CHAPTER I

INTRODUCTION

A. The Trauma Disease

Physical trauma; in our thesis the terms “trauma” and “injury” are interchangeable, is defined by the International Classification of Diseases (ICD-11) of the World Health Organization (WHO) as 'physical or physiological bodily harm resulting from the interaction of the body with energy (mechanical, thermal, electrical, chemical or radiant, or due to extreme pressure) in an amount, or at a rate of transfer, that exceeds physical or physiological tolerance. Injury can also result from lack of vital elements, such as oxygen. Poisoning by and toxic effects of substances are included, as is damage of or due to implanted devices. Maltreatment syndromes are included even if physical or physiological bodily harm has not been reported. Otherwise, psychological effects are not included (e.g. injured feelings). Injury usually has rapid onset in response to a well-defined event (e.g. a car crash, striking the ground after falling, drinking a strongly alkaline liquid, an overdose of a medication, a burn sustained during a surgical procedure). These events are often referred to as external causes of injury. The injurious energy can, however, originate from the injured person and/or from his or her immediate environment (e.g. a person running on a hot day sustains heat exhaustion), and injury can be caused by the injured person (i.e. intentional self-harm). Injury includes manifestations that are evident immediately after onset, which may persist or not, and manifestations that first become evident at a later date' (WHO, 2018b).

The adoption of the ICD system has helped to classify health conditions in the clinical, administrative, public health, and research settings. This success has formed the basis of a global mortality reporting system that helped in prioritizing health system investments, track progress towards global development goals, and guide scientific research (Roth et al., 2018). The WHO, however, classifies trauma on operational terms based on the causality into two categories (WHO, 2018a):

- Unintentional Injuries:
    - Road injury.
    - Poisoning.
    - Falls.
    - Fire, heat and hot substances.
    - Drowning.
    - Exposure to forces of nature.
    - Other unintentional injuries.
- Intentional injuries:
    - Self-harm.
    - Interpersonal violence.
    - Collective violence and legal intervention.

According to the Global Heath Estimates 2016 of the WHO, more than nine people die every minute from injuries, and 4.9 million people of all ages and economic groups die every year from injuries. These injury deaths account for 9 % of the total deaths and have been almost the same since the Global Heath Estimate initiative started in the year 2000. The number of deaths from injuries was 4.5 million, 4.7 million, and 4.8 million in the estimates for years 2000, 2005, and 2010 respectively (WHO, 2018). These numbers are almost 1.7-2 times the number of fatalities resulting from diseases like malaria, tuberculosis, and human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) combined.

Injuries are associated with critical financial costs, in addition to negative physical consequences. The cost of injuries worldwide is estimated to be in trillions of dollars. The International Labour Organization (ILO) estimated that in 2003 the accidents at work and illnesses not only consumed 2 million lives but cost 1.25 trillion dollars. The report also mentions that in some parts of the developing world, the fatalities spike to 4 times those in the safest developed countries (DCOMM, 2003). As it has been evident, trauma is a significant global public health disease. The burden of injury is not limited to disability and death that happen on an immediate basis like the instant death due to major road traffic or loss of limb after a similar accident. Injuries can start with violence, road traffic crashes, burns, poisoning, drowning, and falls, then lead to physical injuries, mental consequences (e.g., depression, anxiety), behavioral changes (e.g., smoking, alcohol and drug misuse, unsafe sexual practices), and unwanted pregnancies (WHO, 2014). On a longer-term, survivable injuries can lead to death, disability, suicide, HIV and other sexually transmitted diseases (STDs), cancer, cardiovascular disease, and other non-communicable diseases (NCDs) (WHO, 2014). Injuries also pose a severe burden at a societal level. In addition to the direct cost of injuries due to the considerable health care costs, other indirect costs form a huge burden. These indirect costs involve the loss of productivity after temporary or permanent disability, sick leaves, early retirement, police cost, judiciary inquiries, and claims for damages (Anders et al., 2013).

Both definitions of trauma adopted by the WHO and the ICD are helpful for the assessment of trauma demographics. Both classifications provide an international standard that makes data collection, pooling, communication, and dissemination accessible and useful. However, they are not specific when describing the severity of an injury.

A variety of systems have been developed to define severely injured patients. Those systems help predict mortality or survival in trauma patients (Baker, O'neill, Haddon & Long, 1974; Champion et al., 1990; Bergeron, Rossignol, Osler, Clas & Lavoie, 2004; Gennarelli & Wodzin, 2006; Jones, Skaga, Søvik, Lossius & Eken, 2014). Those models are mainly based on demographic factors such as age, anatomical variables like the Injury Severity Score (ISS), and physiological variables like the Revised Trauma Score (RTS). The RTS is frequently used at the accident scene, and it has been claimed to correctly identify more than 97 % of non-survivors as requiring care in a trauma center (Champion et al., 1989). The Pediatric Trauma Score (PTS) was developed as an initial assessment tool for the prediction of injury severity in the pediatric population (Tepas, Mollitt, Talbert & Bryant, 1987). ISS, based on the Abbreviated Injury Scale (AIS), has been considered as the gold standard used to grade injury severity (Baker, O'neill, Haddon & Long, 1974; Kingma, Tenvergert, Werkman, Duis & Klasen, 1994; Wong et al., 2016). It is deployed by the National Institute for Health and Care Excellence (NICE) in its major trauma guidelines, the British Trauma Audit and Research Network (TARN), and the National Highway Traffic Safety Administration (NHTSA) crash investigation teams in the US as one of the official injury data collection tools, and various trauma teams (Sasser et al., 2012; NICE, 2016). Also, any newly modified injury severity scores are always compared to the original ISS, as a gold standard (Paffrath, Lefering & Flohé, 2014; Kuo et al., 2017). The ISS is also employed in this thesis to identify severely injured patients. We will discuss these scores in more detail in the background section.

Organized trauma care systems were established within the health care systems of many developed countries. These systems and were effective in reducing the number of preventable trauma deaths and injury incidence. However; developing countries that account for two thirds of the total injury deaths have lacked these trauma systems (Champion, Sacco & Copes, 1992; Forjuoh & Gyebi-Ofosu, 1993; Barringer, Thomason, Kilgo & Spallone, 2006; Wang et al., 2013) .

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Worldwide, many studies have attempted to link the injury assessment scales to the economic impact of trauma, yet no studies have attempted to explore this relationship in the developing countries (Willenberg et al., 2012). This thesis aims to relate the incorporation of ISS scoring, being an index of the severity of the injury, as a predictor for the cost of illness at a tertiary care center in Beirut, Lebanon. This estimation of the economic costs of trauma will contribute to answer several health policy questions and help develop preventive interventions and improve health care. Our thesis will further investigate the socio-demographic, geographic, and health care determinants of the economic and health impact of injuries (Meerding, 2004; Polinder, 2007).

B. Thesis Organization

Our thesis is a study that explores the association between ISS and acute cost of care of trauma, based on a database of 430 patients from 2008 through 2013, obtained retrospectively from the American University of Beirut Medical Center (AUBMC) electronic health records (EHR). The study assesses the correlation between the ISS score and the acute cost of care during hospital admission. This study will attempt to find an equation to help predict the cost based on the ISS score. We will so measure any possible confounders that might affect the exposure; in our case the ISS, and any effect modifiers, that might increase the cost, and we will incorporate any significant result in our analysis and final equation. We believe that a uniform and consistent assessment of the exposure, the outcome, and the confounders will render our results more robust.

By identifying the association between trauma assessment score, the extent of the injury, and the geographic location of injury in relation to the cost of care, we can devise targeted interventions for decreasing the cost of care at the primary, secondary, and tertiary levels.

Before discussing our methodology and exposing our results, we will first provide an epidemiological overview of injuries, the global burden of the trauma disease, and the definitions of the scoring systems.

We will then detail the knowledge gap in the literature and accordingly detail our research questions, hypotheses, and objectives in this thesis. Then, we will review the demographic factors, the risk factors, the mechanism of injuries, and the injury outcomes. Afterward, we will develop the evidence supporting the association between ISS and acute cost of care, with emphasis on the severity scale and possible confounders or effect modifiers.

