadian Task Force on the Periodic Health Examinations provided recommendations on routine health exams (The Periodic Health Examination, 1979). To provide a quantitative description of each recommendation, the authors designated a classification system to characterize the strength based on the medical literature. The highest level of evidence that could be achieved was from a randomized trial while the lowest was an expert opinion.

Since the original description by the Canadian Task Force, there have been numerous modifications and subclassifications. For example, specific criteria have been established for various research questions involving treatment, prognosis, diagnosis and decision analysis studies. One of the examples of a prognostic study classification was proposed by the American Society of Plastic Surgeons (Burns, 2011). The highest level of evidence, Level 1, is obtained from high quality prospective studies. This is followed by lesser quality prospective studies (Level 2), case-control (Level 3), case series (Level 4) and expert opinion (Level 5).

A more thorough classification was developed by the Oxford Centre for Evidence-Based Medicine. This classification distinguishes based on research question and study design. (OCEBM Levels of Evidence Working Group). In general, systematic reviews and randomized trials hold the highest levels of evidence with case-series and expert opinions being the lowest. However, the levels of evidence should be interpreted carefully as they do not necessarily equate to the quality of a study (Burns, 2011).

Therefore, for this study, a randomized trial could provide a high level of evidence. However, there are certain challenges with conducting randomized trials. Randomized trials are very expensive and require significant resources. Such an expenditure would be difficult in a low resource setting such as LMIC. Another concern with randomized trials is a requirement of a control group. Having a control group that would not be eligible to take the TEAM course poses an ethical dilemma. Considering that trauma care in LMIC is a significant concern, withholding educational programs to health care professionals in LMIC that can potentially improve patient care, would not be ethical.

Another question that was considered for this study is selection of an appropriate outcome measure. An ideal measurement would be to compare patient outcomes such as mortality rates. However, collecting data on mortality rates is extremely challenging, particularly in a LMIC due to lack of centralized patient databases. It would also be difficult to track which patients were treated by the physicians that received the TEAM course.

To address the above issues with regards to study design and appropriate outcome, an observational study, specifically epidemiological survey, was developed. Epidemiological surveys are designed to gain access to the thoughts, ideas and opinions of a population (Leedy, 2005).

One of the advantages of survey research is that is it versatile and flexible. It allows one to appropriately gather large volumes of information and can be used in any field. Survey studies are frequently used in education. They provide the ability to obtain constructive feedback regarding teacher job satisfactions, burnout rates, education environment and student and parent opinions. (Wang, 2015). Obtaining such valuable information allows modifications for improvement.

There are two types of epidemiological studies: cross-sectional or longitudinal. Cross-sectional studies allow for collection of data at a single time point. Therefore, some of the benefits include collection of large volumes of data. However, cross-sectional studies cannot determine trends based on time (O'Sullivan, 2003). Longitudinal designs collect data from a sample of responders on multiple occasions (Gay, 2009). Although they can demonstrate variations with time, longitudinal studies are associated with higher attrition rates and loss to follow up (Gay, 2009). This would especially be difficult in this study due to poor mail services and lack of widespread internet access in Haiti. Therefore, a cross-sectional study design was chosen.

4.2.2 Questionnaire

The most important aspect of a survey study is developing an effective questionnaire. A well-designed questionnaire is necessary to elicit appropriate information that the researchers are seeking and increase response rates. A literature search is also recommended for previously used valid questionnaires. Some of the qualities of a well-designed questionnaire are to have visual appeal and to be well-written to motivate responses (Gay, 2009; Leedy, 2005).

A questionnaire should also have separate and clear instructions on how to complete the survey (Berends, 2006; Fraenkel, 2009; Gay, 2009; Leedy, 2005; Mertler, 2008). This is particularly challenging in this study due to language barriers. Some of the languages that are used by the health care providers in Haiti include English, French and numerous dialects of the Haitian Creole. Therefore, the survey had to be carefully translated into French and English and tested to ensure that meaning was not lost. Translators were also available at the time the survey was administered to provide any translations to Haitian Creole. For the health care providers in Bangladesh, an English version was utilized.

The questions used in the survey should be simple and concise without any ambiguity. They should utilize concrete words rather than abstract terms and avoid any field specific terminology that may not be understood by the participants. Questions should have neutrality and not cast any judgement on the participant. They can be constructed to obtain data from the following categories: demographic, knowledge, attitude and behavioral. In this study, questions that focused on attitude of the participants were primarily used.

Questions can also be designed as open-ended or closed-ended. Closed-ended questions are quicker and easier for the participants to respond to and they are simpler to code for analytical purposes for the researchers (Gay, 2009). Open-ended questions do not impose any restrictions set by the investigators. They allow for various interpretations and "out of the box" responses. They are, however, difficult to code for analytical purposes and have a high rate of item non-response due to increased time demands.

In this study a questionnaire with three sections was developed based on the above recommendations (Appendix A). The first section contained clear instructions on how to complete the survey and a field to indicate the participant's profession. Including the participants' professions allowed the data to be stratified based on profession. The second part contained fifteen closed-ended questions to evaluate the course for four categories: relevance to field, teaching methods, effectiveness of the course and overall impression. Participants were asked to rate each question based on the Likert Scale. A scale from one to five was used to rate each question, one being "Completely Disagree" and five "Completely Agree". Incorporating a scale to the survey facilitated easier coding and increased the range of possible responses. In the third part of the survey, open-ended questions were utilized to elicit the strengths, weaknesses and overall suggestions. These questions instructed the participants to write down the responses which were coded by the investigators based on frequency of mention and transferred to an electronic database.

Once completed, the final version of the survey was critically appraised and tested with several volunteers to ensure that all questions were interpreted the same way and the answers provided the information that was intended to be measured. Time to complete the survey was also measured.

4.2.3 Administration of Survey

There are several options to administer the survey. These include mail or electronic mail, telephone, personal interviews and direct administration to a group. Although personal interviews provide the best quality of data, challenges with limited resources often arise (Polit, 2006). An appropriate alternative is to administrate the survey to a group of people at once. Direct administration to a group provides a high response rate and instant clarification on questions. Since only one interviewer is needed, there is significant time and cost savings.

During the administration of the surveys, participants were also informed about the study and their questions were answered. Participation in the study was voluntarily and data that was collected would be anonymous. Once the surveys were completed by the participants, participants were thanked and any remaining questions were addressed.

4.2.4 Limitations of Survey Studies

Although there are significant advantages to using survey research particularly when limited by resources there are some disadvantages. Survey studies are not suited for all types of research. They cannot establish causality and should not be used to determine contributory relationships (Rubin, 2008). Survey research is also dependent on the responders who may not always provide honest responses (Leedy, 2005). To tackle this challenge, strict confidentiality and anonymity should be followed throughout the study (Fraenkel, 2009). Interviewer bias can also be introduced when conducting personal and telephone interviews. Even a well-designed survey study is susceptible to low response rate. Potential participants are often skeptical of surveys, particularly those received in the mail. A response rate of 50% is usually adequate for analysis (Rubin, 2008) and with response rates of 70% being considered excellent.

There are also ethical considerations in survey research. Although there are no interventions on the subjects, personal data is collected. Participants should be thoroughly informed on the investigators, the reasons for the research, confidentiality and potential risks and benefits (Fowler, 2009).

Chapter 5: Manuscript

TEAM: A Low-Cost Alternative to ATLS for Trauma Teaching in Haiti

5.1 Abstract

Introduction: Trauma resuscitation protocols have unified the care of trauma patients and significantly improved outcomes. However, the success of the Advanced Trauma Life Support (ATLS) course is difficult to reproduce in developing countries due to set-up costs, limitations of resources and variations of practice. The objective of this study is to assess the Trauma Evaluation and Management (TEAM) course as a low-cost alternative for trauma resuscitation teaching in Low and Middle Income Countries (LMIC).

Methods: As part of the Team Broken Earth initiative, TEAM course was provided to the health care professionals in Haiti. At its conclusion, participants were asked to complete a survey evaluating the course. Qualitative and quantitative data were analyzed to evaluate the perception of the course.

Results: A total of 80 health care professionals participated in the course. Response was obtained from 69 participants which comprised of 32 physicians, 10 Emergency Medical Technicians (EMT), 22 nurses, and 5 medical trainees. The course was well received by physicians, nurses and EMT with an average score of 90.6%. Question analysis revealed

a lower satisfaction of physicians for the course manual and teaching materials, and information related to decisions for transfer of patients. EMT consistently felt that the course was not tailored to their learning and practice needs. Written feedback demonstrated several areas of weaknesses including need for improvements in translations, hands-on practice, and educational materials.

Conclusions: Overall, the TEAM course was well received. Analysis demonstrated a need for adjustments specific to LMIC including a focus on pre-hospital assessment, increased nursing responsibilities and unavailability of specialist's referrals. Team Broken Earth intends to take these findings into consideration and continue to provide the TEAM course to other LMIC.

5.2 Introduction

Injuries have become a neglected epidemic in Low and Middle Income Countries (LMIC) (WHO, Injuries and Violence: The Facts, 2010). Out of 5.8 million deaths that occur globally due to injuries, 90% occur in LMIC. However, insufficient resources have been allocated to provide relief by the global health community despite estimates that 2 million deaths could be prevented through improvements in trauma care (Mock, 2012; Sethi, 2007)

Since its introduction to the health care community, the Advanced Trauma Life Support (ATLS) protocol has a significant impact on delivery of trauma care with notable reductions in mortality, particularly in High Income Countries (HIC) (Carmont, 2005; Cales, 1984; Lecky 2000; Roberts, 1996). Following its success in HIC, ATLS has been introduced to the global health community and has been delivered to over one million providers in more than 60 countries (ATLS, 2017; Drimousis, 2011).

However, as the ATLS is designed for areas with access to ample medical resources, there is debate whether the course's success is transferable to LMIC (Sethi, 2000; Kirsch, 1998) The course references the use of ultrasounds, computerized tomography scans, and referrals for facilities with subspecialized physicians, intensive care units and various pharmacological agents. Such resources are often absent in LMIC, forcing health care providers to make use of alternative means of diagnosis and management (Quansah, 2008)

Additionally, providing the ATLS course in LMIC has been laden with many financial obstacles. Advance Trauma Life Support is an intensive, hands-on and specialist-driven course with a mandatory one instructor to four students ratio (Mock, 2005). It has been estimated that the average start-up cost to providing an ATLS course is $80,000 USD (Quansah, 2008). It is not surprising that attempting to provide ATLS teaching in LMIC has been difficult.

To address the concerns with the ATLS course with regards to trauma training in LMIC, low-cost replacements have become available. The Trauma Team Training program has been developed as a low-cost alternative to ATLS and has been shown to be an effective course in providing trauma resuscitation knowledge in Tanzania (Bergman, 2008).

Another training protocol, Trauma Evaluation and Management (TEAM), was developed by the American College of Surgeons as an abbreviated ATLS course for medical students during their clinical years. On multiple occasions the TEAM course has demonstrated its efficacy as a valid tool for teaching medical trainees to effectively perform a primary assessment and management of trauma patients (Cherry, 2004; Ali, 2004).

As part of the Team Broken Earth initiative, the goal of this study was to provide the TEAM course to health care providers in Haiti and evaluate its effectiveness at delivering trauma care teaching.

5.3 Materials and Methods

In November of 2015, Team Broken Earth provided two sessions of the TEAM course to health care professionals in Haiti which included physicians, nurses, EMT, and a small subset of medical trainees. Although the majority of health care professionals practiced in Port-au-Price, an urban setting, a small proportion practiced in adjacent rural communities. The course comprised a formal didactic slide presentation, several videos demonstrating appropriate and inappropriate trauma assessments, a series of clinical trauma cases followed by small group discussions and hand-on practical sessions (Appendix B). The course was instructed in English with simultaneous translation into French.

At the end of each session a survey was distributed to the participants to evaluate value, content, and delivery of the TEAM course (Appendix A). Informed consent was obtained at which time the participants were advised that the survey was voluntary, and both complete and incomplete forms would be collected anonymously. Each survey consisted of fifteen questions graded on a Likert scale, and several written questions to evaluate strengths/weaknesses and overall impressions of the TEAM course. Once the surveys were collected, a database was constructed and organized based on medical profession and question responses.

Quantitative data were analyzed using SPSS (Ver. 20; SPSS, Inc. Chicago, IL) for descriptive statistics, one-way analysis of variance (ANOVA) and Fisher's Least

Significant Difference (LSD) analysis. One-way ANOVA was used to compare the differences in responses amongst medical professionals. To detect any differences in question responses amongst a single group of health care professionals, one-way ANOVA was also utilized. If a difference was detected, LSD analysis was performed to isolate the individual questions which demonstrated a different trend of responses. Questions with statistically significant difference compared to at least half of the total questions (greater than seven of possible fourteen) were isolated as outliers. This analysis was meant to exhibit each professional cohort's perceived weakness/strengths of the course.

Written comments were also recorded and analyzed by an independent reviewer for major themes and frequency of mention.

5.4 Results

Out of 80 participants, a response was obtained from 69 participants resulting in a participation rate of 86%. Of the total participants, 32 were physicians, 10 were EMT, 22 were nurses, and 5 others which included medical trainees.

Profession Analysis*:* **Table 3** lists the average scores from the survey based on profession. There was no significant difference detected for the responses amongst the professions ($p=0.164$).

Table 3. Evaluations of the TEAM course by various health care professionals

Profession	Number	Score
Physicians	32	90.8%
Nurses	22	89.5%
Emergency Medical Technicians	10	93.0%
Others	5	90.0%
Total, Mean Score	69	90.6%

Question analysis: The average responses for Questions 1 through 15 from each of the health care professionals are shown in **Figure 2-4**. There was a statistical significance noted amongst the question scores for the physicians (p=0.01). Least Significant Difference analysis revealed that Question 8 (average score: 4.20): Course manual is well written, visually appealing, and a good reference/resource; and Question 13 (average score: 4.16): Course provides information to make transfer decisions and arrangements with receiving facilities; consistently demonstrated significant difference compared to the rest of questions, with eight and ten differences respectively. Regarding the nurse cohort, there was no statistical difference in responses amongst the questions (p=0.87). The EMT group did demonstrate a consistent difference (p<0.01) for responses to Questions 2 (average score: 3.33): Course is relevant to my learning needs; and Question 3 (average score 3.56): Course is pertinent to my practice; with total of thirteen differences for both questions.

