Identifying the Epidemiology of Traumatic Injury in Benghazi, Libya Through the Implementation of an Electronic Trauma Registry

Ali Elgheriani M.D.
Global Surgery, McGill University, Montreal
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List of Abbreviations

A&E	Accident and Emergency
AIS	Abbreviated Injury Scale
BMC	Benghazi Medical Centre
CHY	Central Hospital of Yaoundé
DALY	Daily Adjusted Life Years
ED	Emergency Department
EMS	Emergency Medical Services
ER	Emergency Room
GCS	Glasgow Coma Scale
GSI	Gunshot Injury
HIC	High Income Countries
iOS	iPhone Operating System
ISS	Injury Severity Score
KTS	Kampala Trauma Score
LMIC	Low Middle Income Countries
MNS	Major Trauma Service
MTS	Metropolitan Neurosurgical Service
MVC	Motor Vehicle Collisions
NISS	New Injury Severity Score
NSQIP	National Surgical Quality Improvement Program
NTDB	National Trauma Data Bank
OR	Operating Room
PATOS	Pan-Asian Traumatic Outcome Study
PGY	Postgraduate year
QTR	Quebec Trauma Registry
RTS	Revised Trauma Score
TARN	Trauma Audit Research Network
TBI	Traumatic Brain Injury
TR	Trauma Registry
TRISS	Trauma Score Injury Severity Score
VSTR	Victoria State Trauma Registry
WHO	World Health Organization

Abstract

Introduction: Traumatic injury is the leading cause of morbidity and mortality globally, and there is little data in the literature for low middle-income countries (LMIC), although it is slowly growing. Libya has been suffering from low resources that are further strained by an ongoing civil war. Benghazi Medical Centre (BMC) is the only operating trauma public hospital in the country's eastern region and trauma is on the rise. Currently, there is no system in place to identify the trends of traumatic injuries nor any formal surveillance. The objective of this thesis is to describe the epidemiology of traumatic injuries and identify gaps in the trauma system.

Methods: This is a prospective study conducted at BMC's emergency room through the implementation of an electronic trauma registry, iTrauma application. Data collection occurred during January of 2017 over a 10-day trial period. Upon the traumatic patient's arrival to the emergency department twenty-five data points were collected and entered into iTrauma. Data points included patient demographics, mechanism of injury and clinical outcomes.

Results: A total of 231 patients were evaluated and included into the TR. Males were at higher risk for traumatic injury making up 68% of injured patients. The average age was 31 years old, however, the majority of were in the 0-10 and 31-40 age groups. Falls were the most common cause of injury at 31%, followed closely by motor vehicle collisions at 30%. None of the patients injured in a car collision wore a seatbelt, and half of motorbike collision patients dawned helmets. The most common type of injury was bone fractures at 13% and the most common anatomical region was extremity injuries. The vast majority of trauma patients arrived by private

vehicle (57%), whereas 20% arrived by ambulance. In terms of clinical outcome, 36% of patients were either treated and discharged in the ER or discharged by the 2 weeks follow up. However, there was a mortality rate of at least 11%.

Conclusion: Traumatic injuries lead to a high mortality rate and carry a large burden to the individual clinically and economically. The implementation of a simple TR was shown to be feasible and has a tremendous value in identifying the epidemiology of traumatic injury, most notably falls and motor vehicle collisions. Advocating for programs that address preventative measures can have remarkable benefits in reducing morbidity and mortality. Furthermore, continued support for TR can evolve with the institution and provide ongoing improvement to quality of care.

Résumé

Introduction : Les blessures traumatiques sont la principale cause de morbidité et de mortalité mondiale, et il existe peu de données dans la littérature pour les pays à revenu faible ou intermédiaire (PRFI), malgré une lente croissance. La Libye a des ressources limitées qui sont mises à rude épreuve par la guerre civile en cours. Le centre médical de Benghazi (CMB) est le seul hôpital public de traumatologie en activité dans la région orientale du pays et les traumatismes sont en augmentation. Actuellement, il n'y a pas de système pour identifier les tendances des blessures traumatiques ni aucune surveillance formelle. L'objectif de cette thèse est de décrire l'épidémiologie des blessures traumatiques et d'identifier les lacunes du système de traumatologie.

Méthodes: Il s'agit d'une étude prospective menée aux urgences du CMB grâce à la mise en place d'un registre électronique des traumatismes, l'application iTrauma. La collecte des données a eu lieu en janvier 2017 sur une période d'essai de 10 jours. À l'arrivée du patient blessé au service des urgences, vingt-cinq points de données ont été collectés et saisis dans iTrauma. Les points de données comprenaient les informations démographiques des patients, le mécanisme de blessure et les résultats cliniques.

Résultats: Au total, 231 patients ont été évalués et inclus dans le registre des traumas. Les hommes étaient plus à risque de blessures traumatiques représentant 68 % des patients blessés. L'âge moyen était de 31 ans, cependant, la majorité appartenaient aux groupes d'âge de 0-10 et de 31-40 ans. Les chutes étaient la cause la plus courante de blessures avec 31 %, suivies de près par les collisions de véhicules à moteur avec 30 %. Aucun des patients blessés lors d'une

collision automobile ne portait de ceinture de sécurité, et la moitié des patients victimes d'une collision de motos portaient un casque. Le type de blessure le plus courant était les fractures osseuses à 13 % et la région anatomique la plus fréquente était les blessures aux extrémités. La grande majorité des patients traumatisés sont arrivés en véhicule privé (57 %), tandis que 20 % sont arrivés en ambulance. En termes de résultat clinique, 36 % des patients ont été soit traités et renvoyés aux urgences, soit sortis après 2 semaines de suivi. Cependant, il y avait un taux de mortalité d'au moins 11 %.

Conclusion: Les blessures traumatiques entraînent un taux de mortalité élevé et représentent un lourd fardeau sur les plans clinique et économique. La mise en place d'un registre des traumas simple s'est avérée faisable et a une valeur considérable dans l'identification de l'épidémiologie des blessures traumatiques, notamment les chutes et les collisions de véhicules à moteur. Le plaidoyer pour des programmes qui traitent des mesures préventives peut avoir des avantages remarquables dans la réduction de la morbidité et de la mortalité. De plus, un soutien continu au registre des traumas peut évoluer avec l’institution et fournir une amélioration continue de la qualité des soins.

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Introduction

Ninety percent of the world's trauma deaths occur in low and middle-income countries (LMICs). (1) The burden of traumatic injury is expected to rise if there is a continued lack of intervention to identify and ameliorate the deficits. According to The Lancet Commission's *Global Surgery 2030* paper, 5 billion people do not have access to safe, affordable surgical and anesthetic care. It is no surprise therefore, that traumatic injury is the leading cause of morbidity, disability and mortality on a global scale. Unfortunately, this affects LMICs disproportionately, whether through lack of access to timely surgery, specialist surgical workforce, or available resources due to catastrophic financial costs incurred on the patient and the healthcare system itself. In contrast to high income countries (HIC), the institution of trauma systems and registries in LMIC has been shown to reduce the mortality in severely injured patients. (2–5)

A registry is a database for documenting any type of datapoint pertaining to a patient visit to a hospital. There are multiple databases found in the literature and covering a variety of data points. Examples include registries documenting dermatological diseases, quality of care, cancer outcomes, traumatic injuries, implantable devices, and many others. Trauma registries, particularly in LMICs, are underutilized and the literature about them is sparse. The level of data that can be integrated into a registry can be basic including patient demographic, mechanism of injury, mode of transportation and in-hospital intervention, (6,7) or more complex like prehospital care, physiological measurements, details of injury and interventions, complications, outcomes. This is not a novel idea and can be traced back to ancient Egyptians documenting soldiers' wounds to help them design better armor and protective gear. However modern implementation of a TR was used as early as 1969 in Cook County Hospital in Chicago Illinois.

(6,8) Although trauma registries were initially meant for quality improvement, once they were integrated with trauma systems studies they also revealed a notable reduction in mortality rate. This integration opened their utility to beyond hospital internal review and expanded trauma registries to a national level providing clinically rich information to help reduce the societal burden of injury. (6)

Libya is an oil rich country that has suffered over four decades of dictatorial leadership. Since the ousting of Colonel Muammar Qaddafi during the 2011 Arab Spring, Libya arguably had the world's fastest shrinking economy and consequently sustained a heavy trauma burden on the health care system.(9) Due to the lack of data, it was impossible to identify deficits and therefore directly affected the country's ability to address the gaps in healthcare. Of the scarce literature pertaining to traumatic injury in Libya, a study of gunshot injuries in Benghazi clearly highlighted the difficult operating conditions and limited resources.(10) The data was simple, spanned over a 12-month period in a single, albeit major, hospital in Benghazi. In this focused registry of gunshot injuries (GSI) the authors were able to correlate the astronomical rise of 46-fold in GSI, compared to a decade's average, to the rapid availability of weapons secondary to the Arab Spring uprising. (10) This registry and subsequent data can be used to appeal to policy and law makers for more stringent gun control in the country. It also highlights the invaluable data that can be extracted from the most basic of registries and have meaningful impact in LMIC.

Although Libya remains an upper middle-income country by definition, it is based on historical oil export data that has now fallen to almost nil. (9) Nevertheless, the implementation of a trauma registry would offer insight into the nature of injuries, treatments applied, and outcomes in order for policy and law makers to institute change and interventions that could ultimately decrease morbidity and mortality, and furthermore decrease the burden of trauma. As such, the aim of this study was to identify trauma trends and characteristics, providing the data to implement targeted change in all areas of preventative medicine.

Literature Review

According to the World Health Organization (WHO) over 15,000 lives worldwide are ended prematurely on a daily basis. Injury deaths, which account for 10% of the world's fatalities, have been steadily increasing, especially motor vehicle collisions, homicide and suicide. (11) It was estimated in 2010 that 16.9 million lives were lost secondary to conditions requiring surgical intervention and 77.2 million disability-adjusted life-years (DALYs) could have been averted through life-saving surgeries. (1) DALYs refer to the years of life lost or lived with disability. However, the paucity of data in LMIC is limiting the identification of injury patterns and therefore addressing them has become a major issue. In Uganda, an orthopedic team, Kisitu et al, noted that musculoskeletal injuries are growing in LMICs with an incidence rate of 2-5 times that of HIC. Musculoskeletal injuries represent an exigent contribution to the burden of chronic injury. (12) Mock et al, highlighted that fatal injuries have taken precedent on the global stage over non-fatal injuries and therefore that data is insufficient, which is a large contributor to DALYs. However, a great deal can be accomplished to further injury prevention with appropriate surveillance. (12–14) Kisitu et al, was able to identify injured patients' demographic, injury cause and timing, injury characteristics and care-seeking behavior, which pertains largely to which hospitals the patients presented at. They were able to conclude that farmers and preschool children are at higher risk of delay to treatment. Kisitu et al suggested effective policy change to improve access to trauma care by engaging community leaders and orthopaedic specialists.