CHAPTER II

BACKGROUND

A. An Overview of the Burden of Trauma

To understand the burden of trauma, we have to dissect the economic evaluation of the disease. We need to understand the effects of injuries on both population health and healthcare systems. Population health can be evaluated from studies on the epidemiology of the burden of disease defined by morbidity and mortality. The effects on health care can be assessed from studies about the cost of illness. For this purpose, we are going to assess both of these effects on global and local-Lebanese levels.

1. Epidemiology of Trauma on Global Level

a. Mortality and Morbidity

According to the latest Global Burden of Disease Study (GBD) in 2017, injuries are one of the leading causes of death and have accounted for 4.48 million deaths worldwide, or 8 % of all deaths, an increase of 2.3 % compared to 2007. Of the total 1.65 billion years of life lost (YLLs[1]) in 2017, 11.9 % (11.5–12.1) were from injuries, consuming 195 million YYLs, a decrease of 6.4 % since 2007. Injuries follow the trend of NCDs in terms of the increase of total death. However, NCDs YLL is still on the surge. On the contrary, both the number of death and the YYLs were decreased for communicable, maternal, neonatal, and nutritional diseases (CMNNs) (Roth et al., 2018).

[1] YLL is an estimate of the average years a person would have lived if he or she had not died prematurely (Gardner & Sanborn, 1990)

The 4.48 million deaths are distributed according to the following categories:

- Transport Injuries: 1335 thousand deaths (29.8%)
    - Road injuries: 1243 thousand
        - Pedestrian road injuries: 486.2 thousand.
        - Motorcyclist road injuries: 225.7 thousand.
        - Motor vehicle road injuries: 451.1 thousand.
- Unintentional Injuries: 1804 thousand deaths (40.3%)
    - Falls: 695.8 thousand.
    - Drowning: 295.2 thousand.
    - Fire, heat, and hot substances: 120.6 thousand.
    - Exposure to mechanical factors: 136.5 thousand.
    - Adverse effects to medical treatment: 121.6 thousand.
    - Foreign Body: 124.1 thousand.
- Self-harm and interpersonal violence: 1344.8 thousand (30%)
    - Self-Harm: 793.8 thousand.
    - Interpersonal Violence: 405.3 thousand
        - Physical violence by firearm: 174.4 thousand.
        - Physical violence by other means: 139.5 thousand.
    - Conflict and terrorism: 129.7 thousand.

Injuries across all age groups were significantly more in males than females. It is also a disease of the youth. All injuries, regardless of the mechanism or category, were higher in the age group of 15-49 years. Specifically, age groups of 20-24 years and 25-29 were the highest. Then, there has been a gradual decrease over subsequent age groups.

Morbidity wise, injuries continue to have a considerable burden, while keeping at the 16th position for females (Kyu et al., 2018). The trend is similar to YLL for the numbers at each injury category.

b. Epidemiological Transition of Injuries

There has been a characteristic transition of the epidemiology of trauma depending on the level of development of countries, measured according to the level of the socio-demographic index (SDI[2]). Although there has been a significant spike in mortality during natural disasters or conflicts, the mortality rate from specific injuries can vary as a function of SDI (Lafta et al., 2015; Gosselin, 2016). In general, age-adjusted YLL rates decreased as SDI for a given region increased, with some exceptions. Of these exceptions, conflicts in the Middle East and North Africa have resulted in 1.14 million deaths from 2007 to 2017 (Fujita, Shinomoto & Rocha, 2017). Haagsma et al. (2020) describes that 'for many causes of injury, age-standardised YLL and YLD rates declined strikingly with increasing SDI, with proportionally largest decreases in YLL rates for conflict and terrorism (low SDI level 163.4 YLLs per 100 000; high SDI level 0.06 YLLs per 100 000), animal contact (low SDI level 140.0 YLLs per 100 000; high SDI level 2 YLLs per 100 000) and other unintentional injuries (low SDI level 7993 YLLs per 100 000; high SDI level 8.4 YLLs per 100 000)'.

Road injuries, for example, might increase in the earliest attempts of development of infrastructure in any country when more of the population has exposure

[2] Socio-demographic Index (SDI) is a summary measure of a geography's socio-demographic development. It is based on average income per person, educational attainment, and total fertility rate (TFR)

to transport-related injuries. With increased development, countries start focusing on specific measures and invest in resources to limit such injuries. For instance, advanced trauma care implementation through Advanced Trauma Life Support (ATLS) training has improved mortality in a developing country (Ali et al., 1993). The introduction of pre-hospital emergency medical services (EMS) ‘will not only increase the likelihood that injured victims survive to reach the nearest health-care facility but will also ensure that they benefit from their subsequent surgery, inpatient treatment and post-hospital care’ (Sasser, Varghese, Kellermann & Lormand, 2005). Also, a National Highway Traffic Safety Administration (NHTSA) study in the United States (US) that tried to decrease distracted driving, and showed that high-visibility enforcement (increased police presence supported by paid and earned media) helped reduce the number of people who use handheld cell phones while driving (Chaudhary, Connolly, Tison, Solomon & Elliott, 2015).

Other injuries, like self-harm, have different trends. There is a general decline in the self-harm and fall injuries as SDI increases, because of the better access to medical care. In China, a country ranked as high-middle SDI; for instance, deaths related to self-harm have declined significantly, mainly 'because of improved economic prospects among the poorest individuals' (Roth et al., 2018). A further look into the Chinese trends has revealed interesting, yet eye-opening interventions. The primary method used in China for the completion of suicide has been the use of highly lethal pesticides, especially in rural areas, where 58 % of fatal suicides have been by this method (Phillips et al., 2002). There has been a successful reduction in the suicidal rate due to two reasons. The improved economic prospects for the country's poor individuals and the reduction of access to lethal pesticides due to rapid urbanization and massive work-migration have reduced both the rates and case-fatality of impulsive suicidal behavior (Wang et al., 2008). There are, however, exceptions to this trend in the US and Australia; both are ranked with high SDI (Global Burden of Disease Collaborative Network, 2017).

c. Economic Costs

i. Developed Countries

The CDC's Web-based Injury Statistics Query and Reporting System (WISQAR), based on two Morbidity and Mortality Weekly Reports (MMWR) reports that in 2013, the cost of injuries in the United States was $671 billion. Fatal injuries cost $214 billion, while nonfatal injuries accounted for over $456 billion (Florence, Simon, Haegerich, Luo & Zhou, 2015; Florence, Haegerich, Simon, Zhou & Luo, 2015). These costs include both total lifetime medical and work loss costs.

In Europe, the European Trauma and Audit Research Network (EuroTARN) group reported that in 2007 the costs of injuries that result in a fatality are in the order of €1–6 billion euros and when non-fatal injuries are included, this can rise to €290 billion (Edwards et al., 2007). A report published by the European Agency for Safety and Health at Work (EU-OSHA) in 2017 estimates that the work-related ill-health and injury is costing the European Union 3.3 % of its gross domestic product (GDP), €476 billion every year.

To put it in perspective; the overall median (interquartile range – IQR) cost of one major trauma case calculated from 20 studies reporting cost estimates in the developed countries was $22,448 ($11,819-$33,701) (Willenberg et al., 2012). The median cost of one major trauma case in the US was $22,115 ($13,776-$29,335), Australia $33,130 ($27,907-$38,297), United Kingdom (UK) $18,535 ($11,819 - $25,827), and Germany $41,522 ($37,186 -$76,365).

ii. Developing Countries

Injuries are a neglected epidemic in developing countries, where 90 % of common injury deaths occur (Jamison et al., 2006; Gosselin, Spiegel, Coughlin & Zirkle, 2009). In addition to the scarcity of preventive measures, and the low capacity of healthcare systems to handle injuries, there is no definitive data about the burden of disease.

In China, one study estimated that the estimated annual cost of injury is equivalent to $12.6 billion, four times the budget of the public healthcare service in China, and also attributed to 12.6 million YLL (Zhou, Baker, Rao & Li, 2003). Another study estimated that in 2003 the estimated cost of road traffic injuries was $646 million in Shanghai only (Yan-Hong et al., 2006).