Figure 2. Mean Scores of Individual Question Responses of Physicians

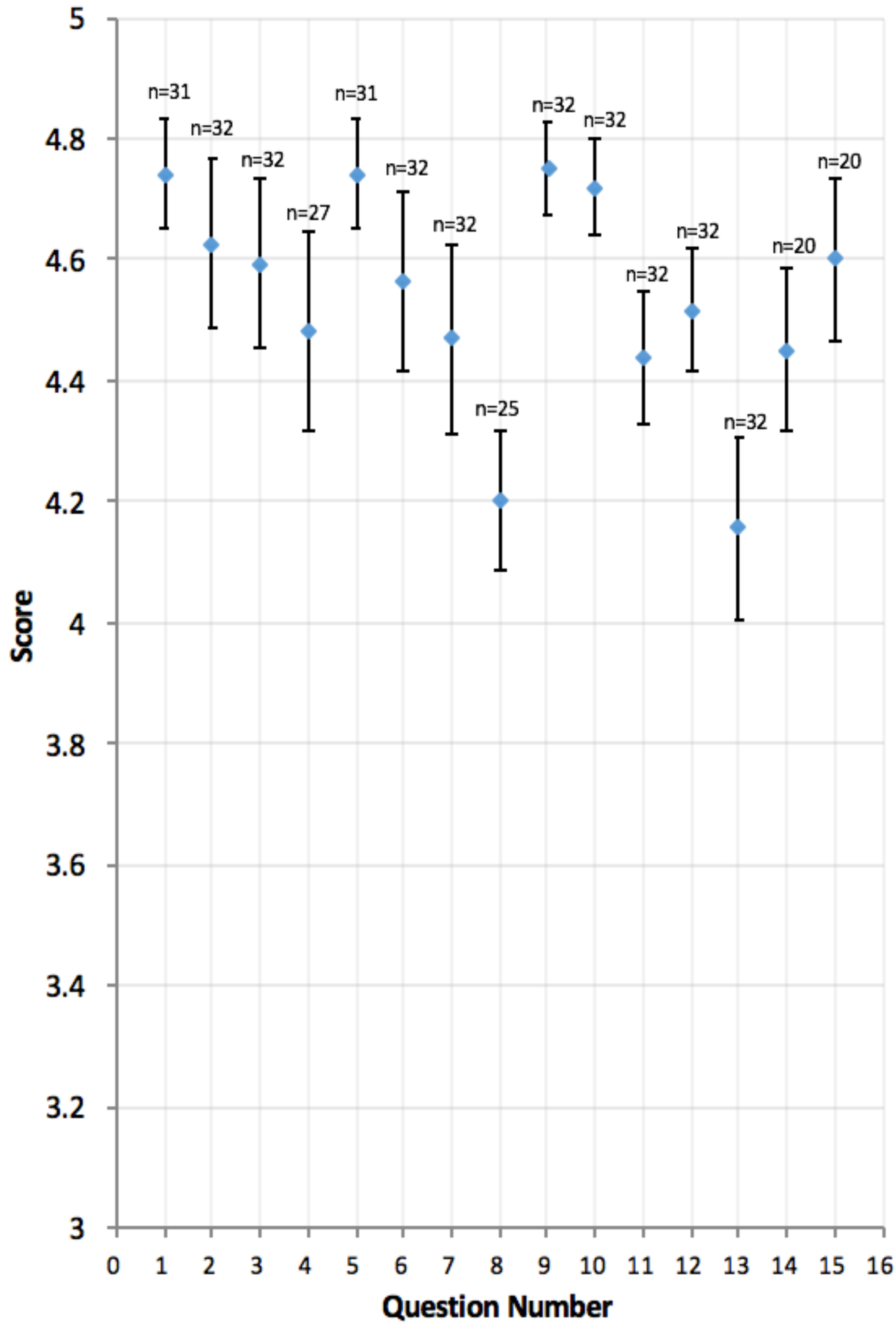


Figure 3. Mean Scores of Individual Question Responses of Nurses

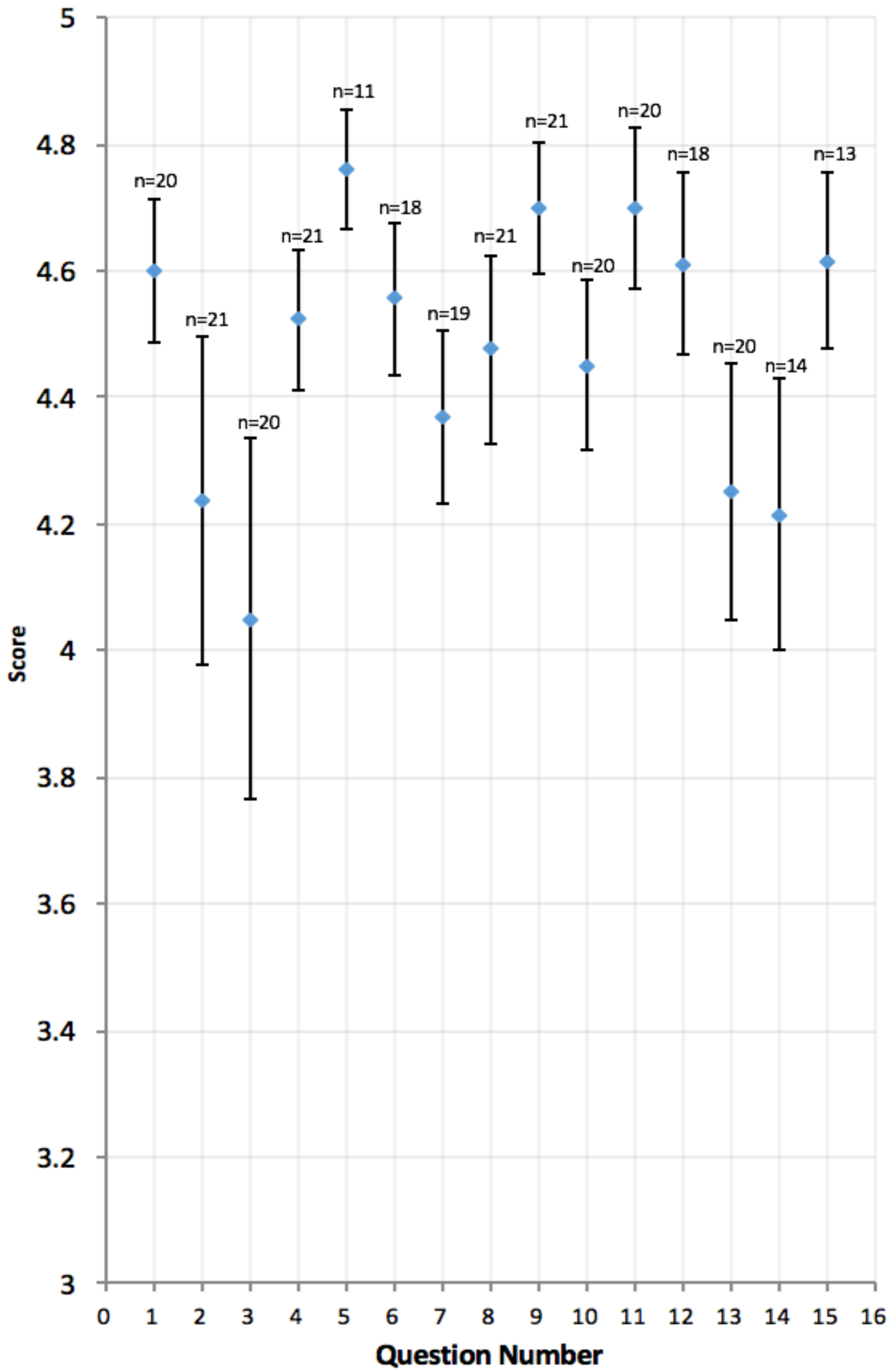
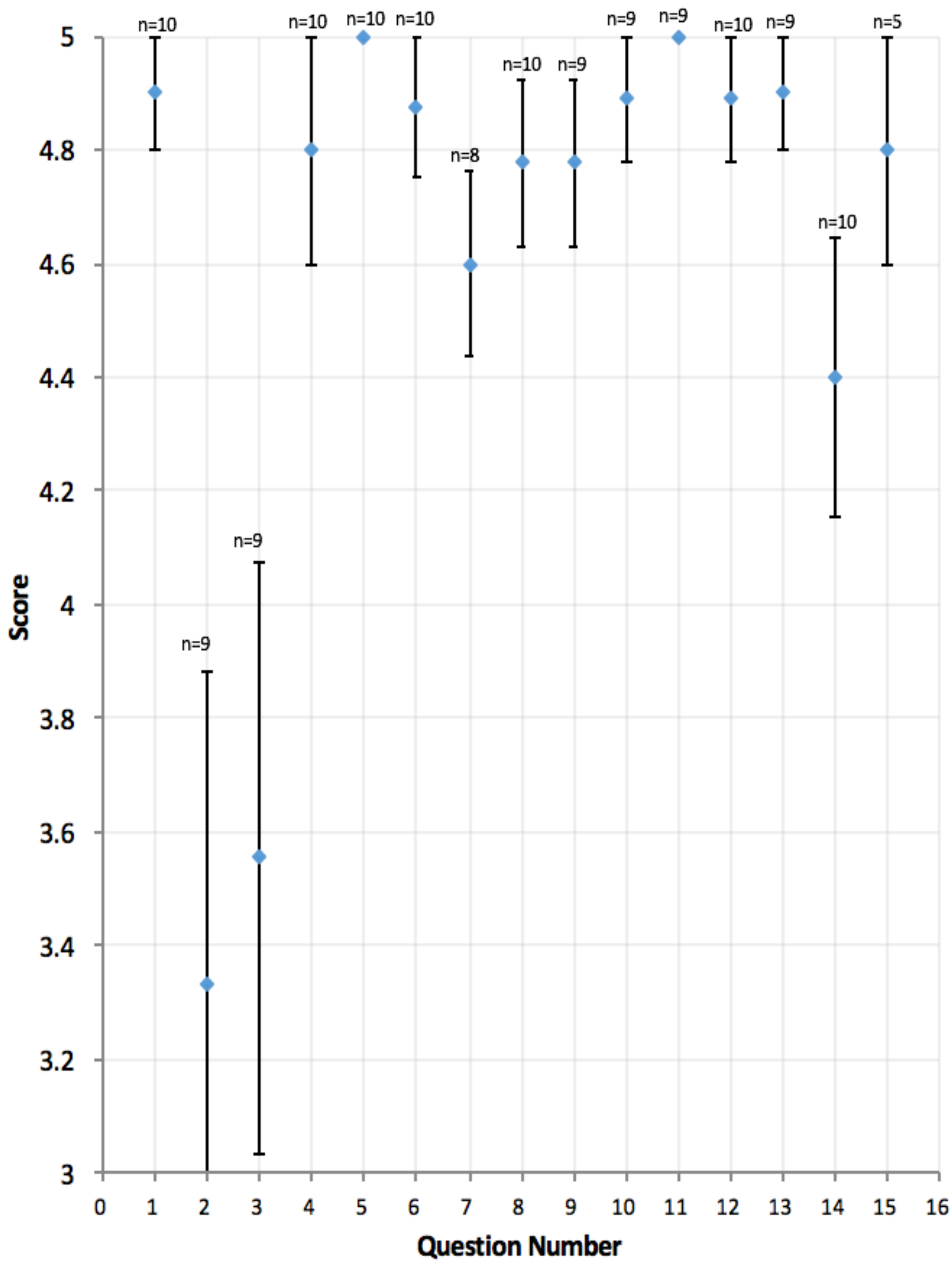


Figure 4. Mean Scores of Individual Question Responses of Emergency Medical Technicians



Written feedback: Surveys were reviewed for written feedback that was provided in the comments section. The major themes that were suggested for improvements were translation, presentations and video supplementation, hands-on practice, and written handouts. **Table 4** shows the frequencies of each of the above themes. Regarding the translation issue, there were several comments on the inappropriate names for medical terms that made the presentation difficult to understand. Evaluators also felt that there were not enough videos provided to supplement the presentations. There were also several individuals that commented on the lack of practice time and materials suggesting more mannequins, less participants per group, and more trauma cases.

Table 4. Suggestions for Improvements.

Issues	Frequency of mention
Translations	8
Hands on practice	8
Presentation/video	4
Handouts/teaching materials	2

5.5 Discussion

Trauma care in LMIC is faced with many challenges, particularly with respect to limited resources. Although it has been demonstrated that implementation of the ATLS protocol in LMIC can improve trauma care, its application to other resource-challenged regions makes it difficult due to financial constraints (Ali, 1993). The TEAM course could function as a low-cost alternative for providing trauma training while still attaining the benefits of improved care and outcomes.

This study's findings confirm that the TEAM course was successfully introduced to health care professionals in Haiti despite financial limitations. Survey analysis demonstrated that the course was well received by all health care professionals. However, as the TEAM course is based on ATLS and trauma care in high-income countries, this study noted several differences of trauma care in LMIC that are worth considering.
It has been previously exhibited that pre-hospital care is a vital component of assessing and managing an injured patient in LMIC (Mock, 2002; Jayaraman, 2009). Arrival time to the hospital after an injury is significantly prolonged in LMIC, which places a greater role on EMT to provide trauma resuscitation (Kobusingve, 2002). In this study the EMT group gave the highest average scores for the course. However, they consistently scored the lowest on questions testing the relevance to learning needs and practice. This finding was also supported by some of the written comments asking for "more information on medical emergencies at the scene of trauma".