Mock et al, in their review paper *The Global Burden of Musculoskeletal Injuries,* focused on the value of trauma registries in improving knowledge base, improving safety, implementing scientifically proven injury prevention strategies, strengthening prehospital trauma care and strengthening hospital trauma care.

Trauma Registry

A trauma registry is an organized pool of information that can range from a simple to a complex database. It can be used for quality improvement, policy development and clinical outcome research. (2,15–17) As patients are received in hospital, datapoints would include but not limited to: patient demographics, geographical and anatomic site of injury, mechanism of injury, injury characteristics, comorbid conditions, vital signs, admission diagnosis, procedures/treatments incurred, length of hospital stay, outcome and mortality. Moreover, registries vary in datapoints collected and inclusion/exclusion criteria, which tailors to specific outcomes such as the circumstances and environment of the trauma centre that utilize them. There are many examples of national trauma databases and their diverse inclusion criteria; National Trauma Data Bank (NTDB, USA), Trauma Audit and Research Network (TARN, UK), Canadian National Trauma Registry, and Israel National Trauma Registry to mention a few. (2,6) Each of these databases/registries have played an integral role in studying traumas and applying changes to address ways to prevent them.

Additionally, registries can offer an exploration of a hypothesis to identify etiology of injuries and develop systems to prevent them. Beyond identifying and describing traumatic injuries, registries offer a tracking system for ongoing audit of quality of care. For example, information collected from the Quebec Trauma Registry (QTR) elucidated the socio-economic status of the injured being younger, less educated, single and unemployed. Also, from a clinical standpoint the same patients were more severely injured. Costa et al, of Montreal, on the other hand, used the same QTR to illustrate the societal cost of Traumatic Brain Injuries (TBI) of helmeted versus non-helmeted cyclists. The societal cost was double in non-helmeted cyclists. (18,19) Effectively these results helped shape road traffic laws in separating cyclists and motor vehicles, as well as making helmets enforceable by law. (19)

Quality improvement

Examples of the benefits of trauma registries are multifaceted. Dunn et al, of Victoria, Australia raised an important question of whether serious traumatic brain injuries (TBI) in older adults can be safely managed outside of a major trauma centre. By implementing a comparative trauma registry that collected functional outcomes and in-hospital mortality between a Major Trauma Service (MTS) and a Metropolitan Neurosurgical Service (MNS). They concluded no difference in functional outcome 6 months post injury nor a difference in mortality whether the patient presented to MTS or MNS. (20) This valuable result from a simple registry may save patients valuable time in unnecessary travel to a neurological centre given that both mortality and functional outcomes are comparable.

In 1982 and 1984, an audit of San Diego hospitals was conducted before and after the implementation and regionalization of trauma systems. Suboptimal care was reduced from 32% to 4% and preventable deaths were impressively reduced from 13.6% to 2.7%. The simple audit revealed that regionalization of trauma care reduced delays, inadequate care, and preventable deaths secondary to traumatic injury. (21) From a clinico-economic perspective, a study was conducted in 14 states in the United States of America comparing mortality rate in trauma versus non-trauma centres to justify the cost of running an expensive sophisticated trauma centre. The study included 18 hospitals with a level 1 trauma centre versus 51 non-trauma centres. The results revealed a significant decrease in trauma related mortality when comparing trauma to non-trauma centres, 7.6% and 9.5% respectively, and allows the researchers to advocate for a continued support for funding major trauma centres. The study did not compare trauma center levels two to four and it was limited to urban American centres which did not account for rural facilities; however, they were able to identify significant mortality data that applied to the communities studied. Furthermore, they did not perform this study as a deep dive into the dollars and cents that run a major trauma centre, however they were able to extrapolate the clinical value of maintaining and continued advocacy for the cost of an expensive trauma centre. It is an important distinction to be made that trauma registries are tailored to the needs of their community and may reflect results that are only applicable to them. (22,23)

Prehospital care

Generally, the major focus of trauma registries has been on in-patient care. However, 54% of deaths are largely due to poor or lack of prehospital care. In fact it is the single largest contributor to DALYs which disproportionately affects LMIC. (24) The Pan-Asian Trauma Outcomes Study (PATOS) established in 2013 represents the first initiative to tackle an international standardized multicentre registry of injury in Asia in an effort to ameliorate the paucity of data related to prehospital care and effectively improve quality of care. They recognized the deficit in Emergency Medical Services (EMS) due to limited resources, and one of their biggest challenges was the large disparity between Asian countries' trauma management systems. (25) Hence, their goal was to collect large data to improve access and compare prehospital care among the participating Asian countries. It allowed for appropriate scrutinization of prehospital care and to address the disparity.

A successful example was a single-institution pilot retrospective study in Cameroon's Central Hospital of Yaoundé (CHY) aimed to understand the pattern of prehospital care. This revealed that wealthier patients used private transport and were more likely to present to CHY. Poorer patients largely used commercial vehicles rather than an ambulance for transport and 20% of patients ultimately treated at CHY's had inappropriately presented to a lower acuity hospital prior to CHY emergency department. (24) Having two thirds of patients arriving to CHY in a commercial vehicle without a trained first responder showed an increased risk of secondary injury as well. In identifying these deficits in the study findings, policy makers along with prehospital care system designers can advocate for improving field triage and transport/referral to the appropriate trauma centre in a timely fashion. Furthermore, an idea was presented to train commercial vehicle drivers in basic life support as a temporizing measure until EMS arrives or the commercial vehicle arrives at the emergency department.

Lessons were learned from Brazil's simple registry studying forensic data of all deaths secondary to motor vehicle collisions (MVC) in the urban setting. Approximately half of the trauma deaths occurred either at the scene or during transport. They introduced a prehospital trauma system and deaths were studied a year later showing a reduction from 7.1% to 5.9%. (26)

Trauma registries in the prehospital setting have been utilized by the US military in assessing prehospital resuscitation care.(27) Trauma deaths in Afghanistan were studied post-mortem from a Prehospital Trauma Registry from January 2013 to September 2014. As per Tactical Combat Casualty Care guidelines patients were to receive fluid resuscitation, however upon closer inspection it was noted that most casualties did not receive prehospital blood or fluid. Schauer et al, were able to make recommendations to the military of carrying blood products, investing in refrigerators and holding unit commanders accountable. (27) Prehospital care has been shown to be essential in reducing mortality, morbidity and ensuring trauma triage to the appropriate centre. It was integral in the regionalization of trauma systems and trauma registries helped identify these gaps.

Trauma Systems

A trauma system is defined as an organized and coordinated effort in a well-defined geographic area that delivers a full scope of health care to all injured patients. It is comprised of pre-hospital care, acute hospital care and quality assurance. It is a regionalized system that is integrated with local public health and is mostly found in major referral/tertiary centre and they provide support to rural communities.(28–30) These systems are costly and difficult to maintain in a LMIC. The high cost is partially due to resources, staffing and training. West et al. noted the importance of regionalized trauma system in the reduction of mortality by approximately two-thirds simply by transporting patients to a trauma centre versus the closest receiving hospital.(31)

Although LMIC may not have a choice of where to transport the patient let alone the availability of a level 1 trauma centre equivalent, this was identified through simple retrospective trauma registries further recognizing the value of data collection. That being said, LMIC can ameliorate some of these deficits by making small changes to their trauma protocols. A study in California comparing a major trauma centre to 13 rural facilities found no difference in survival outcomes.(32) Multiple comparative studies in the United States In Urbana Illinois, Tulsa Oklahoma and Cooperstown New York noted similar results when they corrected for uncontrollable factors such as inherent differences in patient populations. Changes made included but were not limited to early activation of an organized trauma team with set protocols and standardized trauma orders. (32–35) Clearly minor changes can have a significant impact on survivability in a rural setting, which has been demonstrated with a simple communication by EMS to the receiving facility with basic information on the patient's clinical status, vital signs and mechanism of injury. A low-cost solution with significant results.

Trauma Scoring

In the last several decades there has been an increased use of injury severity measures in prehospital and hospital setting for triage and outcome purposes. The Abbreviated Injury Scale (AIS) measures the severity of an anatomic region's injury and it ranges from 1-6, with 1 being minor and 6 being unsalvageable. Literature shows LMIC mostly use the Injury Severity Score (ISS) that relies on a clinical assessment of the AIS which requires a substantial amount of training that is not readily available in low resource settings. Scoring systems such as the Revised Trauma Score (RTS), Glasgow Coma Scale (GSC), New Injury Severity Score (NISS), Trauma and Injury Severity Score (TRISS), and the Kampala Trauma Score (KTS) all boast various tailored benefits to the clinician. The RTS is a clinical/physiological scoring system that uses the GCS, respiratory rate and systolic blood pressure to determine a score from 0-12, where a low score indicates higher severity. The GCS has three components of assessment: motor, eye and verbal response. Although the RTS is simple, its application in LMIC requires field training in clinical and vitals assessment in the prehospital setting. Other scores like TRISS, which is a combination of RTS and ISS, showed deficiencies in evaluating blunt traumas and has not been commonly used in LMIC trauma registries.

Conversely, the KTS was developed specifically for use in Uganda and was found comparable to data collected in Cameroon, Malawi, South Africa and India. Its data points include age, systolic blood pressure, respiratory rate, neurological status and a score for serious injury. The neurological status is a less comprehensive assessment compared to the GCS and contains four categories: alert, response to verbal stimuli, response to painful stimuli and unresponsive. Furthermore, the score for serious injury is quite simple and defined as such; no injury, one injury and more than one injury.(36–39) A study from Mumbai, India showed a similar performance of KTS compared to RTS in resource limited countries, however, these studies have been limited in scope. (40) As diverse as these severity scores are, they are meant to set a baseline for patient care. LMIC trauma registries that utilize trauma scores need to make an informed decision about which score fits their capabilities and manage acceptable variations in assessor scoring as it can be subjective.