In Brazil, in 2004, the cost of treatment for victims of external causes, aggression, and road traffic accidents was equivalent to $830 million, $45 million, $171 million, respectively (Rodrigues, Cerqueira, Lobão & Carvalho, 2009). The same source reports that this comprised 5.23 % of the budget of the public healthcare service (estimated at $20 billion).

Few studies have been published addressing a comparative view among low- and middle-income countries (LMIC). Wesson, Boikhutso, Bachani, Hofman & Hyder (2013) reviewed the studies addressing the economic evidence about the cost of injuries. Only 13 out of 68 studies performed economic assessment studies in 14 out of the 144 LMIC. The mean cost of one injury from a road traffic accident in Jordan was $4200, China $4330, Thailand £3000, and Vietnam $363 (Al-Masaeid, Al-Mashakbeh & Qudah, 1999; Riewpaiboon, Piyauthakit & Chaikledkaew, 2008; Yan-Hong, Rahim & De-Ding, 2011; Nguyen et al., 2012). However, this review concluded that the studies do not reflect the distribution of the burden of injury across regions and injury type (Wesson, Boikhutso, Bachani, Hofman & Hyder, 2013).

The WHO attributes this evident lack of advocacy to address trauma-related diseases to the fact that there is prioritization of other healthcare problems that are perceived as more urgent. These healthcare problems include communicable diseases and nutritional diseases (Gosselin, Spiegel, Coughlin & Zirkle, 2009). Another critical factor that contributes to the scarcity of national data is the fact that most of these studies are performed at care centers levels in countries that provide mostly private healthcare.

Hence, the burden of trauma in developing countries is undeniable, although many obstacles limit appropriate estimation and prevention.

2. Epidemiology of Trauma in Lebanon

To understand the trauma disease in Lebanon, we will provide a historical narrative that helps us understand the epidemiology and the nature of the studies conducted. Lebanon has been experiencing internal and external conflicts that affected all Lebanese either by death, disability, exposure to shelling or combat injuries, and various psychological traumas (Tayara, 2014). Also, the lack of appropriate infrastructure and preventive measures have contributed to road traffic accidents and other types of injuries and the lack of responsive emergency medical services (EMS) to the resulting high mortality and morbidity.

Apart from conflict-related injuries studies (elaborated below), very few studies have addressed other trauma injuries and associated healthcare system problems. One study highlighted the underdevelopment of the EMS services in terms of funding, public access, provider training, and hospital emergency care (El Sayed & Bayram, 2012).

a. Mortality and Morbidity

i. Local Data

Lebanon has been experiencing unsettling conflicts since the day of independence in 1943. Although Lebanon has not been actively involved in the Arab-Israeli war since the establishment of the latter in 1948, Lebanon has been a shelter for Palestinian refugees, who were part of the ensuing civil war. Then in 1958, small-scale conflicts started between the government, who asked for US intervention, and the opposition. Not only did Lebanon have to grapple with internal problems of social and economic organization, but also to struggle to define its position concerning Israel, its Arab neighbors, and Palestinian refugees living in Lebanon (Hirst, 2011). This later developed into a full-blown civil war in 1975 that has torn the country apart, and led to the intervention of Syrian forces. In the middle of the civil war, Israelis fully invaded Lebanon in 1982 after a small-scale invasion to the south in 1978 under the claim to deter the Palestinian influence. The Lebanese civil war ended in 1989, yet Israeli aggression continued through the operation of the "Grapes of Wrath" in 1996 and a full Israeli war in July of 2006.

Lebanese civil war has cost 120,000 deaths, and thousands are missing, most from the youth generations, resulting in further under-estimating resulting costs (UN, 2006). The impact of non-fatal war-related injuries after the 1996 "Grapes of Wrath"

Israeli operation has been assessed on the wounded patients in southern Lebanon. Out of the 343 people injured, 73 % suffered from a specific type of disability; 35 % lost personal independence, and 77 % had motor disabilities, and 51 % lost their ability to return to their social roles (work 44 %, schooling 7 %) (Sibai, Shaar & El Yassir, 2000). The July 2006 war caused 1191 deaths, 4409 injuries, and a million were displaced by the invasion (Higher Relief Council, 2007). Those estimates do not include Lebanese killed since the end of fighting by unexploded Israeli cluster bombs or landmines. Up to November 2008, 40 people were killed and 270 injured by cluster bombs (Lyon, 2008).

The majority of trauma studies have evolved around injuries related to the Lebanese civil war. An analysis of 1500 cases of abdominal trauma sustained during the Lebanese civil war was performed, of which 1343 were penetrating traumas (1314 high-velocity gunshot wounds and 29 stab wounds) and 157 were blunt. The overall mortality was 130 out of the total 1500 cases (8.7%): 9.5 % for gunshot wounds, 3.4 % for stab wounds, and 2.5 % for blunt trauma (Nassoura et al., 1991). Other studies attempted to study penetrating trauma to abdominal vessels, trauma to lower extremities, and head and neck trauma injuries as effects of civil war. Head and neck injuries secondary to bullets, shrapnel, and/or glass were quite frequent: 1,357 injuries in 1,021 patients were taken care of by Otolaryngologist between 1975 and 1984 (Zaytoun, Shikhani, and Salman, 1986). In the same time frame, 1860 patients were admitted within 5 hours of injury to AUBMC sustaining abdominal injuries. Their mean age was 23 years, and had 107 vascular injuries (an incidence of 5.7%), with bullets being the most common injurious agents (Khoury, Sfeir, Khalifeh, Khoury & Nabbout, 1996). At the same center, 386 patients were operated on for vascular injuries to the lower extremities. Of these, 118 had popliteal injuries, 252 had femoral injuries, and 16 had tibial injuries.

The overall mortality rate was 2.33 %. The overall amputation rate was 5.95%, with a 3.17% amputation rate for the femoral injuries group versus 11.86% for the popliteal injuries group and 6.25% for the tibial injuries group (Sfeir, Khoury & Kenaan, 1995).

Only one study has attempted to study the characteristics and epidemiology of general trauma at and its outcomes at AUBMC and attempted to compare the findings to the North America Major Trauma Outcome Study (MTOS) (Tamim et al., 2006). The study was the first to report on the use of formalized trauma score; i.e., the ISS, reflect on the type of injuries and has given recommendations related to the pre-hospital healthcare system. It included 873 patients presented to AUBMC from 2001 to 2003. 564 patients (64%) were males and 314 (35.6%) females. The mean age was 44 years, the proportion of patients in the paediatric (less than 18 years of age) and elderly (more than 65 years of age) age groups was almost identical, 23.3% and 22.8% respectively. More than half the patients (53.1%) were privately insured, only 13.2 % were publicly insured and 23.2% did not have any insurance. Blunt injuries accounted for 90.7% of the cases (799 patients), of which 404 patients (45.8%) suffered from falls. Among patients who experienced falls, 16 cases (3.9%) were from heights greater than 15 feet and 178 cases (20.2%) due to road crashes. Penetrating injuries accounted for 8.9% of the cases (78 patients). The fatality of all injuries was 4.27 percent, causing 30 deaths out of the total of 703 patients (different than the total above mentioned 873 patients because of missing information) and was divided into: road traffic accidents 12, falls 13, burn and electric shock 3, and gunshot/penetrating 2.

The study concluded that the probability of survival was not significantly different that the results from the MTOS. Though the study showed similar numbers compared to its American counterparts, but the results could not be generalized to other hospitals because of the high standard of care at AUBMC. Also, the study highlighted the need of better pre-hospital EMS services, a conclusion shared by other researchers, who pointed out the low use of EMS in priority conditions (El Sayed, Tamim, Chehadeh & Kazzi, 2016).

ii. Reflections from GBD 2017:

Data about Lebanon obtained from the GBD study has shown that the life expectancy for males is 71.7 years, and for females 78.1 years. Injuries have caused 2582 deaths [2274 - 2877], which forms 7.69 % of total deaths. It also caused 129018 YLL [113797 – 143399], which forms 15 % of total YLL, and 189377 disability-adjusted life-years (DALYs) [168280 - 213627] standing for 10.56 % of YLL (Global Burden of Disease Collaborative Network, 2018).