Upon arrival to the hospital in LMIC, the majority of injured patients are initially assessed by a single physician who may be required to perform surgical interventions without the availability of specialist referrals or transfers to facilities with higher capabilities and resources (Mock, 2005). This is supported by the question analysis, as physicians consistently scored lower for the question pertaining to transfer of patients to higher resource facilities.

There are also instances in LMIC where a physician is not available to provide trauma care leaving the responsibility to nurses. While there was no difference found amongst the health care professionals regarding the evaluation of the course, there was a lower trend of scores for the nursing group.

The above findings demonstrate the inherent issue with implementing trauma protocols designed for the high-income countries in LMIC. The TEAM course does not take account for limitations of resources that the health care providers face in LMIC. This stresses the importance of providing not only a low-cost alternative to ATLS but a course that is specific for LMIC. Considerations for differences amongst practices and focus on pre-hospital care, increased nursing responsibilities and the unavailability of specialist referrals should be taken into account when providing trauma teaching in LMIC.

This study also demonstrated some logistical issues related to implementing a trauma course in Haiti. The two official languages spoken in Haiti are French and Haitian Creole. Although the course was simultaneously translated to French with the use of translators and several French speaking instructors, there were issues with translations, particularly with respect to medical terminology. This was supported by several comments suggesting to have "translators that are in the medical domain for better transmission of information". Most of the course's instructors have completed their training and currently practice in an English-based environment, and although some were fluent in French, they were not accustomed to correct French medical terminology. To address this problem, instructors that practice in a French-based setting should be utilized.

Another issue that was noted was lack of resources, particularly the limited number of mannequins and instruments to provide adequate hands-on experience. All materials were brought to Haiti by the instructors, which were limited by the luggage restrictions set out by the airlines. In addition, the turnout was significantly higher than expected suggesting a need for outreaching to local health care authorities for future assistance with provision of materials.

One of the main limitations of this study is its inability to address the influence of trauma teaching on clinical outcomes. Although numerous studies have demonstrated an increase in trauma knowledge of health care professionals, there is limited evidence to determine the effect on outcomes and mortality rates after the implementation of focused trauma education in LMIC (Ali, 1993, 1996, 1998, 2000; Aboutanos, 2007; Williams, 1997; Petroze, 2014; Sethi, 2003). Further research is necessary to explore the effect on clinical outcomes and to support the use of focused trauma education courses in LMIC.

Overall, the TEAM course was a success in Haiti. The instructors and volunteers were impressed by the participation of the health care professionals and their gratitude. It was rewarding to see comments such as “gained a better capacity to provide care in health environment” and “you gave me the possibility to make a difference for our patients”. Team Broken Earth intends on making a few changes as suggested by this study and continue to provide this course to health care professionals in LMIC.

The TEAM course was well received by the health care professionals in Haiti. Several modifications are necessary to reflect the differences in trauma care in LMIC. Additional studies are required to confirm the generalizability to other LMIC and to assess the impact on clinical outcomes.

Chapter 6: Manuscript 2

Versatility of TEAM for Trauma Teaching in Low and Middle Income Countries

6.1 Abstract

Introduction: Challenges to providing the Advance Trauma Life Support to health care providers in Low and Middle Income Countries have resulted in the prevalence of low-cost alternatives. One of the courses previously used is Trauma Evaluation and Management. However, its use so far has only been limited to a single region. The objective of this study is to assess the versatility of Trauma Evaluation and Management to other low resource regions.

Methods: As part of the Team Broken Earth, several sessions of the Trauma Evaluation and Management course were provided to health care professionals in Bangladesh. A survey was administered at the end to assess the various aspects of the course. The data was compared to previously obtained results from health care professionals practicing in Haiti.

Results: The overall score of the Trauma Evaluation and Management course by health care professionals in Bangladesh was 91.6%. When comparing the results with the Haiti cohort, physicians in the Bangladesh group provided a higher rating 93.0% vs 90.8%, p=0.005. This difference was particularly evident in questions evaluating the role of

trauma members and the ability to transfer patients to higher level facilities. No difference was isolated amongst the nursing group.

Discussion: This study further demonstrates a significant satisfaction amongst health care providers in Low and Middle Income Countries. The greater evaluation of the course by the physicians in the Bangladesh group may represent the greater amount of resources available in Bangladesh compared to Haiti.

Conclusions: The Trauma Evaluation and Management course was well received by health care providers and was demonstrated as a feasible method for teaching trauma care in Low and Middle Income Countries.

6.2 Introduction

Challenges to provide the Advanced Trauma Life Support (ATLS) course to Low and Middle Income Countries (LMIC) have resulted in numerous low-cost alternative becoming available (Bergman, 2008; Guidelines for essential trauma care). One of the contenders is the Trauma Evaluation and Management course developed by the American College of Surgeons (ACS). Its low-cost setup and the possibility of modification make it a valuable tool for teaching trauma case for health care providers in LMIC.

Although global patterns of injury can be transferable, it is important to consider the differences between LMIC to develop an appropriate strategy for improvements. Differences in economic developments, rates of industrialization, law enforcements and availability of emergency services can significantly influence the epidemiology of injuries. For example, road traffic accidents are the number one cause of injuries in most LMIC except in African nations where war conflicts cause the most fatalities (Global burden of disease). Furthermore, even nations that are in the same regions differ with respect to trauma care. For example, one of the challenges with Zambia is difficulty arriving to the hospital, with only 21.6% of patients arriving within one hour of injury. This is in contrast to 49.6% of patients arriving within one hour in Kenya (Mowafi, 2016; Botchey, 2017).

The Trauma Evaluation and Management Course has already shown success teaching trauma care to health care professionals in Haiti (Kurdin, 2017). However, its generalizability remains unknown. It is uncertain if TEAM can account for the potential differences in local health care disparities to be an effective tool for trauma teaching in LMIC.

As part of Team Broken Earth, TEAM course was provided to health care professionals in Bangladesh. The objective of this study was to assess the generalizability of TEAM by comparing the results from the Bangladesh group to those obtained in Haiti.

6.3 Materials and Methods

Several sessions of the TEAM course were provided to health care professionals in an urban setting of Dhaka, Bangladesh in May of 2016. The course followed the official outline set out by the American College of Physicians and consisted of a formal didactic slide presentation, several videos demonstrating appropriate and inappropriate trauma assessments, a series of clinical trauma cases followed by small group discussions and hand-on practical sessions (Appendix B).

Following the course, a survey was distributed to the participants to evaluate the value, content, and delivery of the TEAM course (Appendix A). This was the same survey as was used by the authors in Haiti. Informed consent was obtained at which time the participants were advised that the survey was voluntary, and both complete and incomplete forms would be collected anonymously.

Quantitative data were analyzed using SPSS (Ver. 20; SPSS, Inc. Chicago, IL). One-way ANOVA was used to compare the differences in responses amongst medical professionals. Independent samples T-test was used to detect any differences between the health care professionals from the two LMICs. If a difference was detected, a separate analysis was performed to reveal which specific questions contributed to those differences.

Written comments were also recorded and analyzed by an independent reviewer for major themes and frequency of mention.

6.4 Results

Out of a total of 134 participants, 111 responses were collected, response rate of 82.8%. There were 68 physicians, 34 nurses, 2 EMTs and 7 unidentified participants.

Profession analysis

Table 5 lists the averages of each of the professions. There was a significant difference detected amongst physicians and nurses, $p<0.0001$. No differences were found between physicians and EMT $p=0.905$ and nurses and EMTs $p=0.129$.

Table 5. Average scores based on profession

Profession	Number	Score
Physicians	68	92.9%
Nurses	34	89.1%
EMT	2	94.0%
Others	7	88.6%
Total number, Mean Score	111	91.6%

To isolate the cause for the difference seen between physicians and nurses, a subanalysis was performed isolating each question. **Table 6** lists the individual question responses between physicians and nurses. Questions that showed a significantly higher evaluation by the physicians were questions 6 and 12, with p=0.002 and p=0.001, respectively.

Table 6. Physicians vs Nurses

Question	Physicians	Nurses	P-value
1. Course objectives were understood	4.8088	4.5588	0.107
2. The course is pertinent to my learning needs	4.8529	4.4412	0.08
3. The course is pertinent to my work	4.6029	4.3235	0.101
4. The course corresponds to current work trends	4.7353	4.4242	0.135
5. The teaching methods were efficient	4.8235	4.4063	0.024
6. The course was organized in a concise and coherent way	4.7206	4.2121	**0.002**
7. The course was presented at appropriate learning level	4.5522	4.4545	0.467
8. The course manual was well written and good reference tool	4.4444	4.4848	0.779
9. The videos made the presentation better	4.6618	4.5938	0.585
10. The course format encouraged critical analysis and strategies for resolving problems	4.6912	4.5294	0.182
11. The course provides information and necessary skills for assisting a rural trauma	4.2500	4.4545	0.312
12. The course represents the correlation of team members and trauma	4.8088	4.3824	**0.001**
13. The course provides information necessary for making decisions concerning transport	4.4853	4.5588	0.557
14. Please rate the commodities	4.5455	4.4118	0.371
15. Please rate the overall quality of the course	4.7164	4.6471	0.480

Haiti vs Bangladesh

Physicians in the Bangladesh group provided a higher rating (4.6479) compared to the physicians in Haiti (4.5420), p=0.005. **Table 7** demonstrates the specific questions that contributed to the difference between the two cohorts with questions 12 and 13 being scored significantly higher by the Bangladesh physicians, p=0.014 and p=0.029, respectively.

Table 7. Haiti vs Bangladesh physicians

Question	**Physicians Haiti**	**Physicians Bangladesh**	**P-value**
1. Course objectives were understood	4.7419	4.8088	0.523
2. The course is pertinent to my learning needs	4.6250	4.8529	0.129
3. The course is pertinent to my work	4.5938	4.6029	0.949
4. The course corresponds to current work trends	4.4815	4.7353	0.169
5. The teaching methods were efficient	4.7419	4.8235	0.449
6. The course was organized in a concise and coherent way	4.5625	4.7206	0.271
7. The course was presented at appropriate learning level	4.4688	4.5522	0.584
8. The course manual was well written and good reference tool	4.2	4.4444	0.101
9. The videos made the presentation better	4.75	4.6618	0.437
10. The course format encouraged critical analysis and strategies for resolving problems	4.7188	4.6912	0.782
11. The course provides information and necessary skills for assisting a rural trauma	4.4375	4.2500	0.305
12. The course represents the correlation of team members and trauma	4.5161	4.8088	**0.014**
13. The course provides information necessary for making decisions concerning transport	4.1563	4.4853	**0.029**
14. Please rate the commodities	4.45	4.5455	0.566
15. Please rate the overall quality of the course	4.6	4.7164	0.429

No differences were identified between Haiti and Bangladesh nurses, 4.4755 and 4.4591, respectively (p=0.771).

Written feedback:

Table 7 shows the frequencies of major themes that were mentioned by the participants. The most frequent topic of mention was request for more time. There were also comments suggesting more hands-on practice particularly less people per group.

Table 7 Frequency of mention of the written feedback

Issues	Frequency of mention
Increased Time of Course	12
Hands-on practice	9
Translations	3
Additional aspects such as CPR and ACLS	2

6.5 Discussion

Caring for injured patients is a significant challenge in LMIC where lack of resources and timely access to care result in substantial disparities compared to HIC. To attempt to improve patient care in the LMIC, Trauma Evaluation and Management course has been utilized. Although the TEAM course has shown promising results in Haiti, its generalizability has not been confirmed. The aim of this study was to compare the utility of TEAM in Bangladesh and Haiti.

Overall, the results support the use of TEAM for trauma care teaching in Bangladesh. All health care providers found the course beneficial. One of the findings important to note is the lower trend of scores for the nursing group compared to the physicians. The nursing group scored significantly lower on questions pertaining to learning needs and correlation of team trauma members compared to physicians. This is a similar finding as noted in the Haiti group (Kurdin, 2017). In LMIC, nurses play a significantly higher role in treating injuries in patients. This again highlights the issue with the use of courses intended for HIC without making modifications to suit LMIC.

The results of this study also demonstrated the reproducibility of TEAM. Health care providers from both geographic locations provided excellent scores. There was also a higher trend detected by the physicians from the Bangladesh group due to higher responses for questions pertaining to transfer of patients to higher level facilities. One of the explanations for this finding that the authors noted was increased availability of tertiary care centres in Bangladesh compared to Haiti. When presented with a challenging injury that required complex resources, physicians in Bangladesh could transfer such patients to facilities with higher resources. This luxury was often unavailable in many communities in Haiti.

One of the limitations of this study is the comparison of only two geographic areas. Bangladesh and Haiti significantly differ with respect to health care resources and injury profiles. The favorable results of TEAM as an educational tool were reproduced in both settings. However, there needs to be more research further analyzing the reproducibility of TEAM. Furthermore, participation was voluntary and was only provided at a single site in each country. The samples of the responses obtained may not represent each nation’s population.

It is also important to view these findings with caution. This study evaluated only the satisfaction of the health care providers with the TEAM course for trauma teaching. This finding can only suggest the feasibility of TEAM as an educational tool. To confirm the validity of TEAM, more research would be necessary.

Overall, the results of this study further advocate the use of TEAM for trauma teaching in LMIC.

Chapter 7: Use of Telemedicine for Remote Trauma Assessment

7.1 Introduction

Rural trauma has posed several challenges to the health care community. Unfortunately, unavailability of resources results in inadequate patient care with adverse implications on patient outcomes (Baker, 1987; Cales, 1985; Certo, 1983). Patients that sustain traumatic injuries in a rural environment are at an increased risk of death.

Another concern with rural trauma is that there are significant obstacles that diminish the overall effect of numerous improvement strategies. For example, lack of volume predisposes any educational initiatives to loss of skill over time (Ali, 1996, 2001, 2004; Blumenfeld ,1998; Azcona, 2002). With the recent technological advances one of the potential solutions to rural trauma is through the use of telemedicine.