Barriers & benefits of registry

As trauma registries are gaining traction in LMIC, they are not streamlined enough due to various economic barriers. In Australia, the Victoria State Trauma Registry (VSTR) has identified gaps in trauma systems and resulted in a decrease in mortality related to road traffic injuries after implementation. (41) The VSTR evolved into big data for scrutinizing quality improvement and how to improve functional outcomes, however, this is not feasible in LMIC due to cost alone. There will always be limitations to the applicability of trauma registries in LMIC and these challenges differ from county/province to another let alone comparing countries. Trauma registries must be individualized to a facility's capabilities when assessing the applicability of TR. For example, high level traumas that fail to survive and do not reach the hospital are never entered into the registry. This makes it difficult to collect prehospital events/data and as a result underestimating complications and poor data consistency between facilities. (42) Another issue with a lack of consistency in type of data collected can incorrectly show that one hospital provides better care than another. For example, The National Surgical Quality Improvement Program (NSQIP) identified higher complication rates than reported on NTDB. (17) This highlighted NSQIP methodology to be superior in tracking traumatic injuries and reduce related adverse outcomes compared to other TRs. The increased registry sophistication adds another challenging layer for LMIC as it requires increased need for administrative staffing, trainees, technical support and ultimately cost. (17) In the majority of LMIC there is evidence of chronic lack of infrastructure that impedes data tracking and results in complications.

In the PATOS study there are limitations in the design, although their goals are to provide more data that can be used for quality improvement, their inclusion/exclusion criteria can be biased. For example, eligibility criteria were only for patients who used an ambulance, which effectively excludes patients who do not have EMS coverage. Also, PATOS is a voluntary registry and may see participation from well-resourced institutions, therefore may not be an appropriate representation of the entire Asian trauma system. (25)

Another challenge in data collection for a TR is the inability to include patients that arrived intubated. This is especially true for LMIC with limited training and resources to appropriately assess an intubated patient. Their GCS and RTS cannot be calculated due to eyes swollen shut, the use of paralytic for intubation and the intubation itself. The lack of prehospital care and arrival by private vehicle, which is the major mode of transport in LMIC, means that patients arrive without vital signs measured at the site of injury. (43) In instances where there is prehospital care it tends to be limited due to lack of training. Another obstacle was the presence of inadequately trained EMS transporting an intubated patient who is sedated and pharmacologically paralyzed was difficult to appropriately assess their trauma score and GCS. Clearly the challenges are diverse and individually unique to each geographic setting, however, the initiation of simple trauma registries that can evolve with the institution can help define these challenges. Understanding these barriers through the application of a sustainable trauma registry has shown an immense benefit to improve injury surveillance and patient outcomes. While implementing trauma registries in LMIC can be challenging (Bommakanti et al) the benefits of trauma registries outweigh their limitations.

Trauma Registry in Libya

Libya has a population of 6.6 million that is densely populated on the Mediterranean coast. Libya was under dictatorial leadership lead by a military colonel Muammar Qaddafi from 1969-2011 and currently does not have a stable nor a recognized government. Ever since Qaddafi’s military takeover, he almost completely kept the revenue of the country to himself and closest cronies. The country further diminished at the onset of the Arab spring in 2011, catapulting the country into a financial disarray on top of the civil unrest. This resulted in an egregious cost to human life and the center of it is the healthcare system.(43)

The healthcare system has many shortcomings, of which sparse resources is the major influence on quality of care, preparedness, available interventions and surgical outcomes.(44–46) All of these variables are interconnected and the ability to pinpoint the specific gaps in patient care lies, initially, in the implementation of a database or registry. Given Libya's current state, traumatic injury is on the rise and the ability to establish a trauma database may prove to be invaluable in identifying issues from the moment the patient encounter begins, whether in hospital or in the field, to the discharge date and even long-term follow-up.

There is very little data in the literature regarding trauma databases globally and even less, perhaps even non-existent, in Libya. Clinical data is maintained on paper charts and stored in medical records under the department in biostatistics, and death data was collected between police reports, the coroner's office under death certificates and the national death registry. This literature review reveals a handful of studies in Libya exploring traumatic injuries where data was extracted from paper charts without any formal databases. In Tripoli, a published article in 2019 studied the burden of mortality and injury resulting from the Libyan armed conflict between 2012-2017. The data was collected from the National Death Registry combined with collateral questionnaire from family members and witnesses. Daw et al, demonstrated the devastating burden of war on morbidity and mortality. (44,45) Another study utilizing the biostatistics department in Benghazi's major trauma centre, Al-Jalaa Hospital, studied gunshot injuries from the onset of the civil war (2011). It was not clear if the biostatistics department extracted the data from patient charts, medical records or if a formal registry exists within the hospital, the latter being least likely. However, Bodalal et al, identified various data points including age, gender, mechanism of injury, anatomical location and outcome. (10) It was noted that 18–35-year-old males were at highest risk of gunshot injuries and they occurred at the frontlines of the civil war. Bodalal et al, demonstrated, albeit indirectly, that trauma databases are a valuable asset to the improvement of traumatic injury outcomes by simply identifying the problem.

A study attempting to identify the etiology of maxillofacial fractures also relied on a retrospective review of medical records.(47) It was conducted in Tripoli's Ali Omar Askar Neurosurgery University Hospital which has a catchment area of 1.6 million and considered a tertiary referral centre. They concluded that the most common cause of injury was motor vehicle accidents, which have tripled from 2010 to 2012, with assault as a distant second etiology. (47) Due to its retrospective nature, they were unable to identify if patients were wearing seatbelts, whether airbags were deployed, nor any prehospital information to aid in changing policy-making. With the beneficial operationalizing of TR in the developed world, it would be of great benefit to pilot one in a developing country with deficiencies in basic resources such as Libya. Therefore, our research project will offer health care providers, legislators and community organizers with ways to improve health care and access to it.

Methods

Study Setting

A Trauma Registry was used to audit all traumatic injuries encountered in Benghazi Medical Center's (BMC) emergency department. BMC is a 1200 bed hospital in Benghazi, Libya, the second largest city in the country, the largest in the east, and serves a catchment area of greater than a third of the country's population. Traditionally, the major trauma centre in Benghazi was Al-Jalaa Hospital in the eastern part of the country, however due to the civil unrest BMC has become the de facto public trauma hospital. Furthermore, BMC became the only tertiary/referral centre in the east and covering part of western Egypt and as far south to the Chad border. Benghazi's health care system is two-tiered with BMC being a public teaching hospital affiliated with Benghazi University School of Medicine. It has all surgical and medical specialties with exceptions to high level endovascular surgery. The political turmoil causing geographical lockdown makes this hospital an ideal centre to capture all incoming traumas into the registry that will also be representative of the population.

The emergency department is composed of several small rooms that have an inconsistent number of beds. That is mainly due to the scarcity of mattresses to accompany the frames of beds. It is operated by emergency physicians, residents and nurses on a 24-hour basis. Patient records are purely in paper form and notes are written infrequently.

iTrauma Registry

Developed by the Centre for Global Surgery at McGill University, a 25 data point electronic trauma registry. It uses an iPhone interface operated by a Postgraduate Year – 5 (PGY-5) neurosurgery resident at BMC. The resident was trained to use both the smart phone and paper format, along with an electronic guide of how to submit both formats of data. In case of technical failure, data may be collected in paper form (see figure 1). This allows for direct data upload into the iTrauma app, and for registry extraction and analysis at a later time.

Data points are divided into 4 categories; patient demographic, mechanism of injury, characteristics of injury and clinical outcome. Patient demographics includes age, gender, level of education, occupation, co-morbidities, mode of arrival, geographical location where injury occurred and whether the patient was transferred from another facility (see figure 2). Mechanism of injury included cause of injury, intent, geographical setting and substances used (see figure 3). If motor vehicle collision was the primary cause of traumatic presentation then further data points for seat belts, helmets and whether the vehicle is private, public or commercial were collected. The injury section calculates the KTS and other anatomical injuries (see figure 4). Injury data can be further delineated into vital signs and neurological status. Finally, the outcome portion is simplified into resuscitative interventions (airway, breathing, circulation) and outcome from within the ER and at two weeks follow up on whether the patient was discharged, admitted or expired (see figure 5).

CENTRE FOR GLOBAL SURGERY
McGill University Health Centre

Adult Trauma Registry
Data Collection Form

Transferred from other hosp.
- ○ Yes
- ○ No

If yes, which one?

Date & time of trauma / / :

Date & time of arrival / / :

Attended by Dr. / / :

Patient's Identification Number

Origin of patient (suburb, locality, district, area)

Region

District

Place of injury (suburb, locality, district, area)

Region

District

Patient demographic data

Age

Sex
- ○ Male
- ○ Female

Patient's Occupation
- ○ Child or student
- ○ Employed: Manual labourer
- ○ Employed: Office Work
- ○ Employed: Police/Army/Security
- ○ Employed: Farmer
- ○ Employed: Mining
- ○ Employed: Other
- ○ Unemployed
- ○ Retired

Education Level
- ○ Child
- ○ Primary
- ○ Secondary
- ○ College/University

Mode of arrival
- ○ By foot
- ○ Ambulance
- ○ Police
- ○ Private vehicle

Mechanism

Cause of Injury
- ○ Motor Vehicle Collision
- ○ Fall
- ○ Blunt Assault
- ○ Stab/Cut
- ○ Gunshot
- ○ Blast/Landmine
- ○ Burn
- ○ Drowning
- ○ Bite
  - -Human ☐
  - -Animal ☐
- ○ Crush

Settings
- ○ Transportation Accident
- ○ Work
- ○ Home
- ○ School
- ○ Leisure/Sport

Intent
- ○ Unintentional
- ○ Self-inflicted
- ○ Assault

Alcohol
- ○ No
- ○ Suspected/Confirmed
- ○ Unknown

Road Traffic Incident

Type of Vehicule
- ○ Car
- ○ Motorbike
- ○ Tricycle/Bicycle
- ○ Bus
- ○ Truck

Sector
- ○ Private Vehicle
- ○ Public Transit
- ○ Commercial Vehicle

Role on the road
- ○ Driver
- ○ Passenger
- ○ Pedestrian

Helmet Use
- ○ Yes
- ○ No

Seatbelt Use
- ○ Yes
- ○ No

Injuries

Arterial Pressure
- ○ >89mmHg
- ○ 50-89 mmHg
- ○ < 50 mmHg
- ○ Not detectable

Respiratory Rate
- ○ 10-29 /minute
- ○ 30+ /minute
- ○ ≤ 9/minute

Neurological Status
- ○ Alert
- ○ Responds to verbal stimuli
- ○ Responds to painful stimuli
- ○ Unresponsive

Serious Injuries
- ○ None
- ○ One serious injury
- ○ More than one serious injury

Open |Closed
- ☐ ☐ Facial fracture
- ☐ ☐ Fracture spine no paralysis
- ☐ ☐ Fracture spine with paralysis
- ☐ ☐ Fracture upper extremity
- ☐ ☐ Pelvic fracture
- ☐ ☐ Fracture lower extremity
- ☐ ☐ Skull fracture
- ☐ Head injury
- ☐ Neck injury
- ☐ Thoracic injury
- ☐ Abdominal injury
- ☐ Cut/Open wound
- ☐ Sprain/Strain
- ☐ Dislocation upper extremity
- ☐ Dislocation lower extremity
- ☐ Burn

Outcome

Outcome from casualty department
- ○ Treated and sent home
- ○ Admitted to hospital ward
- ○ Taken to operating theatre
- ○ Admitted to intensive care
- ○ Died
- ○ Referred to another hospital

If referred, which hospital?