Road injuries have increased by 26.5 % in terms of YLL from 2007, ranking as the 7th cause of premature death in 2017. Conflict and terror injuries and interpersonal violence injuries have also increased by 89.3 % and 41.9 %, respectively, ranking as the 9th and 10th cause of premature death (Global Burden of Disease Collaborative Network, 2017b).

The all-age standardized cause of death rate per 100 thousand in Lebanon is displayed as follows for injuries (Global Burden of Disease Collaborative Network, 2017a):

- Transport injuries: males 11.2, females 2.5.
- Falls: males 6.11, females 4.85.
- Fire, heat, and electric shock: males 1.674, females 1.215.
- Self-harm: males 6.94, females 1.975.

- Interpersonal violence: males 6.454, females 0.937.
- Conflict and terrorism: No data

These numbers are different than those reported in other developing countries. For instance, in Egypt, the death rate per 100 thousand is displayed as follows for injuries:

- Transport injuries: males 49.85, females 17.6.
- Falls: males 6.43, females 2.56.
- Fire, heat, and electric shock: males 2.19, females 2.28.
- Self-harm: males 7.91, females 2.55.
- Interpersonal violence: males 0.99, females 0.28.
- Conflict and terrorism: males 1.74, females 0.64.

A further interpretation of the transport injuries in Lebanon shows that 75 % of these deaths belong to the 15-39 years old category. The peak is in the most youth groups; 15-19 and 20-24 years old, each has 20 % share of the total death. The same pattern follows the death sustained by self-harm.

b. <u>Economic Burden</u>

A general estimate about the cost of healthcare has been quoted as $1207 per capita, distributed as government health spending (51.1%), out-of-pocket spending (30.5%), prepaid private spending (15.5%), and development assistance for health (4%) (Dieleman et al., 2017). According to the same source, GDP per Capita in Lebanon is $14678, so the health expenditure would be 8.2 % of the total GDP per capita.

However, no appropriate estimation at a national level has been formally conducted to assess the cost of injury on the healthcare system.

B. Major Trauma: Definitions

1. Blunt Trauma:

Blunt impact injuries result from direct contact of a blunt object with a body part, either by impact, injury, or physical attack. ‘A contusion results from the blunt impact of significant force to rupture capillaries underneath the skin surface while leaving the skin surface intact, while an abrasion results from scraping off of the superficial epidermis. Contusions and abrasions may show distinct patterns which can be used to match a specific wound to a potential weapon or implement; for example, a contusion over the forehead with multiple parallel, zig-zag lines may be matched to the sole of a shoe collected at the crime scene. A laceration results from the blunt impact of significant force to tear the skin, leaving strands of subcutaneous tissues bridging the wound. Contusions and lacerations may also be present on internal organs. Blunt impact of significant force to a bone results in a fracture.’ (Simon, Lopez & King, 2020).

2. Penetrating Trauma:

‘Penetrating wounds are caused by objects that penetrate the body, that is, they pierce the skin and lacerate, disrupt, destroy, or contuse adjacent tissue, thus creating an open wound. Penetrating injuries can have multiple etiologies; the most common are gunshot wounds and sharp instruments. The material and anatomic properties of the host and the ones of the injuring element determine the extent of tissue damage.

Some of the instruments involved in penetrating wounds include:

- Firearms: Method that uses a powder charge to fire a projectile.
- Sharp instruments: Knifes, razors, swords, icepicks, or any pointed instruments (e.g., chisel or broken glass)' (Lefebvre et al., 2012).

3. Trauma Scoring Systems

As mentioned earlier, trauma scoring systems are mainly based on physiological classifications, anatomical classifications, or a mixture of both. RTS is based on a physiological factor like the Glasgow Coma Scale (GCS), systolic blood pressure (SBP), and respiratory rate (RR) (Champion et al., 1989). ISS, which is the main score we are incorporating in our thesis, is based on anatomical classification (Baker, O'neill, Haddon & Long, 1974).

a. <u>AIS and ISS</u>

Hugh De Haven, with members of the Cornell Medical School faculty, developed the first research injury scale in 1952 (De Haven, 1952). It was the first scale to classify injuries as minor, moderate, severe, life-threatening, and fatal. At that time, manufacturers like General Motors Corp have developed a scale similar to Cornell's permitting comparison to police scales. In January 1969, the Abbreviated Injury Scale (AIS) was tentatively adopted. AIS is an anatomically based scoring system created by the Association for the Advancement of Automotive Medicine (AAAM) to classify and describe the severity of injuries. AIS is based upon the Cornell Scale, the General Motors Scale, and others using the descriptive terms 'minor, moderate, severe, life-threatening, and fatal' (States, 1969). The latest score incarnation is the 2005 revision (Gennarelli & Wodzin, 2006). The scale is intended for use by non-physicians and physicians and is simple enough to permit the rapid scaling of many cases.

AIS classifies the injuries to nine body regions:

1. Head.
2. Face.
3. Neck.
4. Thorax.
5. Abdomen.
6. Spine.
7. Upper Extremity.
8. Lower Extremity.
9. External and other.

In terms of injury severity, AIS classifies injuries in ordinal order of severity from 1 to 6, one being minor and six being un-survivable:

1. Minor: e.g.
   - General:
     - Minor lacerations, contusions, and abrasions. including fractures and/or dislocation of digits
   - Head and Neck:
     - Cerebral injury with headache, dizziness, no loss of consciousness.
     - “Whiplash” complaint with no anatomical or radiological evidence.
     - Fractures and/or dislocation of nose and teeth.
     - Abrasions and contusions of ocular apparatus, vitreous or

retinal hemorrhage.

2. Moderate: e.g.

    - General:
        - Abrasions and large lacerations.
    - Head and Neck:
        - Cerebral injury with or without skull fracture, less than 15 minutes unconsciousness.
        - Undisplaced skull or facial bone fractures.
        - Disfiguring lacerations.
        - “Whiplash” unresolved in 30 days.
        - Lacerations of the eye and appendages, retinal detachment.
    - Chest:
        - Simple rib or sternal fractures.
        - Major contusions of the chest wall without hemo or pneumothorax, or other respiratory impairment.
    - Abdominal:
        - Significant contusions of abdominal wall.
    - Extremities:
        - Compound fractures of digits or nose.
        - Undisplaced long bone and pelvic fractures. Sprains of major joints.

3. Severe: e.g.

    - Head:

- Cerebral injury with without skull fractures with unconsciousness more than 15 minutes, without severe neurological signs. brief retrograde amnesia less than 3 hours.
- Displaced closed skull fractures without unconsciousness or other signs of intracranial injury.
- Loss of eye, or avulsion of optic nerve.
- Displaced facial bone fractures, or those with antral or orbital involvement.
- Spine fractures without cord damage.

- Chest:
    - Multiple rib fractures without respiratory embarrassment.
    - Hemo or pneumothorax
    - Rupture of diaphragm.
    - Lung contusion
- Abdominal:
    - Contusion of abdominal organs
    - Extra-peritoneal bladder rupture.
    - Avulsion of the ureter.
    - Laceration of the urethra.
    - Fractures of the thoracic and lumbar spine without neurological involvement.
- Extremities:
    - Displaced simple long-bone fractures, or multiple hand

and foot fractures.

- Single open long-bone fractures.
- Pelvic fracture with displacement.
- Dislocation of major joints.
- Multiple amputations of digits.
- Lacerations of the major nerves or vessels of extremities.

4. Serious: e.g.

- General:
  - Severe lacerations with dangerous haemorrhage.
- Head:
  - Cerebral injury with or without skull fracture, with unconsciousness of more than 15 minutes. with definite abnormal neurological signs, retrograde amnesia 3-12 hours.
  - Dorsal and lumbar spine fractures with paraplegia.
  - Compound skull fracture.
- Chest:
  - Open chest wounds, flail chest, pueumomedíastinum, myocardial contusion without circulatory embarrassment and pericardial injuries
- Abdominal:
  - Minor laceration of intra-abdominal contents to include ruptured spleen, kidney, and injuries to tail of pancreas.
  - Intra-peritoneal bladder rupture.