Telemedicine is an emerging solution to provide instant assistance to rural health care facilities and potentially improve patient care. Its use in one form or another has become prevalent is many rural emergency departments. For example, in 2016 nearly half of the emergency departments in New England utilized telemedicine (Zachrison, 2017).

Despite its rapidly increasing popularity, limited evidence exists to support the use of telemedicine (Flodgren, 2015). Majority of the evidence that supports the use of telemedicine has focused on satisfaction rates (Marcin, 2003, 2009; Farmer, 2001).

Regarding clinical outcomes, there have been promising results to suggest improvements in patient outcomes and use of telemedicine (Panlaqui, 2017; Dayal, 2016). However, these conclusions are limited by mainly retrospective designs. Furthermore, a recent systematic review failed to provide concrete evidence for improvements in patient outcomes through the use of telemedicine (Flodgren, 2015).

Besides the lack of evidence to support the use of telemedicine, it is uncertain if virtual representation of a patient would suffice for appropriate diagnosis and management. A clinician relies on numerous situational cues to interpret clinical scenarios, particularly in trauma.

The objective of this study was to evaluate the effectiveness of telemedicine for remote trauma consultations by assessing its ability to convey the necessary clinical information to a treating physician. A randomized simulation study was designed comparing in-person trauma assessment to various modes of telemedicine.

7.2 Methodological Considerations

7.2.1 Study Design

Simulation in the field of medicine utilizes various tools and devices to mimic the environment of a real clinical situation (Cook, 2011). Simulation can be achieved with use of monitors/displays, standardized patients, animal products and cadavers. In recent years, the advancements of technology allowed for the development of highly complex Human Patient Simulators (HPS). Human Patient Simulators have played a tremendous role in educating health care providers as they allow for safe and regulated practice environment (Mikrogianakis, 2011; Loveless, 2011; Hunt, 2007).

Another potential role for simulation is in the field of health care research. Simulation can provide an ethical, safe and feasible option to investigate a research question that would otherwise be difficult in a clinical environment (Vincent, 1999; LeBlanc, 2011). For example, to study the effects of sleep deprivation of health care providers on patient care would be challenging in a clinical setting as it could compromise patient care and lead to detrimental outcomes. However, with the use of simulation, Stratton et al. determined the effects of sleep deprivation on patient care in a safe and an ethical manner (Stratton, 2014).

The success of the use of simulation largely lies with the ability to use mannequin based simulators. With the technological advances, a mannequin can interact with the health care provider, display vital signs and physical exam findings and most importantly change over time to react to the actions of the clinician. This allows the clinicians to develop simulated environments that closely resemble clinical situations. With the use of simulators in clinical research, investigators can identify safety threats, test new technologies and improve health care without subjecting patients to harm (Cheng, 2014).

Besides the avoidance of potential harm to patients, there are other advantages to the use of simulation in research. Given the variability in clinical presentation, patients cannot be standardized or present at predictable times. However, simulated scenarios can be consistent and be available on demand. This particularly would benefit the study of rare conditions. For example, attempting to establish a new way of diagnosing traumatic aortic ruptures would not be feasible in a clinical setting due to the rarity of the condition and the variable severity of possible presentations. The use of simulators can provide an identical clinical scenario every time and allow for an appropriate clinical investigation.

Another advantage to using simulators is their convenience and ease of use. Clinical research can be hindered by issues with recruitment and low participation rates. However, the ability to schedule sessions based on convenience will improve participation rates. Simulation studies can even be simultaneously conducted at multiple sites.

However, there are some challenges that are worth consideration. Authenticity of the simulated clinical scenario is paramount to any clinical investigation (LeBlanc, 2011). It allows the participants to appropriately react as they would in a clinical setting. It is important that the investigators represent patient and environmental cues through the use of monitors, interactive mannequins and ancillary staff (Rudolph, 2007). It is important to note that even with all the necessary efforts from the investigators, some clinical findings particularly physical exam findings may be difficult to simulate and should be verbalized to the participants.

Another challenge of simulation is its relatively recent advent with currently unavailable guidelines for best practice and study design. According to a recent meta-analysis only 5.3% of simulation based research studies reported on clinical or patient outcomes (Cook, 2011). There are also no strategies available in the literature on how to improve the quality of simulation based research (Cheng, 2014). Simulation research is also expensive and requires numerous resources.

7.2.2 Requirements for Simulation Research

Simulation research is a promising solution to conducting clinical studies in a safe environment that does not predispose patients to harm. However, there are several necessities that contribute to its effectiveness.

It is important to initially establish the goal of the investigation and acquire an appropriate simulator. Simulators significantly vary in their ability to represent clinical clues such as ability to open and close eyes, location and quality of pulses, chest rising during respiration and ability to accept interventions pertinent to the investigation.

For this investigation, there were three main requirements to successfully represent a trauma patient. A simulator must provide vital signs at all times and have the ability to change physiological parameters based on the participant's actions. The simulator should have the capacity to provide clinical and physical finding through communication and physical appearance. The mannequin should have the ability for several investigations common to trauma care such as intubation, chest tube placement and cricoidotomy. A Human Patient Simulator (Medical Education Technology Incorporated, Sarasota, FL) was selected for this investigation as it fulfilled all the criteria established by the investigators (Appendix C & D).

Scenarios used for the investigation should be standardized and delivered in a uniform fashion to avoid possible confounders. Strategies for successful scenario designs include predetermined time points where the participant's actions are assessed and programmed verbal or visual simulator responses to the participants' actions. Scenario environment is also a vital part of an appropriate design. The scenario should contain all the usual equipment that would be present in a clinical setting and it should be placed in the same location during each scenario.

For this investigation, three trauma scenarios were utilized. Scenarios were designed to be of equal difficulty and were previously tested by Hogan et al. (Hogan, 2006). The Human Patient Simulator was programmed with the scenarios and thoroughly tested. The environment was also modified to simulate the setting of a trauma bay (Appendix C &

D). A monitor was always available to display vital signs. Crash cart with pharmacological agents was present at all times. Equipment necessary for diagnostic and therapeutic interventions was available to the participants. The location of all the equipment was recorded after the pilot tests and reproduced during each session.

To increase the authenticity of the simulations, confederates such as actors or standardized patients are often available. Confederates can take on various roles including patient relatives or ancillary health care providers. In this investigation, one confederate was utilized to act as a nurse. The confederate assisted with connecting the monitors to the patient, administering fluid resuscitations and pharmacological agents, obtaining blood work and radiographs and providing instructions to the participant. This improved the realism of the clinical scenario and accurately represented the setting in a rural environment where only a single physician and a single nurse are available to assess and manage trauma patients.

Selecting an appropriate outcome is one of the most important aspects of a study as this will provide the basis for clinical inference. This is particularly challenging in simulation study as there are limited number of objective outcomes that can be collected. Options include using the HPS to collect data throughout the session, analyzing clinical outcomes or completing observational checklists.

Modern HPS simulators have the capability to record data points during the simulations. This includes physiological parameters of the simulators and the interventions that were performed by the participant such as frequency of pulse checks, use of appropriate technique during resuscitation and even rate and depth of chest compressions. However, there are a few limitations of collecting such data as an outcome. Human Patient Simulators may not accurately record the data. Another issue is difficulty to make clinical inferences about the recorded data. For example, frequent pulse checks may not correlate with improved patient care.

Although clinical outcomes are considered to be the "gold standard" there are certain challenges. It is difficult to control for confounding variables that could influence patient outcomes and result in a false association. Additionally, there are practical constraints due to the requirement for long term surveillance and collection of data leading to a significant cost and utilization of limited resources.

Observational checklists have been previously used in simulation studies to assess performance and behavior of participants (Cheng, 2013; Auerback, 2011). Checklists are easy to perform and allow for collection of large amounts of data. They should be reliable and have been previously validated. However, there are concerns with the use of checklists in research and education. Checklists are designed to evaluate one's stepwise approach to a problem. They are commonly used in training where the observer "checks off" the sequential steps that the trainee should perform. This method of evaluation does not provide any feedback on the decision making process of the trainee. Checklists have also been shown to overlook trainee errors, lack the ability to evaluate any alternative approaches to the problem and reward a stepwise approach rather than a hierarchical problem solving approach (Wright, 2004; Regehr, 1998). These findings have also been confirmed in a clinical setting where experienced physicians do not use a stepwise approach to evaluate but rather a global comprehension (Hodges, 1999; Hawkins, 2004).

As understanding of the clinical scenario was used as the main outcome to compare the interventions, an accurate quantitative measurement had to be used. One of the alternatives to a traditional checklist is Situational Awareness Global Assessment Technique (SAGAT) based on the concept of Situational Awareness (SA).

7.2.3 Situational Awareness Global Assessment Technique

Situational Awareness was initially described by Endsley (Endsley, 1994). He defined SA as “perception of the elements in the environment…and the comprehension of their meaning and the projections of their status in the future”. He further proposed three levels of awareness that contributed to one’s understanding of a situation.

Level 1 involves the perception of sensatory stimuli of the environment. For a trauma patient, this encompasses vital signs and physical exam findings including lacerations, deformities and subtle findings such as an unstable pelvis. Level 2 includes the comprehension of those perceptions. For example, a low blood pressure and tachycardia coupled with an unstable pelvic injury may indicate hypovolemic shock from blood loss within the pelvis. Level 3 involves the understanding of the anticipated outcome of the scenario and requires a formulation of an appropriate management plan. As for the above example, this would be an understanding that patient's blood loss will continue and may result in death if proper measures with the use of fluid resuscitation and pelvis stabilization are not undertaken.

One of the tools used to measure SA is SAGAT. This method uses several pre-determined stops to measure a participant's SA. Once all the levels are assessed, a quantitative outcome can be calculated. SAGAT has been shown to be a valid tool for assessing SA in aviation, education and health care (Endsley, 1994; Hogan, 2006). For this investigation, the SAGAT was incorporated into the trauma scenarios and used as the main outcome.

Chapter 8: Manuscript 3

The Use of Telemedicine for Remote Trauma Consultation: A Simulation Study

8.1 Abstract

Objectives: Within a health care system which differs with respect to resources based on location, a trauma patient poses a challenge due the inherent complexity of each injury requiring several diagnostic and therapeutic modalities. With the advances of technology, telemedicine may have a role for improving trauma care in rural environments by providing remote specialist teleconsultations. However, virtual representation through telemedicine may not provide the necessary clinical information for an appropriate evaluation. The objective of this study was to assess the effectiveness of remote teleconsultation compared to in-person assessment.

Methods: This was a simulation study using General and Orthopaedic Surgeons as specialist teleconsultants. Participants were each randomized to complete three trauma scenarios with different interventions: standard Ceiling Panoramic Camera (CPC), Smartphone Videoconferencing (VC) and in-person evaluation as Control group. Participants completed the scenarios by providing instructions to a simulated staff member who represented a referring physician in a rural environment. Situation

Awareness Global Assessment Technique (SAGAT) was used to compare interventions' ability to relay clinical information to the teleconsultant.

Results: The average SAGAT scores for Control, Smartphone Videoconferencing and Ceiling Panoramic Camera were 85%, 87% and 81%, respectively. Matched repeated measures ANOVA did not demonstrate a statistical difference between the SAGAT scores amongst the groups (p=0.46).

Conclusions: This study demonstrated that telemedicine is an effective method of assessing and managing trauma patients remotely as compared to in-person evaluation. Although traditional single view camera designs have already shown promising results in several trauma centres, the vast availability, ease of use and low set-up costs make smartphones a valuable tool in providing care to injured patients in remote locations.

8.2 Introduction

The current structure of the health care system involves a network of hospitals and health care providers that differ substantially with respect to resources (ACSCT, 2006). A trauma patient poses a challenge to this system due to the inherent uniqueness of each injury that requires several diagnostic and management modalities which may be unavailable in rural areas (ACSCT, 2006; Ciesla, 2008). To tackle this issue, rural physicians often seek consultation from trauma specialists in tertiary health care centres for assistance in care and for transfer of injured patients for further management.

Unfortunately, such a system of care for trauma patients in rural environments can be less effective. Patients that sustain injuries in rural areas have a higher mortality than those living in urban centres (Rogers, 1997). Additionally, there is a tremendous strain on the health care budget due to secondary overtriages and administrative/transportation costs associated with unnecessary transfers (Ciesla, 2008; Rogers, 1997; Tang, 2014).

With the recent advancements in technology, telemedicine has emerged as one possible solution to improve trauma care and patient outcomes in rural areas. Telemedicine is a remote method of communication amongst health care providers that utilizes visual, auditory and imaging technology. One use of telemedicine that could be employed is to allow a consulting physician to assess a patient remotely and provide guidance for management (Hasselberg, 2014).

Telemedicine has also shown the potential to reduce trauma related health care spending (Duchesne, 2008). Duschesne et al. have demonstrated that telemedicine decreased the transfer of patients by 89%, which resulted in savings of $6.5 million over five years. In addition, use of telemedicine has shown value in identifying more severely injured patients that definitively required transfers to hospitals with advanced resources potentially decreasing the costs associated with overtriages (Duchesne, 2008).

However, limited evidence exists to support improved patient outcomes with the use of this promising technology (Gardiner, 2012; Goh, 1997). Issues with telemedicine also involve the uncertainty of assessments done remotely. Attempting to virtually represent a trauma patient could diminish the quality of the patient assessment performed by the trauma specialist as compared to in-person evaluation (Goh & Lam, 1997).

This study conducted a simulation to evaluate the effectiveness of telemedicine as an alternative to in-person assessment of trauma patients. Two separate methods of telecommunication are compared, a conventional single camera with a panoramic live feed and an operator controlled smartphone videoconferencing system. Participants' situational awareness was measured as an outcome to compare the interventions.

8.3 Methods

Interventions

For this study, General and Orthopaedic Surgery attending physicians and chief residents with successful completion of the Advance Trauma Life Support course were used as simulated consultants. Participants were randomized to order of the cases and interventions.