Outcome filed by (MD, nurse, clerk)

Filled by

Signature

Figure 1 Adult Trauma Registry

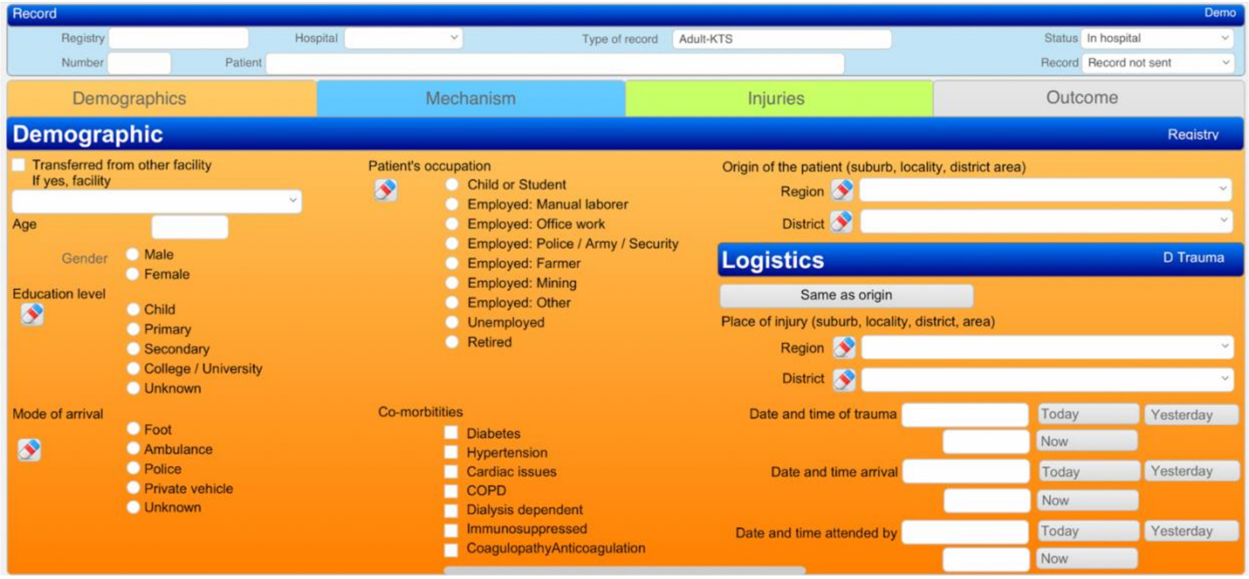

Figure 2 Demographic panel

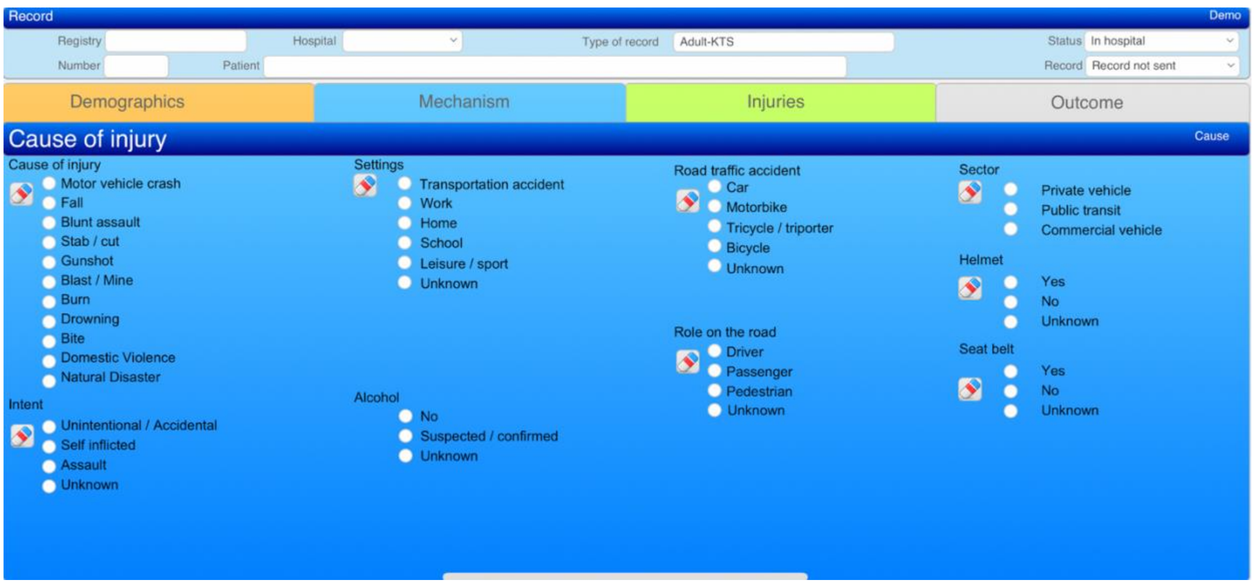

Figure 3 Mechanism of injury panel

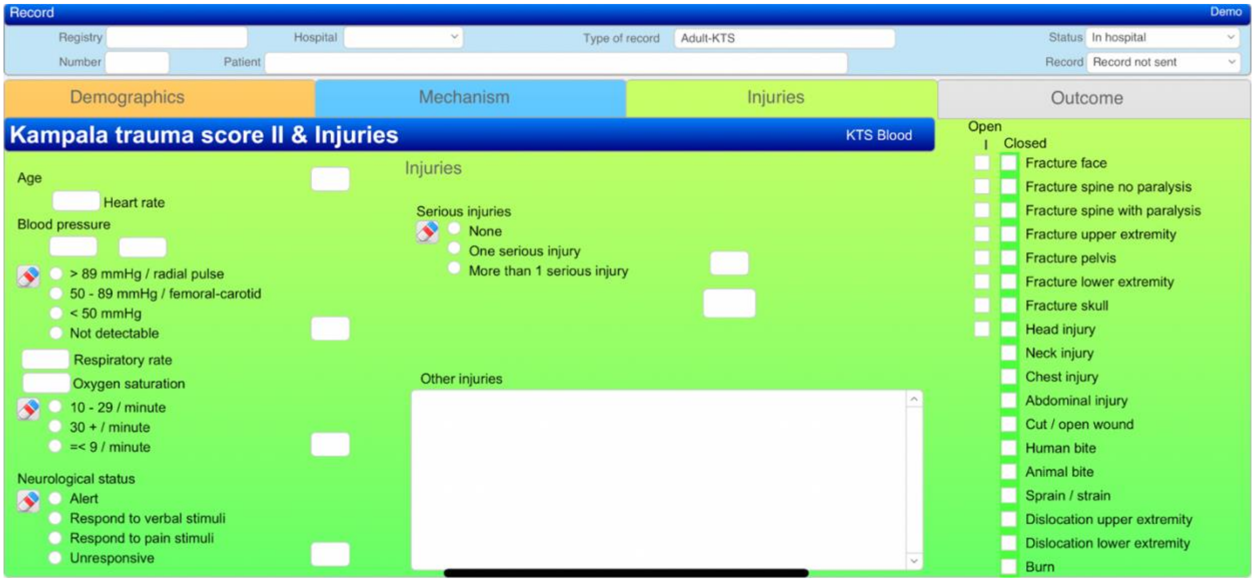

Figure 4 Kampala Trauma Score and injuries panel

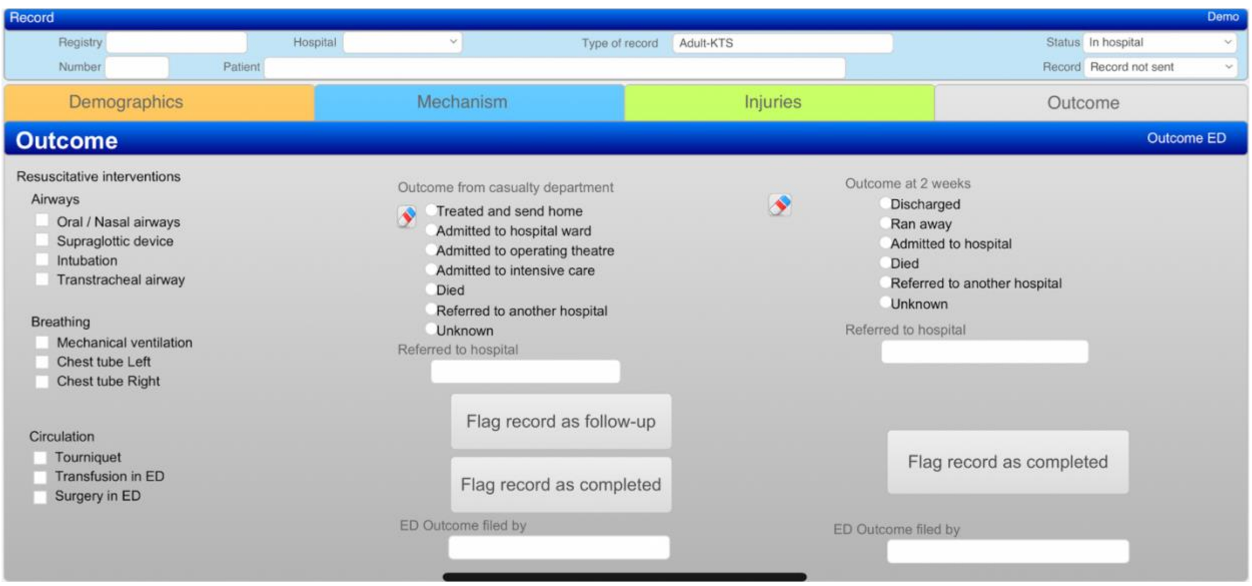

Figure 5 Outcome panel

Inclusion criteria

Patients in the registry included any traumatic presentation to the emergency department of BMC. There were no particular exclusion criteria aside from mild traumatic and non-traumatic injury patients. This was based on an agreement with ER staff contacting the neurosurgery resident to view the chart and enter the data upon triaging of new patients in the ER. Registry data collection took place over a course of a 10 day on-call schedule during the month of January 2017. Finally, data is exported from iTrauma in an excel sheet. It will serve as the principle tool for the detailed systematic audit of quality of patient care for a 10-day trial period in BMC.