        - Avulsion of the genitals.
    - Extremities:
        - Multiple closed long-bone fractures.
        - Amputation of limbs.
5. Critical: e.g.
    - Head and Neck:
        - Cerebral injury with or without skull fracture with unconsciousness of more than 24 hours, retrograde amnesia more than 12 hours, intracranial hemorrhage or signs of increased intracranial pressure, (Decreasing state of consciousness) bradycardia under 60, progressive rise in blood pressure or progressive pupil inequality
        - Cervical spine fracture with quadriplegia.
        - Major airway obstruction.
    - Chest:
        - Chest injuries with major respiratory embarrassment (laceration of trachea, hemomediastinum, etc.).
        - Aortic laceration.
        - Myocardial rupture or contusion with circulatory embarrassment
    - Abdominal:
        - Rupture, avulsion or severe laceration of intra-abdominal or thoracic organs, except kidney, spleen or ureter.
    - Extremities:

- Multiple open limb fractures

6. Unsurvivable: e.g.

    - Fatal region of single region of the body

ISS is an established medical score to assess trauma severity, and it is used to define the term major trauma. The ISS incorporates the sum of all squared AIS values of the three most severely injured areas. Baker, O'neill, Haddon & Long, (1974) proposed the score as a 'valid numerical description of the overall severity of injury in person who have sustained injury to more than one area of the body.' The study that lead to the development of the score included 2128 vehicle occupants, pedestrians, and other road users whose injuries resulted in hospitalization or caused death. It included 8 Baltimore hospitals during the two years from 1968 to 1969.

ISS summons the original nine body regions of AIS into six systems for which an AIS score is given:

1. Head and neck (includes spine).
2. Face (includes the facial skeleton, nose, mouth, eyes and ears).
3. Chest (includes thoracic spine and diaphragm).
4. Abdomen and pelvic content (includes lumbar spine).
5. Upper and lower extremities (includes pelvic skeleton).
6. External injuries.

The later versions of the AIS (AIS-85 and AIS-90) have adopted this six regions system and included codes for penetrating injuries. The 1990 version also extended to severe brain injuries since the AIS-85 under-coded this type of injury.

ISS is defined as the sum of the squares of the highest AIS grade in the three mostly severed systems: $ISS = AIS1^2 + AIS2^2 + AIS3^2$. The highest score per one single area is 25 (square of AIS 5). The range of the ISS score is from 0 to 75. For illustration, if a person suffers from a car accident and has a whiplash neck injury (AIS 1), simple rib fracture (AIS 2), aortic laceration (AIS 5), and urethral laceration (AIS 3), the ISS score would be $2^2 + 3^2 + 5^2 = 38$. Any score of AIS 6, i.e., unsurvivable injury to any area, gives the highest ISS of 75 automatically (Stevenson, Segui-Gomez, Lescohier, Di Scala & McDonald-Smith, 2001).

A major trauma (or polytrauma or severe trauma) is defined as ISS being greater than 15 (Copes et al., 1988; Palmer, 2007). The ISS prediction of the economic burden will be investigated in this paper.

i. Validity of ISS as a Predictor of Major Health Outcomes in Various Types of Trauma

When AIS was established, it has been validated on blunt injuries. The relationship between AIS and patient outcomes was not linear. Mortality increases disproportionately with the AIS rating of the most severe injury (Baker, O'neill, Haddon & Long, 1974). Also, the AIS scale is not an interval scale: the increase in mortality from 2 to 3 is much less from the increase from 4 to 5.

The relationship between AIS and mortality was quadratic. To solve this problem, Baker suggested the ISS score by squaring the highest AIS grades of the most severe injuries. However, ISS was initially validated in blunt traumas in road traffic accidents (Baker, O'neill, Haddon & Long, 1974).

Several studies had attempted to validate the ISS in different trauma settings. In 1975, in Birmingham, UK, Bull showed a positive association of ISS score and age with mortality (Bull, 1975). In 1981, it was applied to a miscellaneous group of trauma patients in the UK, the first of which was caused by a 60 feet fall (Threlfall, Stoner & Galasko, 1981). ISS was used in 1982 for describing the severity of injuries from a bomb explosion in Sweden and applied for blunt trauma in many different causes in the Netherlands (Brismar & Bergenwald, 1982; Goris & Draaisina, 1982). It was until 1984 that ISS was shown to have an association with penetrating injuries, particularly gunshot wounds in the UK (Beverland & Rutherford, 1983).

The Major Trauma Outcome Study (MTOS) was the first study to validate ISS in both penetrating and blunt trauma. The study included 14885 patients from 26 institutions. MTOS included injuries from:

1. Motor Vehicle: 3916.
2. Motorcycle: 961.
3. Pedestrian: 1039.
4. Gunshot wound: 1589.
5. Stabbing: 1814.
6. Fall: 2736.
7. Other: 2830.

MTOS showed that mortality increases with ISS for both blunt and penetrating trauma, and for both age groups of less than 50 years old and greater than 50 years old. The 5.8 % mortality rate of blunt injuries is between the numbers reported by Baker, 12.5% for 2128 patients treated in 1968-1969, and Bull, 4.9%for 1333 road accident casualties treated in 1961 (Baker, O'neill, Haddon & Long, 1974; Bull, 1975). The ISS mortality curve of MTOS for blunt injuries of patients less than 50 years old showed very similar to the results of the original study by Baker and Bull (Copes et al., 1988).

For penetrating injuries, the MTOS study showed that there is an increase of mortality with increasing ISS from one to twenty-five for both patients less than 50 years old and greater than fifty years old. The mortality increases more for patients greater than 50 years. Then mortality does not increase significantly in both age groups up to ISS of 45. After that, mortality increases similarly for both age groups as ISS increases.

In brain injuries, ISS outperformed GCS as a predictor of the outcome on 410 patients with traumatic brain injuries (TBI) (Foreman et al., 2007). This study supported the addition of anatomic measures like AIS and ISS in the clinical studies of TBI.

ii. Reproducibility of Trauma Scores

In Southern Denmark, a prospective study was performed that evaluated the Kappa value for the reproducibility of AIS and ISS scores based on Computed Tomography (CT) and autopsies results (Leth & Ibsen, 2010). Kappa agreement is a more robust measure than simple percent agreement calculation, as Kappa takes into account the possibility of the agreement occurring by chance (Cohen, 1960). The CT scanning and the autopsies were performed independently by two different physicians. The scores of AIS were performed based on the AIS 2005 edition (Gennarelli & Wodzin, 2006). The injuries with the highest AIS scores found by CT and at autopsy were recorded for each of the standard AIS anatomic units, and ISS then calculated. Kappa values for the reproducibility of AIS scores and ISS scores were calculated. A key component in this evaluation is that the autopsy represents an accurate and reproducible technique (Anderson, Hill & Gorstein, 1990). The criteria of interpretation of the Kappa score is presented in Appendix A (McHugh, 2012). The severity scores were the same in 90% of all cases (range, 75–100%). The kappa value for the reproducibility of the severity scores is shown in Appendix B. Out of the 28 body regions, the level of agreement was none (0-0.20), minimal (0.21-0.39), and weak (0.40-0.59) in 0, 2, and 4 regions respectively. This makes a combined total of 21%. The level of agreement was moderate (0.60-0.79), strong (0.80-0.90), and almost perfect (above 0.9) in 8, 5, and 9 regions, respectively. This makes a total of 78%. The ISS scores obtained by CT and by autopsy were calculated and were found to be with no or moderate variation in 85%. This study confirms the reproducibility of AIS and ISS scores.

iii. Local Assessment of ISS

In Lebanon, one study was performed on the function of ISS as a predictor of mortality and morbidity at AUBMC. The study included a total of 891 patients admitted from ED From January 2001 until January 2003. 'This study is the first to examine the statistical performance of the ISS and the NISS in predicting admission to the ICU and length of hospital stay of a trauma population admitted to an urban level I trauma center of a developing country' (Tamim, Al Hazzouri, Mahfoud, Atoui & El-Chemaly, 2008). This study showed that ISS was superior to the new injury severity score (NISS) in predicting both length of stay (LOS) and intensive care unit (ICU) admission.