Two interventions and a control group were used for this study. For the control group, the participant was placed in the same room as the simulated referring physician and the Human Patient Simulator. The two telecommunication interventions isolated the participant in a separate room with access to a single monitor which relayed all visual and auditory stimuli. The two methods of telecommunication that were evaluated were a conventional ceiling mounted camera which displayed a panoramic view of the trauma bay and a portable handheld smartphone with video conferencing capabilities. Both interventions provided real time audio and visual feed to participant's monitor.

SAGAT

One of the challenges of this study was to appropriately evaluate participants' perceptions of the injured patient. This was previously accomplished through checklists which do not assess participants' understanding of the situation, nor the appropriate management that should be pursued.

To address this issue, the concept of situational awareness (SA) has been utilized. Endsley defined SA as perception and comprehension of elements in the environment and projection of their status in the future (Endsley, 1995). To assess the participant's SA, Hogan et al. established the Situation Awareness Global Assessment Technique (SAGAT) (Hogan, 2006). Situation Awareness Global Assessment Technique has been demonstrated as a valid tool in assessing the SA of health care providers in a trauma setting (Crozier, 2015; Morgan, 2014). For this study, SAGAT was utilized as a means of evaluating the effectiveness of the telemedicine methods for the remote assessment of injured patients.

Three trauma scenarios were used in this study. The scenarios have been previously validated by Hogan et al. and were determined to be of equal difficulty (see Appendix E, for an example of a clinical scenario) (Hogan, 2006). Each simulated scenario incorporated three predetermined stops during which all stimuli were removed. No stops were initiated in the first three minutes and each stop after the first were separated by at least one minute as previously recommended by Endsley. At each stop, the participants were asked to suspend their assessments and complete the SAGAT questions. Once the questions were answered, each participant would resume the scenario. Answers to the SAGAT questions were predetermined. Each participant's answer to a single question was graded as correct or incorrect; no partial marks were given. For questions that required specific numerical value, an answer was considered correct if it was within +/-10% of the predetermined numerical value. The percentage of correct answers was used as a single SAGAT score which was meant to represent situational awareness.

Human Simulator

A Human Patient Simulator (Medical Education Technology Incorporated, Sarasota, FL) was used in this study. The simulator was equipped with interactive capabilities, various physical exam findings and monitors for vital signs including heart rate, blood pressure, oxygen saturation and a rhythm strip. The simulator was programmed with the trauma scenarios. Each scenario included two staff members, one meant to simulate a referring physician from a rural hospital and the other as an assistant.

Consent was obtained and subjects were familiarized with the human simulator and its equipment. One at a time, a single participant was presented with a scenario and a brief ambulance report. Once the simulation commenced the subjects were asked to assess and manage an injured patient by providing instructions to the simulated referring physician.

Statistical Analysis

Sample size calculation was performed with the clinically significant difference in SAGAT test scores set at 7%, as previously demonstrated by Stratton et al., with an alpha of 0.05 and beta of 0.20 (Stratton, 2014). The calculated necessary sample size was nine.

Situation Awareness Global Assessment Technique scores were calculated for each participant and analyzed using SPSS (Ver. 20; SPSS, Inc. Chicago, IL). Repeated measures analysis of variance (ANOVA) was utilized to compare matched situational awareness scores of the three groups.

Although the order of cases was randomized, repeated measure ANOVA was also utilized to rule out if the order of scenarios that participants were subjected to contributed to the effects of the intervention groups.

8.4 Results

Ten participants completed the study. Results of the SAGAT scores are displayed in **Table 9**. The average situational awareness for Control, Smartphone Videoconferencing (SV) and Ceiling Panoramic Camera (CPC) were 85%, 87% and 81% respectively. Matched repeated measures ANOVA did not demonstrate a statistical difference between the SAGAT scores amongst the groups (p=0.46).

Table 9. Situational Awareness Scores of the Participants for the Three Interventions

Participant	Control	Smartphone Video Conferencing	Ceiling Panoramic Camera
1	59%	90%	77%
2	86%	79%	85%
3	92%	90%	83%
4	79%	93%	85%
5	86%	79%	92%
6	97%	79%	73%
7	81%	97%	62%
8	96%	96%	79%
9	90%	79%	92%
10	86%	92%	86%
Average	**85%**	**87%**	**81%**

Table 10 demonstrates the SAGAT scores based on the chronological order that participants completed the three scenarios. Repeated measures ANOVA did not demonstrate any statistical differences for the chronological order of completed scenarios ($p=0.371$).

Table 10. Situational Awareness Scores of the Participants in the Chronological Order of Interventions

Participant	1st Scenario	2nd Scenario	3rd Scenario
1	59%	90%	77%
2	85%	86%	79%
3	92%	90%	83%
4	84%	79%	93%
5	92%	79%	86%
6	73%	97%	80%
7	62%	81%	96%
8	79%	96%	93%
9	90%	79%	92%
10	86%	92%	86%
Average	**80%**	**87%**	**87%**

8.5 Discussion

Advances in technology have significantly improved the provision of health care. However, recent developments in telecommunication have made it possible to assess and manage patients remotely. This is of paramount significance particularly in rural areas where access to resources and specialized consultations may be limited (ACSCT, 2006; Ciesla, 2008; Rogers, 1997; Tang, 2014). The results of this study demonstrate that remote patient assessment with the use of telemedicine can yield a realistic virtual representation of an injured patient as compared to in-person evaluation.

One aspect of the results worth considering is the difference between the two interventions, Smartphone Videoconferencing and Ceiling Panoramic Camera. Modern telemedicine systems traditionally utilized a single camera design, similar to the CPC used in this study. Latifi et al. have previously described their experience with such a system that allowed for communication between a rural hospital and a tertiary care centre (Latifi, 2009). The authors noted a limitation of a single camera design as this did not provide the surgeon with a comprehensive depiction of the trauma bay (Latifi, 2009).

Another issue with several telemedicine systems is cost. Setup for a modern system includes expenses for hardware, particularly monitors, routers and cameras, various software programs and expensive IT servicing. Latifi et al. estimated that the cost of their setup was $275,000 USD (Latifi, 2009). Although these large initial expenses do result in significant savings over time, small rural hospitals may not afford such an expenditure.

With continuing advances in personal communication technology, smartphones have become part of daily living. They are compact, mobile and are affordable. Most smartphone are equipped with videoconferencing features with the use of high definition cameras and high speed internet. Although smartphones have started to play a role in the medical community with the replacement of physicians' pagers and enhancements of electronic record systems with ability to upload pictures taken with smartphones, its use of videoconferencing has not been fully utilized (Ozdalga, 2012; Banitsas, 2004; Boissin, 2016; Toomey, 2010; Zangbar, 2014; Putzer, 2012, Przybylo, 2014).

This study demonstrated some aspects of the various technological methods of telemedicine. Although there was no statistical difference found amongst the various telemedicine methods, some conclusions can be drawn. The standard CPV camera design which provided a single unobstructed view of the trauma bay, showed a lower trend of situational awareness as compared to the smartphone videoconferencing. Possible explanations for this finding, which were confirmed by the comments of the participants, included inability to see fine details particularly patients' vital signs monitor and camera's blind spots of the trauma bay. In contrast, the SV allowed the participants to see the details of the scenario and focus their attention on the pertinent aspects of the injured patient by directing the simulated referring physician. This finding may have reached statistical significance with an increased sample size.

One potential issue with more widespread use of SV is patients' privacy due to unsecure internet connections. However, as per HIPAA regulation, no communication data is stored making smartphone communication an acceptable method of patient care (Putzer, 2012). Additionally, majority of smartphones are password protected and equipped with GPS tracking to deter theft and allow personnel to locate and remotely erase all content.

Another finding of this study worth mentioning is the results of the SAGAT scores with respect to the chronological order of scenarios. Although there was no statistical difference demonstrated in SA relating to the order of simulations, there was a lower score trend for participants' first simulation. This may suggest that inexperience with the human simulator may have resulted in artificially lower performance for each participants' initial simulations. This brings up an important point as learning curve with the use of telemedicine and simulation should be considered for clinical and research purposes.

Overall, this study demonstrated that telemedicine is a possible alternative of assessing and managing a trauma patient remotely. Although standard single view camera designs have already shown promising results in several trauma centres, the vast availability, ease of use and low set-up costs make smartphones a valuable tool in providing care to injured patients in remote locations.

Chapter 9: Conclusion

Trauma is an epidemic. If affects all communities and places a significant economic burden on societies. Trauma is especially challenging in areas faced with limited access to resources, such as rural communities and developing nations.

Trauma education is one of the strategies that could improve the care of injured patients in low resource settings. Although the ATLS course is at the forefront of trauma education in developed countries, its use in LMIC has been limited due to significant resource requirements which are simply unavailable in LMIC. The use of low-cost alternatives appears to be a solution. The Trauma Evaluation and Management course is a feasible educational initiative to improve trauma care. As demonstrated by the thesis, it has been well received by all health care professionals and can be applicable despite the diversity seen amongst LMIC.

Furthermore, the rapidly advancing field of technology brings promise to decrease the distances between trauma patients and the resources they may require. Telemedicine can bring the trauma centre to virtually any place on earth. This thesis further supports the effectiveness of telemedicine for the use of remote trauma care, particularly the use of personal communication devices.

Telemedicine could also be utilized for trauma education in LMIC. Perhaps one of the solutions to decrease the costs associated with implementing educational initiatives in low resource settings is telemedicine. With the use of videoconferencing, instructors may be able to demonstrate the principles of caring for trauma patients with the support of real-time, two-way communication with the students. This premise would require future research to evaluate its effectiveness.

Trauma will continue to exist despite the efforts for improvement. It is imperative to continue to develop interventions that can reduce the impact of injuries and provide better care to patients.

Bibliography

Aboutanos, M. B., Rodas, E. B., Aboutanos, S. Z., Mora, F. E., Wolfe, L. G., Duane, T. M., Ivatury, R. R. (2007). Trauma Education and Care in the Jungle of Ecuador, Where There is no Advanced Trauma Life Support. American College of Surgeons. 2017. Available at: https://www.facs.org/quality-programs/trauma/atls. Accessed July 15, 2017.

Advanced Trauma Life Support. The Journal of Trauma: Injury, Infection, and Critical Care,62(3), 714-719.

Ali, J., & Cohen, R. (1996). Teaching Effectiveness of the Advanced Trauma Life Support Program as Demonstrated by an Objective Structured Clinical Examination for Practicing Physicians. World Journal of Surgery; 20(8), 1121-1126.

Ali, J., Adam, R., Butler, A. K., Chang, H., Howard, M., Gonsalves, D., Williams, J. I. (1993). Trauma Outcome Improves Following The Advanced Trauma Life Support Program In A Developing Country. The Journal of Trauma: Injury, Infection, and Critical Care,34(6), 890-899.

Ali, J., Adam, R., Pierre, I., Bedaysie, H., Josa, D., & Winn, J. (2001). Comparison of Performance 2 Years After the Old and New (Interactive) ATLS Courses. Journal of Surgical Research; 97(1), 71-75.

Ali, J., Adam, R., Stedman, M., Howard, M., & Williams, J. (1994). Cognitive and Attitudinal Impact Of The Advanced Trauma Life Support Program In A Developing Country. The Journal of Trauma, Injury, Infection, and Critical Care; 36(5), 695-702.

Ali, J., Cherry, R. (2004). Trauma Evaluation and Management (TEAM): Who Benefits Among Senior Medical Students? Journal of Surgical Research; 121(2), 293-294.

Ali, J., Cohen, R. J., Gana, T. J., & Al-Bedah, K. F. (1998). Effect of the Advanced Trauma Life Support Program on Medical Students Performance in Simulated Trauma Patient Management. The Journal of Trauma: Injury, Infection, and Critical Care; 44(4), 588-591.

Ali, J., Cohen, R., & Reznick, R. (1995). Demonstration of Acquisition of Trauma Management Skills by Senior Medical Students Completing the ATLS Program. The Journal of Trauma: Injury, Infection, and Critical Care; 38(5), 687-691.

Ali, J., Cohen, R., Adam, R., Gana, T., Pierre, I., Ali, E., Winn, J. (1996). Attrition of Cognitive and Trauma Management Skills after the Advanced Trauma Life Support (ATLS) Course. The Journal of Trauma: Injury, Infection, and Critical Care; 40(6), 860-866.

Ali, J., Gana, T. J., & Howard, M. (2000). Trauma Mannequin Assessment of Management Skills of Surgical Residents after Advanced Trauma Life Support Training. Journal of Surgical Research,93(1), 197-200.

Ali, J., Howard, M., & Williams, J. (2002). Is attrition of advanced trauma life support acquired skills affected by trauma patient volume? The American Journal of Surgery; 183(2), 142-145.

American College of Surgeons Committee on Trauma (ACSCT): Resources for Optimal Care of the Injured Patient: 2006. Chicago, IL: American College of Surgeons.

American College of Surgeons. Retrieved December 8, 2017, from https://www.facs.org/quality-programs/trauma/atls/team.

Aprahamian, C., Nelson, K.T., & Thompson, B.M. (1984) The Relationship of the Level of Training and Area of Medical Specialization With Registrant Performance in an Advanced Trauma Life Support course. J Emerg Med; 2(13), 137–140.

Ariyanayagam, D.C., Naraynsingh, V., & Maraj, I. (1992) The Impact of the ATLS Course on Traffic Accident Mortality in Trinidad and Tobago. West Indian Med J; 41(33), 72–74.

Arreola-Risa, C., & Speare, J.O.R. (1999) Trauma in Mexico. Trauma Quarterly; 14(3): 211–220.

Auerbach, M., Kessler, D., & Foltin, J. C. (2011). Repetitive Pediatric Simulation Resuscitation Training. Pediatric Emergency Care,27(1), 29-31.