Data analysis

Data was extracted onto a Microsoft Excel and analyzed for trends across available variables. Data points were also cross referenced, and a comparative analysis was conducted between datasets in qualitative and quantitative forms. Qualitative data was further analyzed with Nvivo® for frequency of key words when analyzing typed-in information that was added outside of the available options in iTrauma.

Ethics approval

This study was approved by Benghazi Medical Centre administration and the department of biostatistics.

Results

Patient Demographic

A total of 231 traumatic injuries were collected over the course of 10 days. Gender distribution was unsurprisingly male dominant at 68% versus 33% female (see figure 6). The average age of a trauma patient was 31 years old with the mode age being 30 (see figure 7). The youngest patient was one year old and the oldest 92 years old. Age distribution trends reveal the most affected group is between 35-59 years of age when divided into three age groups. However, plotting a bar graph with age groups every 10 years shows ages 0-10 are at highest risk for trauma.

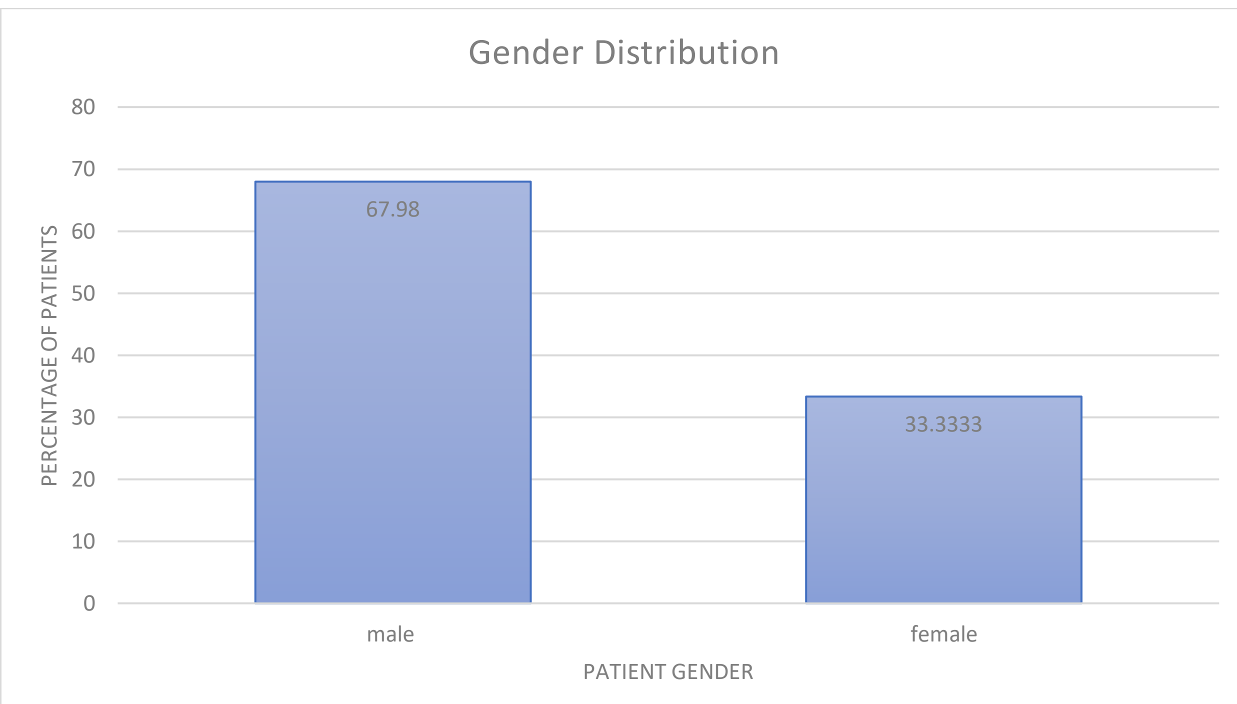

Figure 6 Gender distribution of injured patients

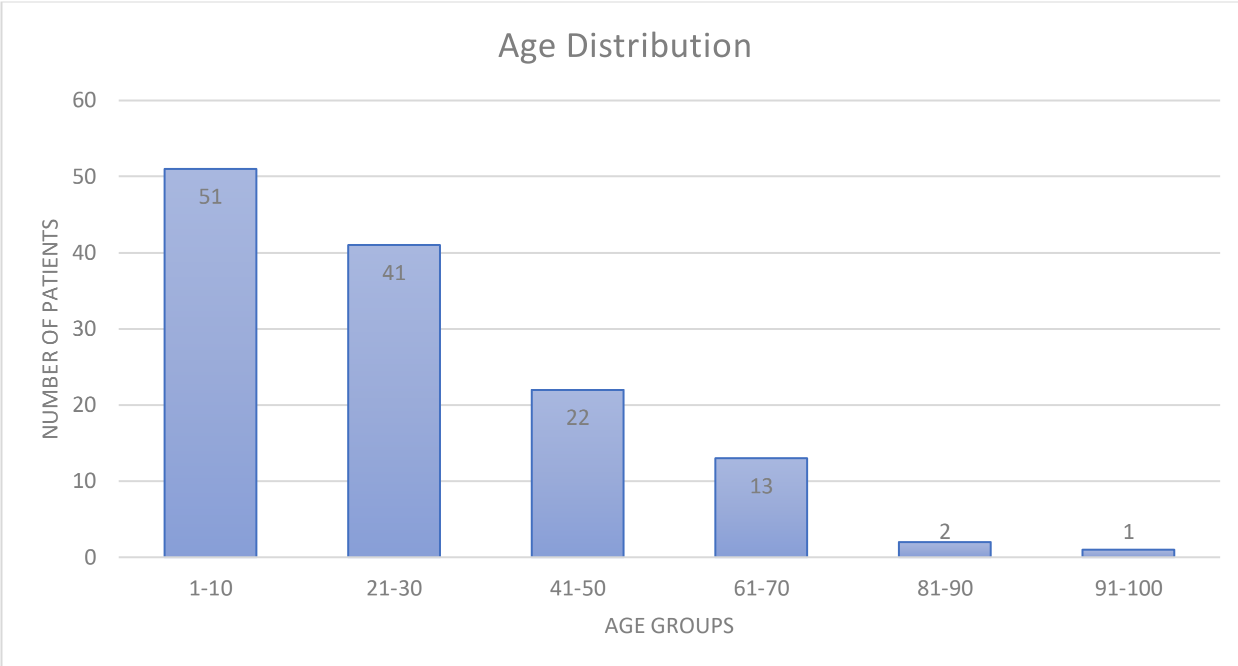

Figure 7 Age distribution

One hundred and fifty-five patients' employment demographics were collected out of the total 231. The majority of them were identified as Child/student in the iTrauma tool. They accounted for 32% of all traumas. Followed by unemployed (23%), other (10%) and office worker (10%) (see figure 8). The remaining categories including; farmer, police/army/security, manual labor and retirees accounted for less than 7% each.

In terms of level of education, 32% have a primary level of education and 25% have a secondary level (see figure 9). Twelve percent (12%) of patients with traumatic injury have a university or college degree. A significant number of patient's education level was not captured and amounts to 17%.