In our thesis, ISS will be used for all types of trauma: penetrating, blunt, and severe head injuries.

iv. ISS as a Predictor of Healthcare Costs

ISS has been utilized as a tool for the prediction of the hospital's cost of care in high-income countries. Many studies have proved the increase in the cost of treatment with ISS severity in different types of traumas: polytrauma, penetrating, and blunt trauma. Also, these studies were conducted in different settings; level 1 Trauma centers, tertiary referral centers, university trauma centers, and regional pediatric trauma centers (Thomas et al., 1988; Mock, Pilcher, and Maier, 1994; Buckley et al., 1994; Spaite et al., 1995; Kizer, Vassar, Harry & Layton, 1995; Goldfarb, Bazzoli & Coffey, 1996; Rogers, Osler, Shackford, Cohen & Camp, 1997; O'Keefe et al., 1997; Taheri et al., 1998; Young, Cephas & Blow, 1998; Taheri, Butz, Watts, Griffes & Greenfield, 1999; Sartorelli et al., 1999; Rösch et al., 2000; Park et al., 2001; Dueck, Poenaru & Pichora, 2001; Schmelz, Ziegler, Beck, Kinzl & Gebhard, 2002; Lanzarotti et al., 2003; Ganzoni, Zellweger & Trentz, 2003; Grotz et al., 2004; Sikand, Williams, White & Moran, 2005; Small, Sheedy, & Grabs, 2006; Davis, Joshi, Tortella & Candrilli, 2007; Christensen, Nielsen, Ridley, Lecky & Morris, 2008; Zarzaur, Magnotti, Croce, Haider & Fabian, 2010; Rowell et al., 2011)

In the US, in a Level 1 trauma center in the state of New Jersey, the cost of injuries increased linearly with the severity of injury based on the ISS scale (Schwab et al., 1988). The system of ISS grouping was an accurate method of cost analysis, and prospectively, ISS grouping allowed prediction of length of stay and total hospital cost.

Rogers, Osler, Shackford, Cohen & Camp (1997) used ISS scoring on 1119 patients who sustained trauma in rural environments. The mean cost of trauma increased with the increase of the ISS score:

- ISS 0-16: $8666.
- ISS 17-25: $22979.
- ISS>25: $57559.

In the UK, researchers also categorized trauma costs based on ISS severity. For blunt trauma, 36564 patients' data were distributed as follows: ISS 0-9: 60%, ISS 10-16: 17%, ISS 17-25: 12%, 1SS 26-75: 11% (Christensen, Ridley, Lecky, Munro & Morris, 2008) . The mean cost per trauma followed an increasing trend with ISS categories was:

- ISS 0-9: $11248.
- ISS 10-16: $16313.
- ISS 17-25: $25780.
- ISS 26- 75: $38426.

The same author also assessed penetrating injury costs in relation to ISS. 1365 patients were identified; 16% with ISS 1-8, 50% ISS 9-15, 15% ISS 16-24, 16% ISS 25-34, and 4% with ISS 35-75 (Christensen, Nielsen, Ridley, Lecky & Morris, 2008). The mean cost per trauma also followed an increasing trend:

- ISS 1-8: $11798.
- ISS 9-15: $10952.
- ISS 16-24: $17155.
- ISS 25-45: $22408.
- ISS 46-75: $29832.

Willenberg et al. (2012) performed a comprehensive synthesis of the cost of trauma studies in high-income countries, including the US, Australia, Europe, and the UK. 'In all publications reviewed, predictors of cost included ISS, surgical intervention, hospital and intensive care, length of stay, polytrauma and age.' The overall median cost of major trauma calculated from the 20 studies was $22,448 with interquartile range (IQR) $11,819- $33,701. The median cost per country of major trauma is:

- US: $22,115 (IQR $13,776- $29,335).
- Australia: $33,130 (IQR $27,907-$38,297).
- Germany: $41,522 (IQR $37,186 -$76,365).
- UK: $18,535 (IQR $11,819 - $25,827).

The cost of trauma varies depending on the type of trauma:

- Polytrauma: $26,521 (IQR $14,686-$43,000).
- Penetrating trauma: $19,651 (IQR $13,161- $22,365).
- Blunt trauma: $16,342 (IQR $11,541-$25,827).

Also, the review showed that the median cost varies as function of ISS:

- ISS≥15: $29,886 (IQR $22,581-$40,009).
- ISS≤15: $12,988 (IQR $11,152- $19,229) (Willenberg et al., 2012).

The evidence points to an increase in costs with the increase in the severity of ISS in developed countries.

C. Knowledge Gap

Despite extensive research (reviewed above) about the association of an increase in trauma costs with the severity of ISS, many questions remain unanswered, especially in developing countries where limited research is invested in trauma. Except for the study by lead by Kaya in Turkey, no study in developing countries has been found to assess the validity of ISS in predicting trauma costs (Kaya, Ozguc, Tokyay & Yunuk, 1999). In this study, a total of 347 patients had complete data available for analysis. The mean ISS was 13.3+/-0.5. The average acute cost per patient was $1,577, and total hospital charges were $547,391. The study concluded that there is a positive correlation between ISS and hospital charges. The remarkable thing about this study is that it mimics the Lebanese healthcare coverage. In this study, 54.2 % of the patients were self-payer, and the rest (45.8 %) had some form of health insurance.

However, this study does not analyze any other confounding variables that might affect the degree of injury severity, nor it addresses any effect modifiers that might affect the cost of care. It studies merely the relationship between ISS and cost with no other factors.

Besides, no research, including those in developed countries, has studied the association of geographical location of trauma with the cost of care.

Our thesis is the first to investigate the role of ISS in predicting the economic burden of trauma in Lebanon, a developing country, hence bridging the gap of knowledge. In particular, the study investigates the cost of care in the emergency department (ED) and in-hospital stay, in addition to the length of stay at AUBMC, a tertiary care center in Beirut, Lebanon. The study is the first to offer a map view of the locations and try to offer an in-depth view of the economic aspect of injuries based on location.

D. Research Questions

We will address the following research questions:

- Does ISS association with the acute cost of care differ according to the severity of trauma? How does this association change when controlled for sociodemographic and clinical variables?
- Does ISS association with length of stay differ according to the severity of

trauma? How does this association change for patients in ED vs admitted patients?

- What is the set of variables leading to the modification of the association between ISS and the economic burden of trauma that can be used in health service planning, fiscal management decisions, and resource allocation?

E. Hypotheses

1. ***(Hyp 1): There is a significant correlation between the ISS score and acute care cost of trauma patients admitted through ED.***

We hypothesize that the increase in the severity of trauma described as an increase in ISS score will be significantly associated with the increase in the acute cost of care of patients admitted to the hospital through ED.

2. ***(Hyp 2): There is a significant correlation between the ISS score and length of stay in hospital of trauma patients.***

We hypothesize that the increase in the severity of trauma described as an increase in ISS score will be significantly associated with the increase in the length of stay of patients admitted to the hospital through ED.

F. Objectives

The objectives of our thesis are to:

- validate the association of ISS as a predictor of economic burden to patients admitted to the hospital through the ED, defined as the acute care costs; the total ED and hospital charges.

- assess the possible confounders and effect modifiers that might affect ISS scores and acute cost of care respectively.
- establish a subgroup analysis of ISS scores (minor, moderate, and major trauma) and acute cost of care.
- check the validity of ISS as a predictor of ED and hospital length of stay (LOS).
- describe characteristics of trauma patients such as demographics, geographical location, injury patterns, clinical characteristics, management interventions, and outcomes

CHAPTER III

METHODS

A. Study Design

A retrospective chart review (RCR) research design was chosen for data collection. The harmful effects of clinical exposure in our study, i.e., trauma, makes it impossible and unethical to randomize patients in order to answer our clinical question in a controlled study. Also, it is impractical to address the potential trauma database in prospective study design (Worster &Haines, 2004). RCR, also known as a medical record review, is a type of research design in which pre-recorded, patient-centered data are used to answer one or more research questions (Vassar & Holzmann, 2013). The sources of information include physician and nursing notes, ambulance call reports, diagnostic tests (e.g., electrocardiograms, radiographs, laboratory tests); clinic, industry, administrative, and government records; and computerized databases (Worster & Haines, 2004).