Azcona, L. A., Gutierrez, G. E., Fernandez, C. J., Natera, O. M., Speare, O. R., & Ali, J. (2002). Attrition of Advanced Trauma Life Support (ATLS) Skills Among ATLS Instructors and Providers in Mexico. Journal of the American College of Surgeons; 195(3), 372-377.

Baker, M.S. (1994) Advanced Trauma Life Support: Is It Adequate Standalone Training for Military Medicine? Mil Med; 159(5), 587–590.

Baker, S. P. (1992). The Injury fact book. New York: Oxford University Press.

Baker, S. P., Whitfield, R., & Oneill, B. (1987). Geographic Variations in Mortality from Motor Vehicle Crashes. New England Journal of Medicine; 316(22), 1384-1387.

Banitsas, K., Georgiadis, P., Tachakra, S., & Cavouras, D. (n.d.). (2004) Using handheld devices for real-time wireless teleconsultation. The 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society.

Baxt W.B., Berry C.C., & Epperson M.D. (1989) The Failure of Prehospital Trauma Prediction Rules to Classify Trauma Patients Accurately. Ann Emerg Med; 18, 21.

Ben-Abraham, R., Stein, M., Shemer, J., Kluger, Y., Barzilay, Z., & Paret, G. (1999) Advanced Trauma Life Support (ATLS®) Courses: Should Training Be Refocused Towards Rural Physicians? European Journal of Emergency Medicine; 6(2), 111-114.

Berends, M. (2006). Survey Methods in Educational Research. Handbook of Complementary Methods in Education Research. Washington, DC: Lawrence Erlbaum Associates, Inc.

Bergman, S., Deckelbaum, D., Lett, R., Haas, B., Demyttenaere, S., Munthali, V., Razek, T. (2008). Assessing the Impact of the Trauma Team Training Program in Tanzania. The Journal of Trauma: Injury, Infection, and Critical Care,65(4), 879-883.

Bird, K. (1975) Telemedicine: Concept and Practice. Springfield, IL: Charles Thomas, 1975, pp. 89–112.

Bishai, D., Hyder, A., Ghaffar, A., Morrow, R. (2003) Rates of Public Investment for Road Safety in Developing Countries. Case Studies from Uganda and Pakistan. Health Policy Plan; 18, 232-5.

Blumenfeld, A., Abraham, R. B., Stein, M., Shapira, S. C., Reiner, A., Reiser, B., & Shemer, J. (1998). Cognitive Knowledge Decline after Advanced Trauma Life Support Courses. The Journal of Trauma: Injury, Infection, and Critical Care; 44(3), 513-516.

Boissin, C., Blom, L., Wallis, L., & Laflamme, L. (2016). Image-based teleconsultation using smartphones or tablets: qualitative assessment of medical experts. Emergency Medicine Journal,34(2), 95-99.

Botchey, I.M., Hung, Y.W., Bachani, A.M., Saidi, H., Paruk, F., Hyder, A.A. (2017) Understanding Patterns of Injury in Kenya: Analysis of a Trauma Registry Data from a National Referral Hospital. Surgery; 162(6S):S54-S62.

Burns, P. B., Rohrich, R. J., & Chung, K. C. (2011). The Levels of Evidence and Their Role in Evidence-Based Medicine. Plastic and Reconstructive Surgery, 128(1), 305–310.

Cales, R. H. (1984). Trauma mortality in Orange County: The effect of implementation of a regional trauma system. Annals of Emergency Medicine,13(1), 1-10.

Cales, R. H. (1985). Preventable Trauma Deaths. Jama; 254(8), 1059.

Carmont, M.R. (2005) The Advanced Trauma Life Support Course: A History of its Development and Review of Related Literature. Postgraduate Medical Journal; 81(952):87-91.

Celsus, C. (1938). De Medicina, Vol. VIII. Cambridge: Harvard University Press.

Certo, T. F., Rogers, F. B., & Pilcher, D. B. (1983). Review of Care of Fatally Injured Patients in a Rural State. The Journal of Trauma: Injury, Infection, and Critical Care; 23(7), 559-565.

Champion H.R. (1986) Trauma Care Systems. Rockville, MD: Aspen Publishers.

Champion, H. R., & Cushing, B. (1999). Emerging Technology For Vehicular Safety And Emergency Response To Roadway Crashes. Surgical Clinics of North America; 79(6), 1229-1240.

Cheng, A., Auerbach, M., Hunt, E.A., Chang, T.P., Pusic, M., Nadkarni, V., Kessler, D. (2014) Designing and conducting simulation-based research. Pediatrics; 133(6):1091-101.

Cheng, A., Hunt, E.A., Donoghue, A., et al. (2013) Examining pediatric resuscitation education using simulation and scripting debriefing: a multicenter, randomized-controlled trial. JAMA Pediatr; 167(6):528–536.

Cherry, R., & Ali, J. (2004). Trauma Evaluation and Management (TEAM): Who benefits among senior medical students? Journal of Surgical Research,121(2), 293-294.

Christoffel, T. (1999) Injury Prevention and Public Health: Practical Knowledge, Skills, And Strategies.

Ciesla, D. J., Sava, J. A., Street, J. H., & Jordan, M. H. (2008). Secondary Overtriage: A Consequence of an Immature Trauma System. Journal of the American College of Surgeons,206(1), 131-137.

Cook, D. A., Hatala, R., Brydges, R., Zendejas, B., Szostek, J. H., Wang, A. T., Hamstra, S. J. (2011). Technology-Enhanced Simulation for Health Professions Education. Jama,306(9).

Crozier, M. S., Ting, H. Y., Boone, D. C., O'Regan, N. B., Bandrauk, N., Furey, A., Hogan, M. P. (2015). Use of Human Patient Simulation and Validation of the Team Situation Awareness Global Assessment Technique (TSAGAT): A Multidisciplinary Team Assessment Tool in Trauma Education. Journal of Surgical Education,72(1), 156-163.

Dahdah, S., & McMahon, K. (2008) The True Cost of Road Crashes: Valuing Life and the Cost of a Serious Injury. Washington: International Road Assessment Programme, World Bank Global Road Safety Facility.

Dayal, P., Hojman, N. M., Kissee, J. L., Evans, J., Natale, J. E., Huang, Y., Marcin, J. P. (2016). Impact of Telemedicine on Severity of Illness and Outcomes Among Children Transferred From Referring Emergency Departments to a Children's Hospital PICU. Pediatric Critical Care Medicine; 17(6), 516-521.

Debas, H.T., Gosselin, R.A., McCord, C., Thind, A. (2006) Disease Control Priorities in Developing Countries. 2nd edn. New York, NY: Oxford University Press.

Dept of Transportation (US), National Highway Traffic Safety Administration (2008). Traffic Safety Facts: Children. Washington (DC).

Dragutinovic, N., Twisk, D. (2005) Use of Mobile Phones While Driving – Effects on Road Safety. Leidschendam, Netherlands: SWOV Institute for Road Safety Research.

Drimousis, P. G., Theodorou, D., Toutouzas, K., Stergiopoulos, S., Delicha, E. M., Giannopoulos, P., Katsaragakis, S. (2011). Advanced Trauma Life Support Certified Physicians in a Non-trauma System Setting: Is it Enough? Resuscitation; 82(2), 180-184.

Drucker, C. (2008) Surgery Issue: Ambroise Paré and the Birth of the Gentle Art of Surgery. The Yale Journal of Biology and Medicine, 81(4), 199.

Duchesne, J.C., Kyle, A., Simmons, J., Islam, S., Schmieg, R.E. Jr, Olivier, J., McSwain, N.E. Jr. (2008) Impact of telemedicine upon rural trauma care. J Trauma; 64(1):92-7.

Elvik, R. (2009) The Handbook of Road Safety Measures, 2nd ed. Bingley, UK: Emerald Group Publishing Limited.

Emerman, C. L., Shade, B., & Kubincanek, J. (1991). A Comparison of EMT Judgment and Prehospital Trauma Triage Instruments. The Journal of Trauma: Injury, Infection, and Critical Care; 31(10), 1369-1375.

Endsley, M. R. (1995) Toward a theory of situation awareness in dynamic systems. Human Factors; 37(1): 32-64.

Endsley, M. R., & Bolstad, C. A. (1994). Individual Differences in Pilot Situation Awareness. The International Journal of Aviation Psychology,4(3), 241-264.

Erke, A. (2008). Effects of electronic stability control (ESC) on accidents: A review of empirical evidence. Accident Analysis & Prevention; 40(1), 167-173.

Esposito, T. J., Sanddal, N. D., Hansen, J. D., & Reynolds, S. (1995). Analysis of Preventable Trauma Deaths and Inappropriate Trauma Care in a Rural State. The Journal of Trauma: Injury, Infection, and Critical Care; 39(5), 955-962.

Farmer, J. E., & Muhlenbruck, L. (2001). Telehealth for Children with Special Health Care Needs: Promoting Comprehensive Systems of Care. Clinical Pediatrics,40(2), 93-98.

Fingerhut, L. A., & Warner, M. (1997). Health, United States, 1996-97: Injury Chartbook.

Finkelstein, E. A., Corso, P. S., & Miller, T. R. (2006). The Burden of Injuries. The Incidence and Economic Burden of Injuries in the United States; 160-174.

Flodgren, G., Rachas, A., Farmer, A. J., Inzitari, M., & Shepperd, S. (2015). Interactive telemedicine: effects on professional practice and health care outcomes. Cochrane Database of Systematic Reviews.

Fowler, F. J. (2009). Survey Research Methods (4th ed.). Thousand Oaks, CA: SAGE Publications.

Fraenkel, J. R., & Wallen, N. E. (2009). How to Design and Evaluate Research in Education (7thed.). New York, NY: McGraw-Hill.

Gardiner, S., Hartzell, T.L. (2012) Telemedicine and plastic surgery: A review of its applications, limitations and legal pitfalls. J Plast Reconstr Aesthet Surg; 65:e47-e53.

Gay, L. R., Mills, G. E., & Airasian, P. (2009). Educational Research (9th ed.). Upper Saddle River, NJ: Pearson Education.

Girdley, F.M., Cohen, D.J., Birnbaum, M.L. (1993) Advanced Trauma Life Support: Assessment of Cognitive Achievement. Mil Med; 158:623–627 15.

Global burden of disease. (n.d.). Retrieved December 10, 2017, from http://www.who.int/topics/global_burden_of_disease/en/

Global status report on road safety 2015. (n.d.). Retrieved July 13, 2017, from http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/

Goh, K.Y., Lam, C.K., Poon, W.S. (1997) The impact of teleradiology on the inter-hospital transfer of neurosurgical patients. Br J Neurosurg;11(1):52-6.

Goh, K.Y., Tsang, K.Y., Poon, W.S. (1997) Does teleradiology improve inter-hospital management of head-injury? Can J Neurol Sci; 24(3):235-9.

Grande, C.M. (1990). Mechanisms and Patterns of Injury: the Key to Anticipation in Trauma Management. Crit Care Clin; 6(1), 25-35. Review.

Guidelines for essential trauma care. (n.d.). Retrieved October 13, 2017, from http://www.who.int/violence_injury_prevention/publications/services/guidelines_traumacare/en.

Guzzo J.L., Bochicchio G.V., Napolitano L.M., et al (2005) Predictions of Outcomes in Trauma: Anatomic or Physiologic Parameters? J Am Coll Surg; 201:891.

Haddon, W. (1968). The Changing Approach to the Epidemiology, Prevention and Amelioration of Trauma: The Transition to Approaches Etiologically Rather than Descriptively Based. USA: American Journal of Public Health.

Haddon, W. (1980) Advances in the Epidemiology of Injuries as a Basis for Public Policy. Public Health Reports; 95(5):411-421.

Hanson, M. (1999). Hippocrates on Head Wounds. Berlin: Akademie Verlag.

Hasselberg, M., Beer, N., Blom, L., Wallis, L.A., Laflamme, L. (2014) Image-Based Medical Expert Teleconsultation in Acute Care of Injuries. A Systematic Review of Effects on Information Accuracy, Diagnostic Validity, Clinical Outcome, and User Satisfaction; 9(6):e98539.

Hawkins, R., Gaglione, M. M., Laduca, T., Leung, C., Sample, L., Gliva-Mcconvey, G., Ciccone, A. (2004). Assessment of patient management skills and clinical skills of practicing doctors using computer-based case simulations and standardised patients. Medical Education,38(9), 958-968.

Health Spending. (2017, November 06). Retrieved from https://www.cihi.ca/en/health-spending.

Hicks, T.C., Danzl, D.F., Thomas, D.M., et al (1982) Resuscitation and Transfer of Trauma Patients: A Prospective Study. Ann Emerg Med; 11:296.

Hjelm, N. M., H. W. Julius. (2005) Centenary of Tele-Electrocardiography and Tele Phonocardiography. J. Telemedicine and Telecare; 11: 336–338.

Hodges, B., Regehr, G., Mcnaughton, N., Tiberius, R., & Hanson, M. (1999). OSCE checklists do not capture increasing levels of expertise. Academic Medicine,74(10), 1129-34.

Hofman, K., Primack, A., Keusch, G., Hrynkow, S. (2005) Addressing the Growing Burden of Trauma and Injury in Low- and Middle-Income Countries. American Journal of Public Health; 95(1), 13-17.

Hogan, M. P., Pace, D. E., Hapgood, J., & Boone, D. C. (2006). Use of Human Patient Simulation and the Situation Awareness Global Assessment Technique in Practical Trauma Skills Assessment. The Journal of Trauma: Injury, Infection, and Critical Care,61(5), 1047-1052.

Hogan, P. M., Pace, E. D., Hapgood, C. J., Boone, C. D. (2006) Use of human patient simulation and the situation awareness global assessment technique in practical trauma skills assessment. J Trauma; 61:1047-1052.

Houtchens, B. A. (1977). Major Trauma in the Rural Mountain West. Journal of the American College of Emergency Physicians; 6(8), 343-350.