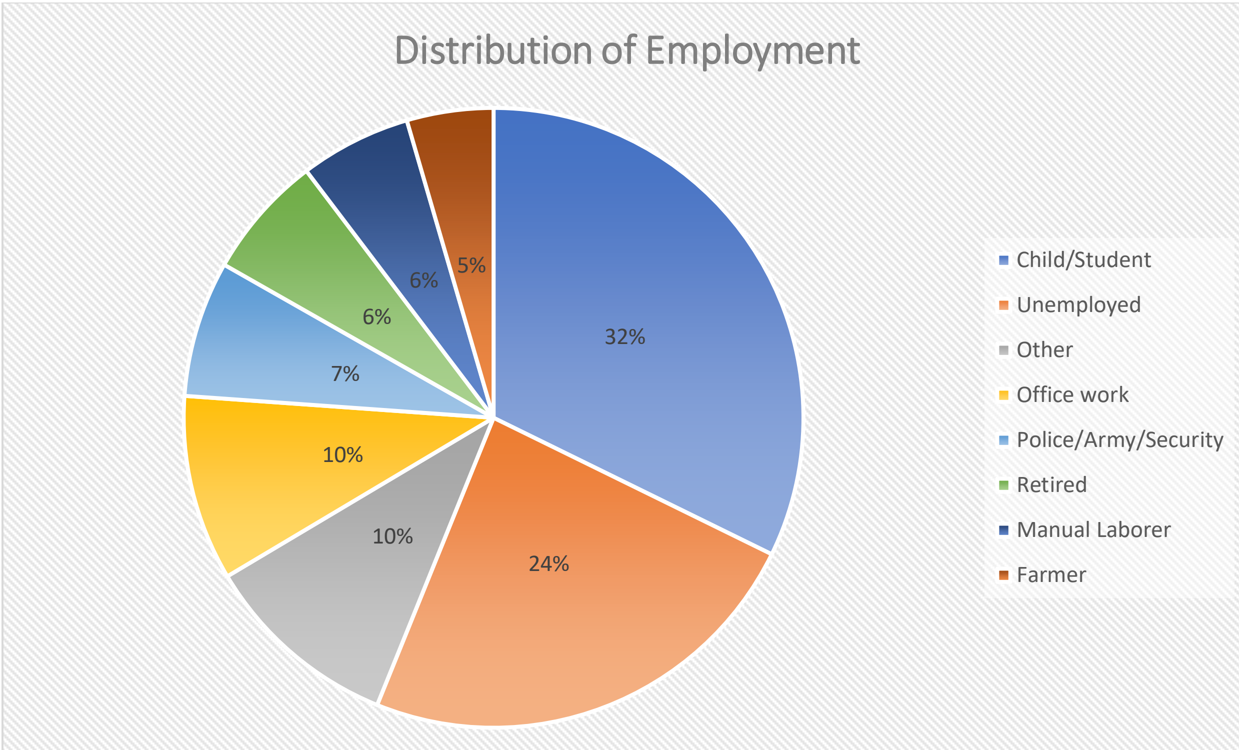

Figure 8 Distribution of employment

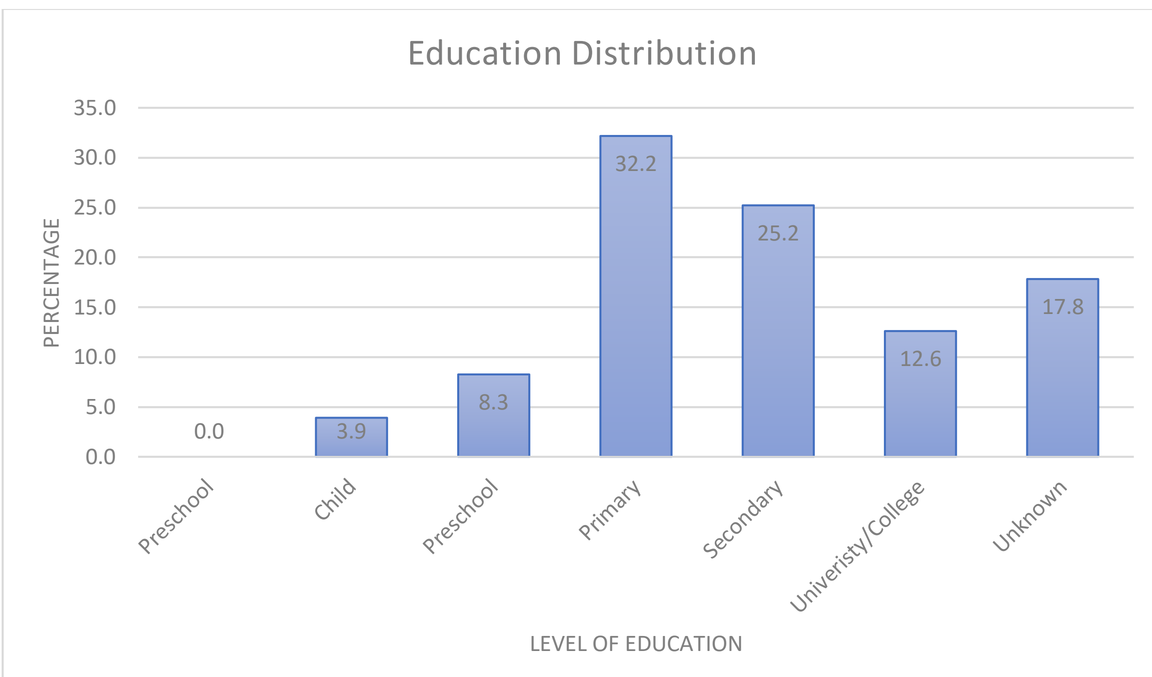

Figure 9 Education Distribution

Mode of Transportation

57% of patients presented to the emergency department by private vehicle (see figure 10). There were no further characteristics recorded as to the relationship of the patient to the owner of respective mode of transport (private, public or commercial). There were 20% of trauma patients that had no data recording of their mode of arrival. These particular patients were either direct to ICU, multi-trauma, died in the ER or potentially transferred from another facility. Another 20% were transferred by ambulance, 3% by foot and 1% by police escort. The geographical location from which patients arrived was not recorded at all and the time stamp generated from iTrauma was frequently erroneous.

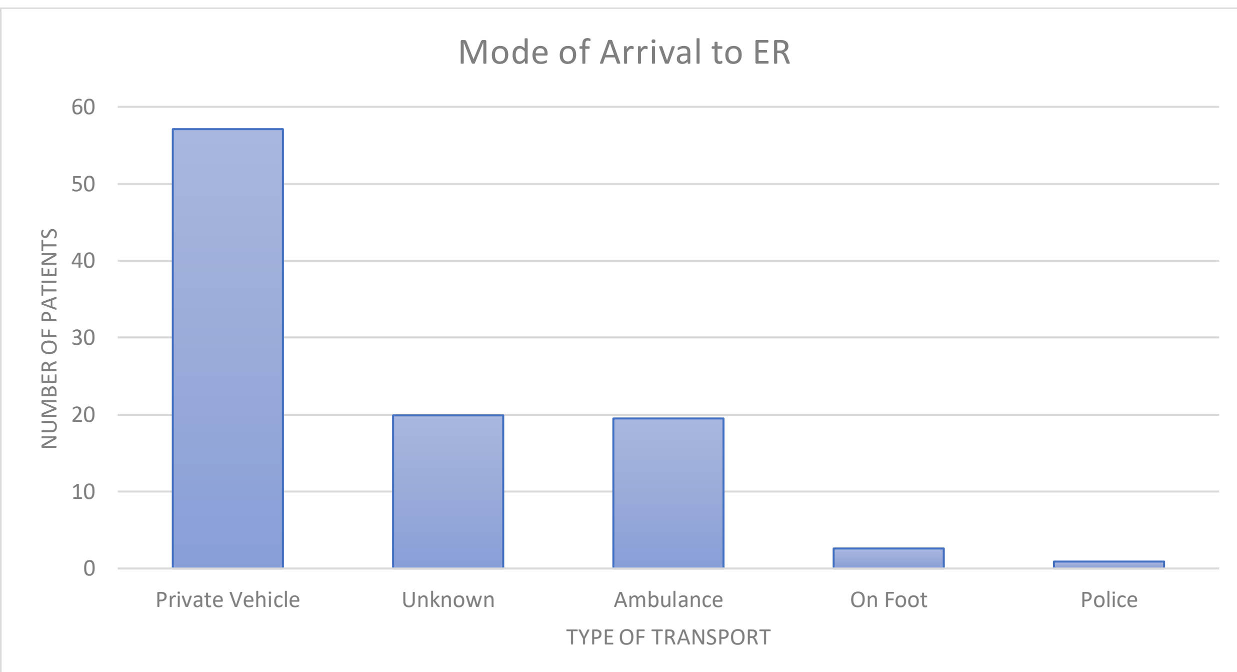

Figure 10 Mode of arrival to the emergency room

In terms of intoxication by alcohol or illicit drug use; 73% of patients denied any intake, 15% were suspected or confirmed by laboratory findings and 12% are unknown due to either declining the exam or never being done at all.

Characteristic and causes of injury

The cause of injuries was recorded in 201 out of 231 patients which is an 87% data collection completion. The most common cause of injury was from falls at 31% and followed very closely by motor vehicle collisions at 30% (see figure 11). Blunt assault (14%), gunshot (7%), blasts from land mine explosions (7%), stab or penetrating wound (5%) and burn injuries (5%) complete the total trauma recorded. Domestic violence and animal bites are represented in 3 % and 2% cases respectively. In comparing traumatic injuries on a gender distribution, it is noted that males predominantly have a higher predilection for traumatic injury. Falls have been shown to affect males and females relatively equally.

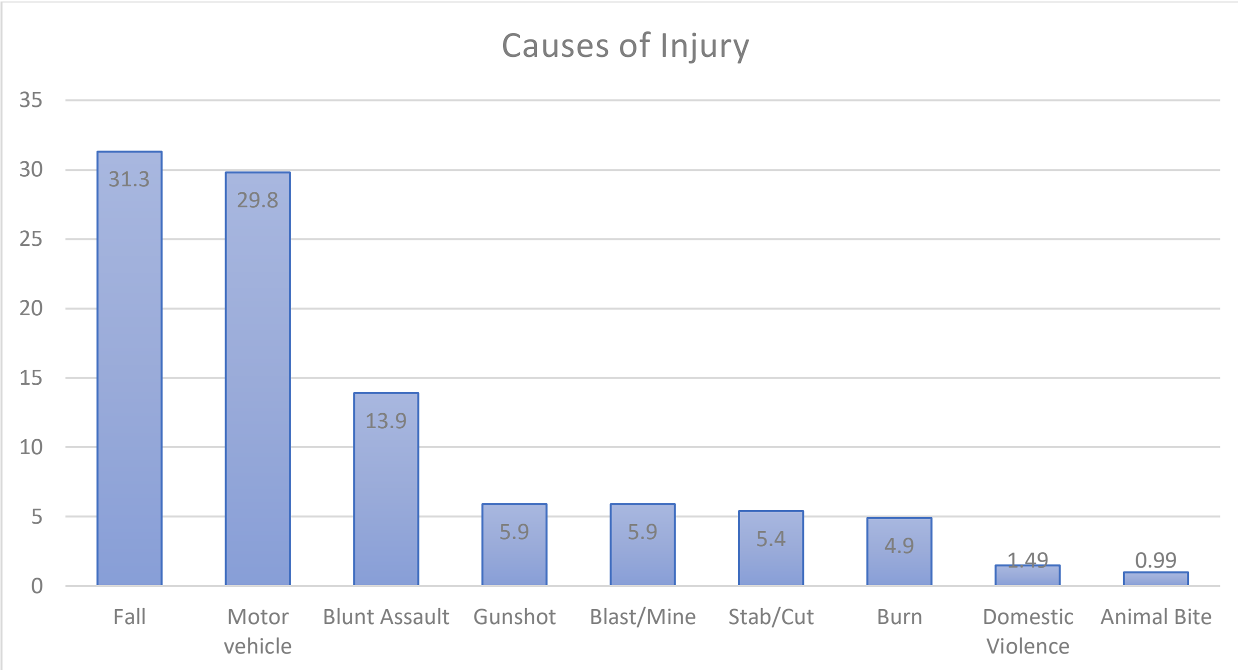

Figure 11 Cause of injury

On the Age-Gender distribution bar graph patients below age 10 are most affected with males at higher risk (see figure 12). The most common cause of trauma in the same age group is falls (40% injured children from falls within the age group), while 31-40-year-olds are mostly injured in motor vehicle collisions (35% within the age group).