B. Setting

The present thesis aims to address the above research questions and hypotheses by employing data obtained from a database created specifically to answer the above questions. The database involves 430 patients who presented to AUBMC ED from 2008 through 2013, with data obtained retrospectively from AUBMC EHR.

AUBMC is considered the main tertiary/quaternary referral medical center in Lebanon and the region. AUBMC operates 376 beds, serving 42,230 inpatients annually. The outpatient facilities receive 404,958 outpatient visits annually, of which 55,789 are emergencies (AUBMC, 2018).

C. Data Source and Population

The presenting chief complaint is a frequently used case selection criterion for ED-based studies, assuming it is always recorded accurately. However, a critical barrier to the use of chief complaints for studying performance measurement lies in the lack of standardization of complaint-based nomenclature, and how chief complaints are organized, categorized, and assigned. In addition, if the chief complaint is used as the sole selection criterion to identify cases in a study, many cases of the disease of interest might be missed. Similarly, the use of the discharge diagnosis as the sole selection criterion creates a risk of missing patients who have no diagnosis listed or have more than one discharge diagnosis (Worster & Haines, 2004).

To maximize the sensitivity and effectiveness of the case selection process, we used the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) discharge codes billed by the administrative department, which enhances the validity of the study results. AUBMC medical records department was contacted and provided us with a comprehensive list of all potentially eligible cases.

For the sake of this database, a questionnaire document has been created to address all the demographic, medical, and trauma scoring variables. The questionnaire is attached as Appendix C.

1. Eligibility Criteria

All patients of all age groups who were treated for trauma-related injuries during the study period were considered eligible for enrolment.

For the purpose of this study, a trauma patient is defined as a patient sustaining a traumatic injury and meeting the following criteria:

a. Inclusion Criteria

Inclusion criteria are based on definitions used in building Trauma registries in the US (National Trauma Data Bank, 2013). More specifically, codes from the ICD-9-CM were adopted. ICD-9 CM codes 800-999 stand for injury and poisoning. For poisoning, ICD-9 codes starting with 960 and above have been chosen selectively to resemble trauma injuries. Similarly, codes starting with E (external injury) have been selected for the same purpose. The use of ICD-9 code criteria misses some injuries, hence decreases the accuracy of inclusion. This is because the codes are entered manually by scribers who are non-medical personnel in a retrospective manner after diagnosis. However, the use of these codes is to try to include as much data with injury as possible. The sample of 435 patients included provides a robust sampling method.

Hence, eligible patients must have one of the following injury diagnostic codes:

- 800–804: Fracture of skull.
- 805–809: Fracture of neck and trunk.
- 810–819: Fracture of upper limb.
- 820–829: Fracture of lower limb.
- 830–839: Dislocation.
- 840–848: Sprains and strains of joints and adjacent muscles.
- 850–854: Intracranial injury, excluding those with skull fracture.
- 860–869: Internal injury of thorax, abdomen, and pelvis.
- 870–879: Open wound of head, neck, and trunk.

- 880–887: Open wound of upper limb.
- 890–897: Open wound of lower limb.
- 900–904: Injury to blood vessels.
- 910–919: Superficial injury.
- 920–924: Contusion with intact skin surface.
- 925–929: Crushing injury.
- 940–949: Burns.
- 950–957: Injury to nerves and spinal cord.
- 958–959: Certain traumatic complications and unspecified injuries.
- 987.9: Smoke Inhalation.
- 994.0: Lightning.
- 994.1: Drowning and nonfatal submersion.
- 994.7: Asphyxiation and Strangulation, includes Hanging.
- 994.8: Electrocution.
- E-code 905.0: Snakebites, venomous.
- E-code 906.0: Dog bite.

b. <u>Exclusion Criteria</u>

Patients with missing charts were excluded from the study, in addition to those with isolated injuries, and with the following injury diagnostic codes:

- 905-909.9: late effects of injury
- 930-939.9: foreign bodies

2. Sampling and sample size

There will be no sampling carried out for this study, as all eligible patients during the study period will be included.

As for the sample size, this study will aim to study the correlation between two continuous variables; the ISS score and the cost. Based on a positive correlation assumption between the two variables, the sample size calculation was performed. This sample size calculation was based on the model suggested by Bonett and Wright (2000).

We started with an assumed Pearson coefficient of 0.5 (0.1 is no correlation, 0.9 is high correlation), and a narrow 95% confidence interval width of 0.2 (for example [3.4-3.6]) of significance level (α) 0.05. Assuming a normal distribution of both variables (ISS and cost), the Pearson correlation yields a sample size of n= 219. If the assumption of bivariate normality cannot be justified, Kendall or Spearman correlations yield n=246 and n=99 respectively (Bonett & Wright, 2000) (Check Appendix D). Hence the sample size at most would be n=246. Missing data and charting was found in 32.2% of ED visits (Stiell, Forster, Stiell & van Walraven, 2003). To account for missing data differences in ISS categories' sizes and data storage problem the sample size will be increased to 430.

3. Data collection

As mentioned earlier, a questionnaire, or rather a trauma registry form, is created for the sake of this database. This form divided into different sections. It takes into consideration data elements included in international trauma registries. Two researchers trained on Collaborative Institutional Training Initiative (CITI) have attempted data collection. Both researchers were trained on data collection and abstraction was monitored. A sample of email exchanged for cross data review is attached in (Appendix E). Following is a brief description of the different sections of the form (Appendix C)

- Demographic information (e.g., age, sex, address)
- Injury-related information (e.g., place of injury, Emergency Severity Index (ESI) score)
- Patient-related information (e.g., past medical history, home medications)
- ED evaluation and workup (e.g., ISS and AIS score)
- Hospital course (procedures, transfusions, medications)
- Disposition and outcomes (discharge destination and charges)

The ED evaluation section includes physical examination which aligns explicitly with the ISS score. Hence it displays in a table format the six systems for which an AIS score is given to the nine body regions as follows:

- - Head

  - Neck

  - Vertebral column
- Face (includes the facial skeleton, nose, mouth, eyes, and ears).
- Chest (includes thoracic spine and diaphragm).
- Abdomen and pelvic content (includes lumbar spine).
- - Upper extremities

  - Lower extremities (includes pelvic skeleton).
- External injuries.

D. Measures

All measures mentioned here have been described with most accuracy to mimic the data collection and analysis sheets. So numbers assigned to any variable are the same numbers that exist on the data collection sheet (Appendix C) and data analysis SPSS file.

1. Dependent Variables

a. <u>Acute Cost of Care</u>

(C) is the dependent variable measuring the acute cost of care. It is a numerical value measured in US dollars. This variable has been obtained with help from the Decision Support Unit (DSU) personnel.

We defined the acute cost of care as the cost of care in the ED and hospital stay combined. For logistic reasons, the DSU could not separate the cost to differentiate the cost of each service, but this will not affect our results or analysis.

b. <u>Length of Stay</u>

(L) is the dependent variable measuring the length of stay. It is a numerical value measured in days and constructed by measuring the difference between the date of discharge (hospital discharge, death, or transfer) and the date of admission.

2. Independent Variables

(I) is the independent variable measuring ISS. ISS, as elaborated earlier, is measured using the AIS scoring system. ISS is the sum of the squares of the highest AIS grade in the three mostly severed systems: $ISS=AIS1^2+AIS2^2+AIS3^2$.

AIS classifies injuries in ordinal order of severity from 1 to 6;

- 1 = Minor
- 2 = Moderate
- 3 = Severe
- 4 = Critical,
- 5 = Serious
- 6 = Unsurvivable

The highest score per one single area is 25 (square of AIS 5). The range of ISS score is from 0 to 75. If for any reason, the AIS score is 6 for any of the systems, the ISS is automatically scored as 75.