Hunt, E. A., Heine, M., Hohenhaus, S. M., Luo, X., & Frush, K. S. (2007). Simulated Pediatric Trauma Team Management. Pediatric Emergency Care,23(11), 796-804.

Injuries and violence: the facts. Retrieved December 01, 2017, from http://www.who.int/violence_injury_prevention/key_facts/en/.

Injury Prevention & Control. (2017). Retrieved December 1, 2017, from https://www.cdc.gov/injury/wisqars/fatal.html.

Islam, A. (2014). Health System in Bangladesh: Challenges and Opportunities. American Journal of Health Research,2(6), 366.

Jacobs, G., Aeron-Thomas, A., Astrop, A. (2000) Estimating Global Road Fatalities. Crowthorne, Transport Research Laboratory.

Jayaraman, S., Mabweijano, J. R., Lipnick, M. S., Caldwell, N., Miyamoto, J., Wangoda, R., Ozgediz, D. (2009). First Things First: Effectiveness and Scalability of a Basic Prehospital Trauma Care Program for Lay First-Responders in Kampala, Uganda. PLoS ONE,4(9).

Jayaraman, S., Sethi, D. (2009) Advanced Trauma Life Support Training for Hospital Staff. Cochrane Database Syst Rev. 2009 Apr 15;(2):CD004173.

Joshipura, M.K., Shah, H.S., Patel, P.R., Divatia, P.A., Desai, P.M. (2003) Trauma Care Systems in India. Injury; 34: 686–692.

Killoran, A. (2010) Review of Effectiveness of Laws Limiting Blood Alcohol Concentration Levels to Reduce Alcohol-related Road Injuries and Deaths. Centre for Public Health Excellence NICE.

Kirkpatrick J.R., Youmans R.L. (1971) Trauma Index: An Aid in Evaluation of Injury Victims. J Trauma; 11:711.

Kirsch, T.D. (1998) Emergency Medicine Around the World. Annals of Emergency Medicine; 32(2):237-238.

Knudson, P., Frecceri, C. A., & Delateur, S. A. (1988). Improving the Field Triage of Major Trauma Victims. The Journal of Trauma: Injury, Infection, and Critical Care; 28(5), 602-606.

Kobusingye, O. C. (2002). Citywide trauma experience in Kampala, Uganda: a call for intervention. Injury Prevention,8(2), 133-136.

Kyriacou D.N., Hutson H.R., Anglin D. (1999) The Relationship Between Socioeconomic Factors and Gang Violence in the City of Los Angeles. J Trauma; 46(2):334–339.

Landercasper, J., Cogbill, T. H., & Strutt, P. J. (1990). Delayed Diagnosis of Flail Chest. Critical Care Medicine; 18(6), 611-613.

Latifi, R., Hadeed, G.J., Rhee, P., O'Keeffe, T., Friese, R.S., Wynne, J.L., et al. (2009) Initial experiences and outcomes of telepresence in the management of trauma and emergency surgical patients. Am J Surg; 198:905–910.

Latifi, R., Poropatich, R., Hadeed, G. (2010) Telemedicine for Trauma, Emergencies and Disaster Management. Artech House.

Leblanc, V. R., Manser, T., Weinger, M. B., Musson, D., Kutzin, J., & Howard, S. K. (2011). The Study of Factors Affecting Human and Systems Performance in Healthcare Using Simulation. Simulation in Healthcare: The Journal of the Society for Simulation in Healthcare,6.

Lecky, F., Woodford, M., & Yates, D. (2000). Trends in trauma care in England and Wales 1989–97. The Lancet,355(9217), 1771-1775.

Lee, M. (2011). The history of Ephedra (ma-huang). Journal of the Royal College of Physicians of Edinburgh; 41(1), 78-84.

Leedy, P. D., & Ormrod, J. E. (2005). Practical Research: Planning and Design (8th ed.). Upper Saddle River, NJ: Pearson Education.

Leigh, J.P., Markowitz S.B., Fahs M., Shin C., Landrigan P.J. (1997) Occupational Injury and Illness in the United States. Estimates of Costs, Morbidity, and Mortality. Arch Intern Med; 157(14):1557-68.

Li, M. S., Brasel, K. J., Schultz, D., Falimirski, M. E., Stafford, R. E., Somberg, L. B., & Weigelt, J. A. (2006). Effective Retention of Primary Survey Skills by Medical Students After Participation in an Expanded Trauma Evaluation and Management Course. The American Journal of Surgery; 191(2), 276-280.

Lie, A., Tingvall, C., Krafft, M., & Kullgren, A. (2006). The Effectiveness of Electronic Stability Control (ESC) in Reducing Real Life Crashes and Injuries. Traffic Injury Prevention; 7(1), 38-43.

London, J.A. et al. (2001) Priorities for Improving Hospital-based Trauma Care in an African City. The Journal of Trauma; 51, 747–753.

Loveless, M. B., Finkenzeller, D., Ibrahim, S., & Satin, A. J. (2011). A Simulation Program for Teaching Obstetrics and Gynecology Residents the Pediatric Gynecology Examination and Procedures. Journal of Pediatric and Adolescent Gynecology,24(3), 127-136.

MacKenzie E.J., Rivara F.P., Jurkovich G.J., Nathens A.B., Frey K.P., Egleston B.L., Salkever D.S., Scharfstein D.O. (2006) A National Evaluation of the Effect of Trauma-center Care on Mortality. N Engl J Med; 354(4):366-78.

Mackenzie, E. J., Siegel, J. H., Shapiro, S., Moody, M., & Smith, R. T. (1988). Functional Recovery and Medical Costs of Trauma: An Analysis by Type and Severity of Injury. The Journal of Trauma: Injury, Infection, and Critical Care; 28(3), 281-297.

Mackersie, R. C. (1989). Intra-abdominal Injury Following Blunt Trauma. Archives of Surgery; 124(7), 809.

Maio, R. F., Green, P. E., Becker, M. P., Burney, R. E., & Compton, C. (1992). Rural Motor Vehicle Crash Mortality: The Role of Crash Severity and Medical Resources. Accident Analysis & Prevention; 24(6), 631-642.

Marcin, J. P., Ellis, J., Mawis, R., Nagrampa, E., Nesbitt, T. S., & Dimand, R. J. (2003). Using Telemedicine to Provide Pediatric Subspecialty Care to Children With Special Health Care Needs in an Underserved Rural Community. Pediatrics,113(1), 1-6.

Marcin, J. P., Shaikh, U., & Steinhorn, R. H. (2015). Addressing Health Disparities in Rural Communities Using Telehealth. Pediatric Research; 79(1-2), 169-176.

Marcin, J. P., Trujano, J., Sadorra, C., & Dharmar, M. (2009). Telemedicine in Rural Pediatric Care: the Fundamentals. Pediatric Annals,38(4), 224-226.

Martin, G. D., Cogbill, T. H., Landercasper, J., & Strutt, P. J. (1990). Prospective Analysis of Rural Interhospital Transfer of Injured Patients to a Referral Trauma Center. The Journal of Trauma: Injury, Infection, and Critical Care; 30(8), 1014-1020.

Mcswain, N. E., & Belles, A. (1990). Motorcycle Helmets—Medical Costs and the Law. The Journal of Trauma: Injury, Infection, and Critical Care; 30(10), 1189-1199.

Mehne, P.R., Allison, E.J., Williamson, J.E. (1987) A Required, Combined ACLS/ATLS Provider Course for Senior Medical Students at East Carolina University. Ann Emerg Med; 16:666–668 14.

Mertler, C. A., & Charles, C. M. (2008). Introduction to Educational Research (6th ed.). Boston, MA: Pearson Education.

Mikrogianakis, A., Kam, A., Silver, S., Bakanisi, B., Henao, O., Okrainec, A., & Azzie, G. (2011). Telesimulation: An Innovative and Effective Tool for Teaching Novel Intraosseous Insertion Techniques in Developing Countries. Academic Emergency Medicine,18(4), 420-427.

Milzman, D. P., Boulanger, B. R., Rodriguez, A., Soderstrom, C. A., Mitchell, K. A., Magnant, C. M. (1992). Pre-existing Disease in Trauma Patients. The Journal of Trauma: Injury, Infection, and Critical Care; 32(2), 236.

Mobile Phone Use: A Growing Problem of Driver Distraction. (2011) Geneva: World Health Organization.

Mock, C. N., Adzotor, K. E., Conklin, E., Denno, D. M., & Jurkovich, G. J. (1993). Trauma Outcomes In The Rural Developing World. The Journal of Trauma: Injury, Infection, and Critical Care; 35(4), 518-523.

Mock, C. N., Jurkovich, G. J., Nii-Amon-Kotei, D., Arreola-Risa, C., & Maier, R. V. (1998). Trauma Mortality Patterns in Three Nations at Different Economic Levels. The Journal of Trauma: Injury, Infection, and Critical Care; 44(5), 804-814.

Mock, C. N., Quansah, R., Addae-Mensah, L., & Donkor, P. (2005). The development of continuing education for trauma care in an African nation. Injury,36(6), 725-732.

Mock, C. N., Tiska, M., Adu-Ampofo, M., & Boakye, G. (2002). Improvements in Prehospital Trauma Care in an African Country with No Formal Emergency Medical Services. The Journal of Trauma: Injury, Infection, and Critical Care,53(1), 90-97.

Mock, C., Arreloa-Risa, C., Quansah, R. (2003) Strengthening Care for Injured Persons in Less Developed Countries: A Case Study of Ghana and Mexico. Inj Control Safety Promotion; 10:45–51.

Mock, C., Joshipura, M., Arreola-Risa, C., & Quansah, R. (2012). An Estimate of the Number of Lives that Could be Saved through Improvements in Trauma Care Globally. World Journal of Surgery,36(5), 959-963.

Moeller, D. W. (2011) Environmental health. Harvard University Press.

Moore, E. E., Feliciano, D. V., & Mattox, K. L. (2008). Trauma. New York: McGraw-Hill Education.

Morgan, P., Tregunno, D., Brydges, R., Pittini, R., Tarshis, J., Kurrek, M., Ryzynski, A. (2014). Using a situational awareness global assessment technique for interprofessional obstetrical team training with high fidelity simulation. Journal of Interprofessional Care,29(1), 13-19.

Mowafi, H., Oranmore-Brown, R., Hopkins, K.L., White, E.E., Mulla, Y.F., Seidenberg, P. (2016) Analysis of Prehospital Transport Use for Trauma Patients in Lusaka, Zambia. World J Surg; 40(12):2868-2874.

Muelleman, R. L., Walker, R. A., & Edney, J. A. (1993). Motor Vehicle Deaths. The Journal of Trauma: Injury, Infection, and Critical Care; 35(5), 717-719.

Murray Christopher J.L. (2003). Executive Summary of the Global Burden of Disease. World Health Organization.

Murray, C.J.L., Lopez, A.D. (1996) Global Health Statistics: A Compendium of Incidence Prevalence and Mortality Estimates for Over 200 Conditions. Cambridge, Mass: Harvard University Press.

Murray, C.J.L., Lopez, A.D. (2005) The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability From Diseases Injuries, and Risk Factors in 1990 and Projected to 2020. American Journal of Public Health; 95(1).

Nader, R. (1965) Unsafe at Any Speed: The Designed-In Dangers of the American Automobile.

Naghavi M, Abolhassani F, Pourmalek F, et al. (2009) The Burden of Disease and Injury in Iran 2003. Population Health Metrics; 7:9.

National Center for Health Statistics. (2001) Age Adjusted Death Rate for Selected Causes of Death According to Sex, Race and Hispanic Origin: United States Selected Years 1950-2000. Centers for Disease Control and Prevention. Atlanta.

O'Sullivan, E., Rassel, G. R., & Berner, M. (2003). Research Methods for Public Administrators (4th ed.). New York, NY: Addison Wesley Longman.

OCEBM Levels of Evidence Working Group. The Oxford 2011 Levels of Evidence. Oxford Centre for Evidence-Based Medicine. http://www.cebm.net/index.aspx?o=5653.

Olden, G. D., Meeuwis, J. D., Bolhuis, H. W., Boxma, H., & Goris, R. J. (2004). Advanced Trauma Life Support Study: Quality of Diagnostic and Therapeutic Procedures. The Journal of Trauma: Injury, Infection, and Critical Care; 57(2), 381-384.

Olson, C. J., Arthur, M., Mullins, R. J., Rowland, D., Hedges, J. R., & Mann, N. (2001). Influence of Trauma System Implementation on Process of Care Delivered to Seriously Injured Patients in Rural Trauma Centers. Surgery; 130(2), 273-279.

Ornato, J., Mlinek, E. J., Craren, E. J., & Nelson, N. (1985). Ineffectiveness of the Trauma Score and the CRAMS Scale for Accurately Triaging Patients to Trauma Centers. Annals of Emergency Medicine; 14(11), 1061-1064.

Ostlin, P., Braveman, P., Dachs, N. (2005) Force on Research Priorities for Equity in Health; WHO Equity Team. Priorities for research to take forward the health equity policy agenda. Bull World Health Organ; 83: 948-53.

Ozdalga, E., Ozdalga, A., & Ahuja, N. (2012). The Smartphone in Medicine: A Review of Current and Potential Use Among Physicians and Students. Journal of Medical Internet Research,14(5).

Panlaqui, O.M., Broadfield, E., Champion, R., Edington, J.P., Kennedy, S. (2017) Outcomes of telemedicine intervention in a regional intensive care unit: a before and after study. Anaesth Intensive Care; 45(5):605-610.

Papp, K. K., & Miller, F. B. (1995). A Required Trauma Lecture Series for Junior Medical Students. The Journal of Trauma: Injury, Infection, and Critical Care; 38(1), 2-4.

Peden, M. (2004) World Report on Road Traffic Injury Prevention. Geneva, World Health Organization.

Peden, M., McGee, K., Sharma, G. (2005) The Injury Chart Book: A Graphical Overview of the Global Burden of Injuries. Geneva, Switzerland: World Health Organization.