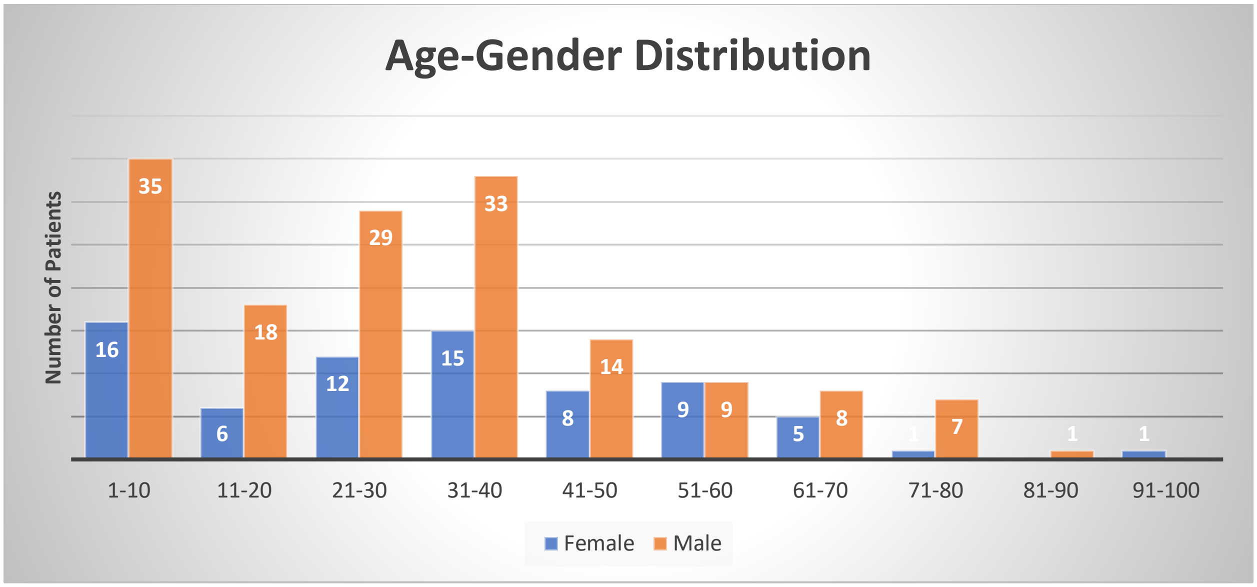

Figure 12 Age-Gender distribution

Upon plotting the cause of injury on a distribution of age groups (see figure 13) it is noted that falls and blunt assault disproportionately affects children 0-10 years of age. Surprisingly, 0-10 is also the second highest affected group by blasts/mine explosions and the most affected by burn injuries. Patients under the age of 40 make up the bulk of the top two causes of injury; motor vehicle collisions and falls.

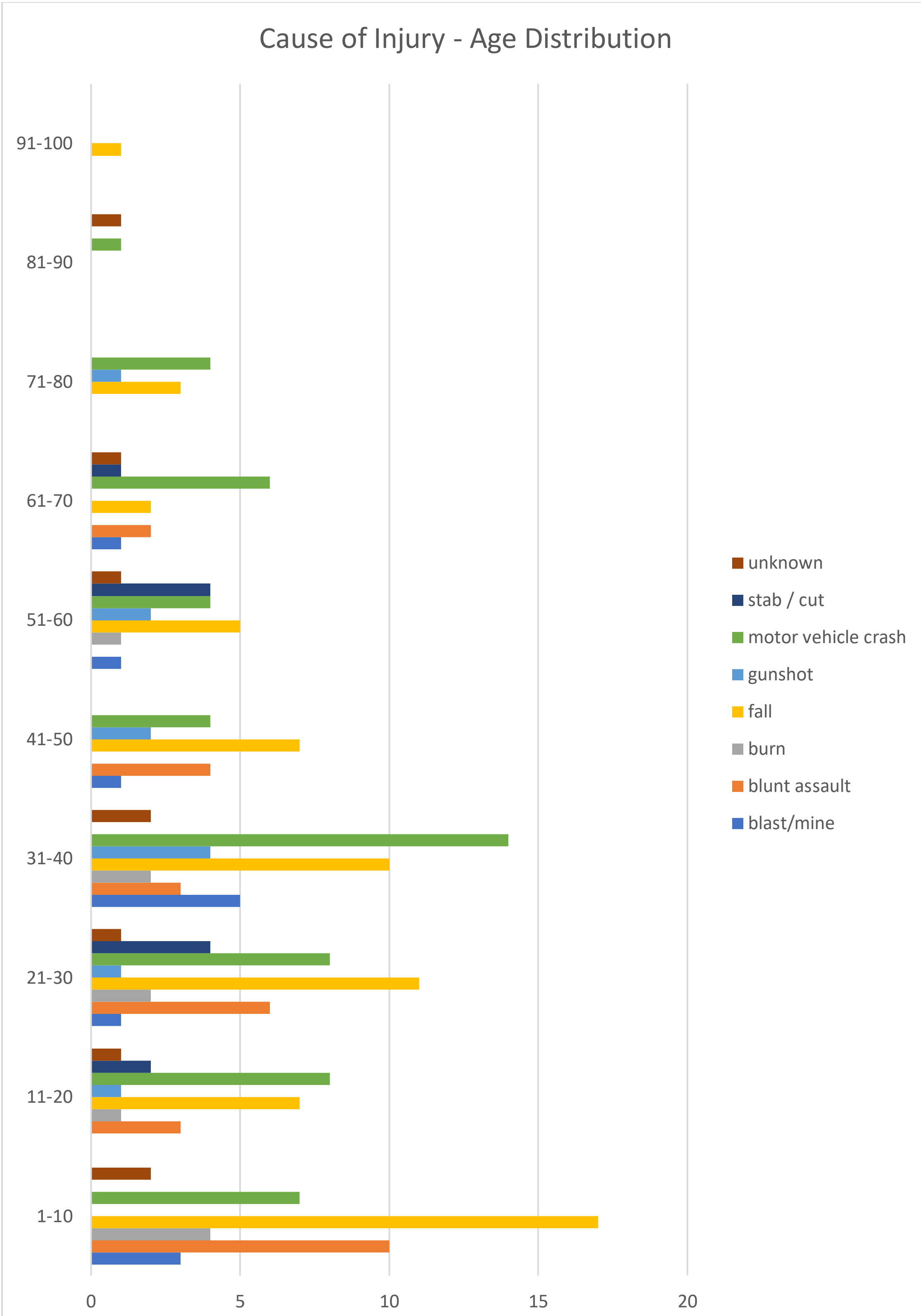

Figure 13 Cause of injury-age distribution

Types of Vehicles

In comparing motor vehicle collisions 90% of traumas were caused by cars and 8% by motorbikes. 41 out of the 43 patients involved motor vehicle collisions did not wear seatbelts. There were only four recorded motorbike collisions and half of them wore helmets. Again, the remaining 2% percent of patients were not recorded. Nine patients accounting for 23% of the total injured in motor vehicle collisions died and one was admitted to the ICU and lost to follow up beyond the data collection dates. The remainder of patients were either treated and discharged or admitted for a short length of time then discharged. There were no recordings of public transport as the infrastructure nor the service exist in Libya. All paid transport services are private vehicles used at the owner’s discretion without any regulatory body or corporate ownership.

Types of Injuries

The 231 trauma patients had at least 436 distinct injuries. Some presented with complex polytrauma, and the majority presented with more than one anatomical injury per patient. Fractures were the most common type of injury amounting to 13% and upper/lower extremities were the most affected anatomical location (see table 1). Chest injuries accounted for 3.92% and affected 26 of the 231 patients which was equal in injury frequency to stabbings or cut related injuries and open wounds. There were various other injuries which includes: neck injuries, burns, abdominal, spine with and without paralysis, pelvic, dislocations and animal bite related injuries. Each of the aforementioned injury frequency ranged between 0.75% – 3% individually.

Table 1 Injury Characteristics

Injury	Frequency	Percentage
Fractures	84	13
Extremity injury	82	12.37
Chest injury	26	3.92
Stab/cut	26	3.92
Open wound	26	3.92
Neck Injury	19	2.87
Burn injury	15	2.26
Abdominal injury	13	1.96
Spine injury with paralysis	13	1.96
Pelvic injury	10	1.51
Dislocation injury	8	1.21
Animal bite	5	0.75

Only 93 observations were collected pertaining injury setting. 35 occurred at home, 22 during some form of transportation, 15 during a leisurely activity or a sporting event, 2 work related, 2 in school and 17 were unknown. It is difficult to ascertain the reason for lack of data in the remaining 138 patients. Injuries were almost exclusively unintentional with the few exceptions of assault.

Outcome

The majority of patients were either treated and sent home from the ER or discharged by the 2 weeks follow up (see figure 14). Albeit 153 of the 231 patients had recorded outcomes and of those 36 were discharged from the ER, 9 admitted to the hospital and 48 discharged after a short admission. 26 patients died either in the ER, ICU or on the ward, 5 absconded and 28 were lost to follow up.

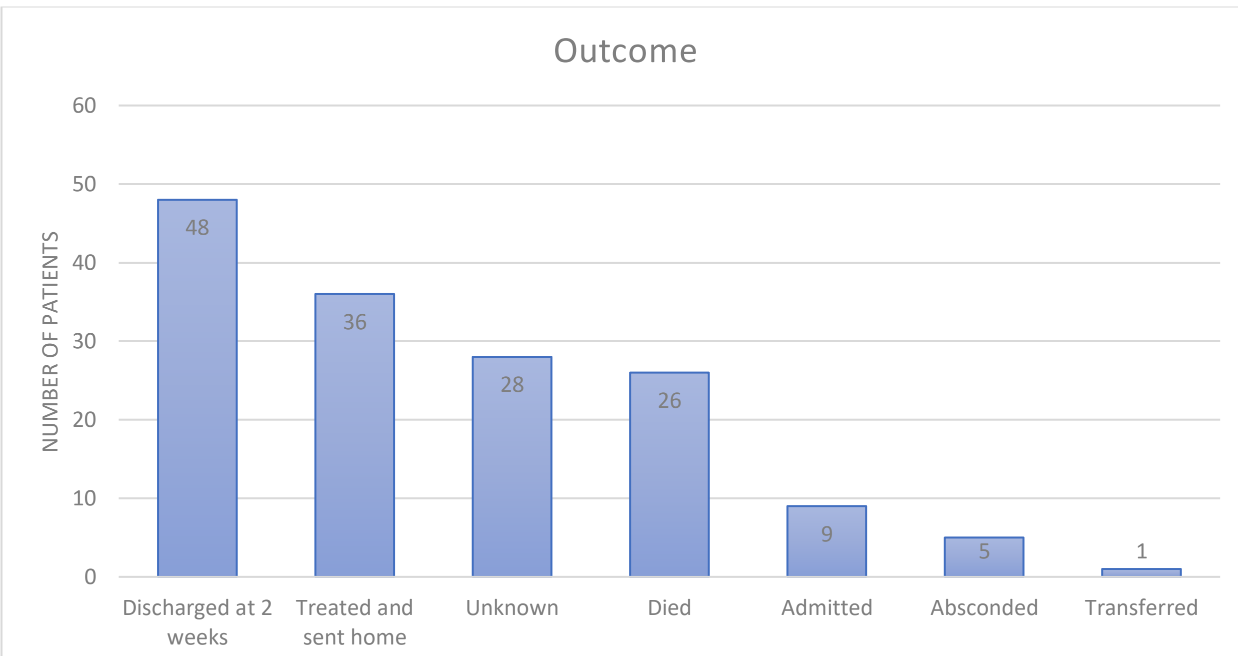

Figure 14 Clinical outcome

There is copious data in the iTrauma app that was not sufficient in each category to be analyzed. The Kampala Trauma Score (KTS) was a large part of that missing data, which includes systolic pressure, respiratory rate, neurologic status and the number of injuries. This was an obstacle in concluding with an objective and verified trauma score.