Petroze, R. T., Byiringiro, J. C., Ntakiyiruta, G., Briggs, S. M., Deckelbaum, D. L., Razek, T., Calland, J. F. (2014). Can Focused Trauma Education Initiatives Reduce Mortality or Improve Resource Utilization in a Low-Resource Setting? World Journal of Surgery; 39(4), 926-933.

Polit, D. F., & Beck, C. T. (2006). Essentials of Nursing Research (6th ed.). Philadelphia, USA: Lippincott Williams & Wilkins.

Przybylo, J. A., Wang, A., Loftus, P., Evans, K. H., Chu, I. and Shieh, L. (2014), Smarter hospital communication: Secure smartphone text messaging improves provider satisfaction and perception of efficacy, workflow. J. Hosp. Med; 9: 573–578.

Putzer, G.J., Park, Y. (2012) Are physicians likely to adopt emerging mobile technologies? Attitudes and innovation factors affecting smartphone use in the Southeastern United States. Perspect Health Inf Manag; 9:1b.

Quansah, R. (2001) Availability of Emergency Medical Services Along Major Highways. Ghana Medical Journal; 35:8–10.

Quansah, R., Abantanga, F., & Donkor, P. (2008). Trauma Training for Nonorthopaedic Doctors in Low- and Middle-income Countries. Clinical Orthopaedics and Related Research; 466(10), 2403-2412.

Quansah, R.E. (2001) Availability of Emergency Medical Services Along Major Highways. Ghana Med J; 35:8–10.

Redelmeier, D. A., & Tibshirani, R. J. (1997). Association Between Cellular-Telephone Calls and Motor Vehicle Collisions. New England Journal of Medicine; 336(7), 453-458.

Regehr, G., Macrae, H., Reznick, R. K., & Szalay, D. (1998). Comparing the psychometric properties of checklists and global rating scales for assessing performance on an OSCE-format examination. Academic Medicine,73(9), 993-7.

Resources for Optimal Care of the Injured Patient 2014/Resources Repository. Retrieved December 27, 2017, from https://www.facs.org/quality-programs/trauma/vrc/resources.

Richardson, J.D., Cross, T., Lee, D., Shively, E., Bentley, E., Weiss, D., Brock, K., Petrocelli, J., Miller, F.B., Polk, H.C. (1997) Impact of Level III Verification on Trauma Admissions and Transfer: Comparisons of Two Rural Hospitals. J Trauma; 42(3):498-502.

Rizoli, S. B., Boulanger, B. R., Mclellan, B. A., & Sharkey, P. W. (1994). Injuries Missed During Initial Assessment of Blunt Trauma Patients. Accident Analysis & Prevention; 26(5), 681-686.

Roberts, I., Campbell, F., Hollis, S., Yates, D. (1996) Reducing Accident Death Rates in Children and Young Adults: The Contribution of Hospital Care. BMJ; 313(7067):1239-1241.

Rogers, F. B., Osler, T. M., Shackford, S. R., Martin, F., Healey, M., & Pilcher, D. (2001). Population-Based Study of Hospital Trauma Care in a Rural State without a Formal Trauma System. The Journal of Trauma: Injury, Infection, and Critical Care; 50(3), 409-414.

Rogers, F. B., Shackford, S. R., Osler, T. M., Vane, D. W., & Davis, J. H. (1999). Rural Trauma: The Challenge for the Next Decade. The Journal of Trauma: Injury, Infection, and Critical Care; 47(4), 802.

Rogers, F.B., Shackford, S.R., Hoyt, D.B., Camp, L., Osler, T.M., Mackersie, R.C., Davis, J.W. (1997) Trauma deaths in a mature urban vs rural trauma system. A comparison. Arch Surg; 132(4):376-81.

Rosén, E., Stigson, H., & Sander, U. (2011). Literature Review of Pedestrian Fatality Risk as a Function of Car Impact Speed. Accident Analysis & Prevention; 43(1), 25-33.

Rubin, A., & Babbie, E. R. (2008). Research Methods for Social Work (6th ed.). Belmont, CA: Thomson Brooks/Cole.

Rudolph, J. W., Simon, R., & Raemer, D. B. (2007). Which Reality Matters? Questions on the Path to High Engagement in Healthcare Simulation. Simulation In Healthcare: The Journal of the Society for Simulation in Healthcare,2(3), 161-163.

Rutledge, R., Fakhry, S. M., Baker, C. C., Weaver, N., Ramenofsky, M., Sheldon, G. F., Meyer, A. A. (1994). A Population-Based Study of the Association of Medical Manpower with County Trauma Death Rates in the United States. Annals of Surgery; 219(5), 547-567.

Sanders, J.L., Raja, A.S., Hasegawa, K., Bittner, J., Espinola, J.A., Olamiju, B., Sullivan, A.F., Camargo, C.A. (2016) Decline in Consultant Availability in Massachusetts Emergency Departments: 2005 to 2014. Ann Emerg Med; 68(4):461-6.

Sethi, D. D., Habibula, S., & Kelly, A. (2003). Advanced trauma life support training for hospital staff. Cochrane Database of Systematic Reviews.

Sethi, D., Aljunid, S., Saperi, S. B., Clemens, F., Hardy, P., Elbourne, D., & Zwi, A. B. (2007). Comparison of the effectiveness of trauma services provided by secondary and tertiary hospitals in Malaysia. Annals of Emergency Medicine,49(1).

Sethi, D., Aljunid, S., Sulong, S. B., & Zwi, A. B. (2000). Injury care in low- and middle-income countries: identifying potential for change. Injury Control and Safety Promotion,7(3), 153-164.

Shackford, S. R., Hollingworth-Fridlund, P., & Eastman, A. B. (1986). The Effect of Regionalization Upon the Quality of Trauma Care as Assessed by Concurrent Audit Before and After Institution of a Trauma System: A Preliminary Report. The Journal of Trauma: Injury, Infection, and Critical Care; 26(9), 812-820.

Stabilization and Transport, Advanced trauma life support: ATLS student course manual. (2012). Chicago: American College of Surgeons.

Stratton, A., Furey, A., & Hogan, M. (2014). The Effect of Sleep Deprivation on a Resident's Situational Awareness in a Trauma Scenario. Journal of Orthopaedic Trauma,28(7).

Tang, A., Hashmi, A., Pandit, V., Joseph, B., Kulvatunyou, N., Vercruysse, G., Zangbar, B., Gries, L., O'Keeffe, T., Green, D., Friese, R., Rhee, P. (2014) A critical analysis of secondary overtriage to a Level I trauma center. J Trauma Acute Care Surg; 77(6):969-73.

The Periodic Health Examination. Canadian Task Force on the Periodic Health Examination. (1979). Canadian Medical Association Journal, 121(9), 1193–1254.

The Safety Triangle Explained. (2017, February 21). Retrieved December 1, 2017, from https://safesitehq.com/test/.

Toomey, R.J., Ryan, J.T., McEntee, M.F., Evanoff, M.G., Chakraborty, D.P., McNulty, J.P., Manning, D.J., Thomas, E.M., Brennan, P.C. (2010) Diagnostic efficacy of handheld devices for emergency radiologic consultation. AJR Am J Roentgenol; 194(2):469-74.

Trunkey, D. D. (2008). The Development Of Trauma Systems. Current Therapy of Trauma and Surgical Critical Care; 1-5.

US department of labor. Injuries, Illnesses, and Fatalities - Bureau of Labor. Retrieved December 8, 2017, from https://www.bls.gov/iif/oshsum.htm.

Vestrup, J. A., Stormorken, A., & Wood, V. (1988). Impact of Advanced Trauma Life Support Training on Early Trauma Management. The American Journal of Surgery; 155(5), 704-707.

Vincent, C., Taylor-Adams, S., & Stanhope, N. (1998). Framework for analysing risk and safety in clinical medicine. Bmj,316(7138), 1154-1157.

Wang, P., Li, N.P., Gu, Y.F. (2010) Comparison of Severe Trauma Care Effect Before and After Advanced Trauma Life Support Training. Chin J Traumatol; 13:341–344.

Wang, V. C. (2015). Handbook of Research on Scholarly Publishing and Research Methods. Hershey, PA: Information Science Reference.

West, J. G. (1983). Impact of Regionalization. Archives of Surgery; 118(6), 740.

West, J. G. (1988). Trauma Systems. JAMA; 259(24), 3597.

Wilkinson DJ. (1993). The History of Trauma Anesthesia. Textbook of Trauma Anesthesia and Critical Care. St. Louis: Mosby-Yearbook Inc.

Williams, M. J., Lockey, A. S., & Culshaw, M. C. (1997). Improved trauma management with advanced trauma life support (ATLS) training. Emergency Medicine Journal,14(2), 81-83.

Wilson, W., Grande, C. and Hoyt, D. (2007). Trauma. London: Informa Healthcare.

World Health Organization. Assessing the quality of primary care in Haiti. (2017, September 04). Retrieved from http://www.who.int/bulletin/volumes/95/3/16-179846/en/. Accessed 22 April 2018.

World Health Organization. Injuries and violence: the facts, Geneva 2010. Available at: http://www.who.int/violence_injury_prevention/key_facts/en/index. html. Accessed 10 January 2017.

Wright, M. C. (2004). Objective measures of situation awareness in a simulated medical environment. Quality and Safety in Health Care,13(Suppl_1), I65-I71.

Zachrison, K.S., Hayden, E.M., Schwamm, L.H. (2017). Characterizing New England Emergency Departments by Telemedicine Use. Western Journal of Emergency Medicine; 18(6):1055-1060.

Zangbar, B., Pandit, V., Rhee, P., Aziz, H., Hashmi, A., Friese, R.S., Weinstein, R., Joseph, B. (2014) Smartphone surgery: how technology can transform practice. Telemed J E Health; 20(6):590-2.

Appendix A. TEAM course evaluation survey

TEAM Course Participant Evaluation

Circle level of learner: Physician Nurse Pre-Hospital Other____________

Directions: Please evaluate the course by using the scale of 1 (Poor or Strongly Disagree) to 5 (Excellent or Strongly Agree).

Criteria	1	2	3	4	5	Comments
1. Course objectives were understood						
2. Course is pertinent to my learning needs						
3. Course is pertinent to my practice						
4. The course reflects current standards of practice.						
5. Teaching methods (lecture, skill stations) are effective						
6. Content is organized in a concise, logical sequence.						
7. Course content is presented at the level of the learner.						
8. Course manual is well written, visually appealing, and a good reference/resource.						
9. The audiovisuals enhance the presentation.						
10. Course format (lecture and skill station scenarios) stimulates critical thinking and problem solving experiences needed to care for trauma patients.						
11. The course provides information and skills needed to assist with the development of a rural trauma team.						
12. Course reflects the interrelationships of trauma team members.						
13. Course provides information to make transfer decisions and arrangements with receiving facilities.						
14. Please rate the physical facilities.						
15. Please rate the overall quality of the program						

Please use other side of the sheet for any additional comments

Overall impression of the course:

Strengths:

Areas for improvement:

Name (optional):____

Appendix B. TEAM Course Outline

TEAM
Trauma Evaluation and Management

Schedule designed to accommodate 32 participants with a minimum of 6 instructors

<u>**Time**</u>	<u>**Schedule**</u>
0800-0815	Introduction
0815-0830	Initial Assessment Demonstration
0830-0930	TEAM slides
0930-0945	Initial Assessment Demonstration
0945-1005	Break

Participants divide into 4 equal Groups

Station I	Airway and Ventilator Management
Station II	Shock Assessment and Management
Station III	X-ray Identification of Thoracic Injuries (Physicians)/ MSK (Nursing)
Station IV	Surgical Skills (Chest Decompression & Cricothyroidotomy)

Time	<u>**Group A**</u>	<u>**Group B**</u>	<u>**Group C**</u>	<u>Group D</u>
1005-1055	Airway	Shock	X-Rays/MSK	Surgical Skills
1055-1145	Shock	X-Rays/MSK	Surgical Skills	Airway
1230-1320	X-Rays/MSK	Surgical Skills	Airway	Shock
1320-1410	Surgical Skills	Airway	Shock	X-Rays/MSK

1145-1230 Lunch

1410-1510

Groups A & B: Simulation Scenarios & Debriefing (4 instructors with 4 in each group)
Groups C & D: Communication & Team Work Discussion & Video (1 instructor/16 participants)

1510-1520 Break

1520-1620

Groups A & B: Communication & Team Work Discussion & Video (1 instructor/16 participants)
Groups C & D: Simulation Scenarios & Debriefing (4 instructors with 4 in each group)

1620-1630 Days Summary

1630-1715 FAST (Optional - For anyone interested)

Appendix C. Human Patient Simulator

Image obtained through the Ceiling Mounted Camera.

Appendix D. Human Patient Simulator

Image obtained from the mobile Videoconferencing.

Appendix E. Sample SAGAT Questions of a Single Case

Scenario: 25 year old involved in a motorcycle accident. Found unresponsive on the street. Intubated on the scene. Patient arrived to your emergency department at a rural community centre and placed on the monitor. You are the trauma leader.

SAGAT Questions

Level 1 (Perception)	Level 1 (Perception) Predetermined Answers
1) What is the patient's blood pressure? 2) What is your rectal exam? 3) What is your finding on pelvic examination?	1) 70/40 +/- 10% 2) Diffuse blood with palpable sharp edges 3) Gross instability
Level 2 (Comprehension)	**Level 2 (Comprehension) Answers**
1) What is the cause of the vital signs? 2) What is the explanation of the blood on rectal exam? 3) What is the cause of the instability of the pelvis?	1) Bleeding into the pelvis 2) Rectal injury from pelvic fracture 3) Pelvic ring fracture
Level 3 (Projection)	**Level 3 (Projection) Answers**
1) What do you expect to happen to patients pulse in the next two minutes? 2) How can you temporarily stabilize the pelvic instability? 3) What should be done to stabilize patient's vital signs?	1) Continued rise in pulse 2) Application of a pelvic binder 3) Fluid resuscitation

Score: __/9