Discussion

Benghazi Medical Centre is the largest hospital in eastern Libya, possibly the entire country. It has become the de facto major trauma centre due to an ongoing civil war. This war effectively shut down many geographical zones and one of the red zoned war sites lies Al-Jalaa Hospital, a level one trauma centre. Hence BMC was chosen as an ideal location and the only available public hospital to implement a trauma registry.

Our study is the first and only prospective study in Libya that covers all traumas coming into the emergency department. There has been less than a handful of retrospective studies and none of them are prospective, reviewing the impact of war on traumatic presentation in the emergency department. Literature review revealed a few infectious disease studies that benefited from a registry design, however, no data pool can be found and rather they drew from old charts for the specific purpose of their hypothesis. (10,44–50)

The findings from this study show the feasibility of implementation of a trauma registry, the wealth of data collected, the value in identifying population trauma trends, the etiology and ultimately insight into prevention. The data shows that males have a higher risk of traumatic injury than females. This was illustrated in figure 6 where males composed 66% of trauma versus 33% of females. That is more than double the risk. This could be due to the patriarchal culture and traditions in Libya. Males tend to be the “bread winners” and physical laborers, who generally have a higher predilection for traumatic injuries. Interestingly, patients with primary and secondary school level education comprised the majority of poor outcomes. They represented 62% of mortality relating to traumatic injury. Although there is a correlation between increased trauma and low socioeconomic status, Libya has a high literacy rates in both genders at 99.6%. The country's education level is almost evenly distributed on primary, secondary and tertiary levels of education.(43,51) Students were most commonly affected followed by unemployed patients which is consistent with global trends. (52–54) There is a clear correlation here between education level and increased risk of injury, which is difficult to address by attempting to encourage a higher enrolment in schools. Nevertheless, education is key in mitigating traumatic injury risk. Furthermore, unemployment is associated with increased injury as well. Libya has an 18% unemployment rate (55) and perhaps investing in local job creation would ameliorate the burden of trauma in unemployed populations. Perhaps an oversimplified approach to a complex matter, however, unemployment and low level of education have been identified globally as a risk factor to traumatic injury, poor clinical outcomes and lower DALYs.

The average age was 31 years old and age groups of 0-10 are at highest risk of trauma. Therefore, the youngest and the bulk of the work force in Benghazi is suffering from a substantial decrease in DALYs.(10,44,45) Additionally, the youngest and lowest socioeconomic status bear the worst outcome. This result accentuates the importance of education to improve outcome for poorer populations. For example, age group 0-10 suffer most from falls. Perhaps better social supports and programming for parents to prevent or reduce falls in children.

The age-gender distribution further confirms increased risk for males and a downward trend in injuries with increased age for both genders. Females show highest peaks in ages less than 10 followed by 31-40 years of age. That again can be explained by social norms where prepubescent females play and venture outdoors freely, then become restricted by culture to stay indoors unless they are attending school or visiting friends and family or married with children. Again, it can be extrapolated that in the 31-40 years of age females are out more in the community as they become a larger part of the work force and hence a second peak in traumatic injury. Young males have a higher propensity for risky behaviour, the young male syndrome, leading to greater risk of injury and more severe morbidity and mortality. (56)

The mode of arrival to the emergency department has been predominantly by private vehicle at 57%. Ambulances were used in 20% of cases. There are very limited emergency medical vehicles in the facility and they mostly operate as a taxi service with limited, if any, prehospital care capabilities. Another challenge is geographical. Benghazi is a large city of at least 700,000 and is not built on a grid pattern but rather chaotic winding roads, not dissimilar to London's maze of streets. Also, there are no street names or house numbers and hence directions rely purely on landmarks. This is an inferred observation pertaining to geographical navigation; however, transporters of injured patients have a firm belief that they will arrive faster to a hospital as opposed to explaining directions to EMS. Moreover, there is a significant number of unknown modes of arrival that amounts to 20% of recorded trauma patients. There are various variables that interfered with transport data collection and some of which include the unconscious/unresponsive patient, missing data at time of arrival and failure to ask patients as a data collector. Some low-cost solutions include hiring a dedicated dispatcher and advertising locally for an emergency service number can improve prehospital services and consequently patient outcomes. Although training paramedics may not be considered a low-cost solution, the financial cost of severe trauma on a public health system can be higher. Prehospital care provided by appropriately trained paramedics can reduce fatal outcomes and in effect reduce cost of care. (26,57,58) This is however a general statement and more studies pertaining to prehospital care and clinical outcomes are needed to make this correlation clearer.

Falls were the most common cause of injury and predominantly affected ages 0-10. Libya does not have a local nor national database to compare national trends, and hence this is assumed to be representative of at least Benghazi's population. Although the nature of the fall in itself is unknown, the majority occurred at home. The results from our registry is consistent with other studies from the United States, India and Turkey. (59–64) The level of supervision for the children included in the study is also unknown and would be interesting to investigate whether injuries occurred due to negligence, lack of supervision or parental abuse. For injuries that occurred outside of the home could be attributed to accidental falls, whether from own height, an elevation, bicycle or horseplay. Remarkably, only 9% of patients over 60 years of age presented with falls. This results was not consistent with global trends of falls in the elderly. (65–68) This discrepancy in lower fall rates relative to the rest of the world could be attributed to the civil war forcing elderly populations to stay indoors and cultural norms for multigenerational homes. This could represent a protective factor for traumatic injury in the elderly population. It should be noted that the data was collected over a course of ten non-consecutive days and although it offers great insight into traumatic injury, it does have a limitation to generalize or represent Benghazi's population.

One hundred and sixty-seven (72%) of total traumas affected ages under 50, again further demonstrating that the young and healthy are at highest risk for traumatic injury. This could mean that a young population with a higher life expectancy could live with reduced quality of life or lifetime disability depending on the severity of their trauma. This is merely speculative as this study did not record disability outcome nor a long term follow up. Motor vehicle collisions (MVCs) were a close second at 30% of all traumas and amongst traffic injuries 90% were cars. The data thus far is consistent with global trends, in that falls and MVCs top the most common causes of injury, albeit globally MVCs are the most common cause followed by falls. (69–72) Furthermore, 100% of patients in MVCs involving cars did not wear a seatbelt. In contrast, motorbike collisions accounted for only 9% of MVCs and half of the patients wore helmets. Libya's traffic laws do not include an enforceable seatbelt nor helmet laws. The data shows a very clear and stark prevalence of MVCs' 26% mortality rate when seatbelts are not worn. It is known that seatbelts reduce morbidity and mortality, and 50-80% of all deaths could be prevented by seatbelts. Considering that MVCs are a leading cause of death, killing more than 1.2 million worldwide and disabling more than 50 million patients, it is prudent to address seatbelt enforcement to policy and law makers. (73–76) Other countries have found success in reducing fatalities by implementing a public awareness campaign and enforcing punitive fines on seatbelts and helmets. (18,19,74,77,78)

Injury characteristics were quite diverse, and the majority of patients presented with more than one anatomical injury. Fractures, of any anatomical region, were the most common presenting injury at 13% and animal bites were the least common at 0.75%. Head injuries were the most injured anatomical region in all traumatic presentations. This could be attributed to a selection bias from the emergency department as they page the data collector, a neurosurgery resident in this case, to assess the head trauma.

Only 66% of patient outcomes were collected. Outcomes were collected at two different times; in the emergency department and again at 2 weeks. 36 patients were treated and discharged home from the emergency department with minor injuries and 48 were discharged within 2 weeks of follow up. Although these numbers reflect that the majority were amenable to discharge, we do not know the severity of their disability.

Study limitations

The implementation of a trauma registry in Libya has inherent challenges. A single healthcare provider was able to collect an impressive wealth of data in 10 short days, however, the volume collected is not representative of the hospital daily traumatic presentations. This could be perceived that the vast majority of traumas are simple and treatable without complications. However, this data was collected over ten days that spanned over a month. Also, the neurosurgery resident would have spent a significant amount of his time in the operating room (OR) or on the ward, missing the traumas that would have presented to the ER, admitted, expired or sent home. That could also mean that whilst he was in the OR, higher acuity traumas were managed quickly, and staff could not wait for the trauma registry resident or did not alert him. Also, not all ER staff were willing to page the resident for data collection leading to further loss of data capture. Another challenge is presented in the form of private hospitals which have the reputation of better care, while in reality they have similar resources. Traumas could have been missed by presenting there instead of BMC. Furthermore, severe traumas leading to deaths in the prehospital setting were not captured. A few ways to ameliorate poor data capture is recruiting more staff. Perhaps a joint effort between nursing and physicians to complete one patient. For example, a triage nurse may enter demographics and vital signs upon initial assessment, the ER physician enters the clinical data, and the most responsible physician may enter interventions and outcomes. A solution that requires a multidisciplinary approach, is low-cost, practical and easy to implement. Again, it is important to recognize that this study offered a 10-day snapshot of traumatic injury at BMC and can be difficult to infer that these trends are consistent nation-wide. However, these days were non-consecutive, included weekdays and weekends, it occurred during the month of January and schools were active. It is fair to infer that it can very well be representative of a winter month of the year.

Other large challenges were faced using the software itself. The iTrauma was only compatible with iPhone Operating System (iOS) and the vast majority of physicians used android operated devices. An iPad was initially supplied to them, however, that was far too appealing for theft and hence went missing along with its data in the initial pilot stages. A far less luxurious old iPhone 5 was supplied; however, the screen was 4 inches in size and very cumbersome to collect data. In the end the iPhone 5 survived the entire study. The software requires major tweaks as the data could not be remotely uploaded nor could the iPhone be tethered to a computer and have the data extracted. That is due to the rigid iOS compatibilities that would not allow for more than one computer to be associated with each iPhone device. These challenges were overcome with a data dump that required an inordinate amount of time to clean up and come up with meaningful data.

Conclusion

Our trauma registry was able to capture the epidemiology of injury in Benghazi Medical Centre for the first time and offered insight into potential preventative measures. We clearly illustrated the feasibility of a trauma registry implementation. Given the inherent challenges, there is an evident need for ongoing incorporation of this registry to continue to identify gaps in care. This will require efforts from health care professionals and law makes to improve clinical outcomes for the community in Benghazi. High quality data can ultimately reduce morbidity and mortality, as well as generate data for quality improvement as the registry evolves with the facility.

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