We created three categories of ISS:

- Minor: 0-4
- Moderate: 5-15 and
- Major trauma: greater than 16

E. Control Variables

1. Age

We recorded age as a continuous variable indicating number in years.

2. Sex

We recorded sex as a categorical variable. The two categories of our variable are:

- Male = 1
- Female = 2

3. Nationality

We recorded nationality as a categorical variable. The two categories of our variable are:

- Lebanese = 1
- Non Lebanese = 2

4. Marital Status

We recorded marital status as a categorical variable. The four categories of our variable are

- Single = 1
- Married = 2
- Separated/Divorced = 3
- Widowed = 4

5. Residency Address

Lebanon lacks a standardized address format for the majority of the country apart from the administrative part of the capital Beirut. So, we recorded the area of residence as words describing the following two variables:

- City
- Street

6. Smoking Status

We recorded smoking as a categorical variable. The three categories of our variable are:

- Smoker = 1
- Non-smoker = 2
- Ex-smoker = 3

7. Insurance type

Healthcare in Lebanon is provided via a mixture of public or private third party coverage, or self-payment. Public coverage is provided mainly via the Lebanese National Social Security Fund (NSSF). Private coverage is provided via insurance companies. AUBMC provides its students, employees and their beneficiaries with a private health insurance known as Health Insurance Plan (HIP).

So we recorded insurance type as a categorical variable. The six categories of our variable are:

- Private = 1
- NSSF = 2
- Self = 3
- Combination with NSSF = 4
- HIP = 5
- Others (specify) = 6

8. Alcohol Consumption

We recorded alcohol consumption as a categorical variable. The two categories of our variable are:

- Yes = 1
- No = 0

9. Place of injury

We recorded place of injury as a categorical variable. The thirteen categories of our variable are:

- Industrial place = 1
- Recreation/sport = 2
- Street/Highway = 3
- Public building = 4
- Educational institution = 5
- Airport = 6
- Home/residence = 7
- Nursing home = 8
- Residence/Institution = 9
- Physician office/clinic = 10
- Hospital = 11
- Jail = 12
- Other, specify = 13

10. Police Informed

We recorded if the police were informed as a categorical variable. The two categories of our variable are:

- No = 0
- Yes = 1

11. Work-related Accident

We recorded if the accident was work-related as a categorical variable. The four categories of our variable are:

- No = 0
- Yes = 1

- Not applicable = 2
- Unknown = 9

12. Cause of Injury

We recorded the cause of injury as a categorical variable. The three categories of our variable are:

- Intentional = 1
- Unintentional = 2
- Unknown = 9

13. Alcohol Intake When Injured

We recorded if there was concomitant alcohol intake during the time of injury as a categorical variable. The three categories of our variable are:

- No = 0
- Yes = 1
- Unknown = 9

Also, we recorded if the patient was intoxicated and included that as a conditional question if the patient had alcohol intake during the time of injury. We recorded this as a categorical variable. The three categories of our variable are:

- No = 0
- Yes = 1
- Unknown = 9

14. Mode of Transportation

We recorded if there was concomitant alcohol intake during the time of injury as a categorical variable. The four categories of our variable are:

- EMS = 1
- Private = 2
- Walking = 3
- Others = 4

Also, we recorded if the patient was immobilised during transport and included that as a conditional question if the patient had been transported by EMS. We recorded this as a categorical variable. The three categories of our variable are:

- No = 0
- Yes = 1
- Unknown = 9

In addition, when immobilization was placed, two specific categories apply:

- Cervical Collar = 1
- Back Board = 2

15. Emergency Severity Index (ESI) at Triage

We recorded the ESI at triage as an ordinal numerical variable. The ESI triage stratifies patients into five groups, from level 1 (most urgent) to level 5 (least urgent)

16. Mechanism of Injury

We recorded the mechanism of injury as a categorical variable. The ten categories of our variable are:

- Blunt = 1
- Penetrating = 2
- Driver motor vehicle collision (MVC) = 3

- Passenger MVC = 4
- Driver motor cycle collision (MCC) = 5
- Passenger MCC = 6
- Pedestrian = 7
- War-related trauma = 8
- Domestic violence = 9
- Other, specify = 10

17. Past Medical and Surgical History

We recorded the medical history of the patients as a categorical variable. Sixteen trauma-relevant items comprised the past medical and surgical history.

- (1) Does the patient has a history of hypertension (HTN)?
    - No = 0
    - Yes = 1
    - Unknown = 9
- (2) Does the patient has a history of diabetes?
    - No = 0
    - Yes = 1
    - Unknown = 9
- (3) Does the patient has a history of coronary artery disease (CAD)?
    - No = 0
    - Yes = 1
    - Unknown = 9
- (4) Does the patient has a history of congestive heart failure (CHF)?

- No = 0
- Yes = 1
- Unknown = 9

- (5) Does the patient has a history of myocardial infarction?
  - No = 0
  - Yes = 1
  - Unknown = 9
- (6) Does the patient has a history of angina?
  - No = 0
  - Yes = 1
  - Unknown = 9
- (7) Does the patient has a history of asthma?
  - No = 0
  - Yes = 1
  - Unknown = 9
- (8) Does the patient has a history of chronic obstructive pulmonary disease (COPD)/emphysema?
  - No = 0
  - Yes = 1
  - Unknown = 9
- (9) Does the patient has a history of seizures?
  - No = 0
  - Yes = 1
  - Unknown = 9

- (10) Does the patient has a history of stroke?
    - No = 0
    - Yes = 1
    - Unknown = 9
- (11) Does the patient has a history of physical handicap? Please specify
    - No = 0
    - Yes = 1
    - Unknown = 9
- (12) Does the patient has a history of kidney problem/failure?
    - No = 0
    - Yes = 1
    - Unknown = 9
- (13) Does the patient has a history of cancer? Please specify
    - No = 0
    - Yes = 1
    - Unknown = 9
- (14) Does the patient has a history of psychiatric problems (schizophrenia/MDD/…)?
    - No = 0
    - Yes = 1
    - Unknown = 9
- (15) Does the patient has a history of bleeding tendency?
    - No = 0
    - Yes = 1

- Unknown = 9

- (16) Does the patient has a history of previous trauma?
  - No = 0
  - Yes = 1
  - Unknown = 9
- (17) Does the patient has a history of surgeries? Please specify
  - No = 0
  - Yes = 1
  - Unknown = 9

18. Home Medications

We recorded if the patients were taking any anticoagulant/antiplatelet as part of their routine medications prior to injury onset. The variables upon which the assessment is based are:

- (1) Does the patient take any Vitamin K inhibitor (Warfarin /Coumadin /Sintrom)?
  - No = 0
  - Yes = 1
- (2) Does the patient take any clotting factor Xa inhibitor (Lovenox /Innohep /Low molecular weight heparin(LMWH)/Heparin)?
  - No = 0
  - Yes = 1
- (3) Does the patient take any platelet cyclooxygenase (COX) inhibitor (Aspirin)?
  - No = 0

- Yes = 1

- (4) Does the patient take any Adenosine diphosphate (ADP) receptor inhibitors (Plavix/Clopidogrel /Parsugrel/Ticagleror/Pradaxa)?
    - No = 0
    - Yes = 1
- (5) Does the patient take any other anticoagulant/antiplatelet medication? Please specify
    - No = 0
    - Yes = 1

19. ED Discharge Disposition

We recorded discharge disposition from ED as a categorical variable. The eight categories of our variable are:

- Home = 1
- Left against medical advice = 2
- Transferred to another hospital = 3
- Admitted to ICU = 4
- Admitted to OR = 5
- Admitted to Floor = 6
- Death on arrival = 7
- Death in ED = 8

20. Procedures During Hospital Course

We recorded procedures during hospital course as categorical variables. The variables upon which the assessment is based are:

- (1) Was endotracheal intubation done in the ED?
    - No = 0
    - Yes = 1
- (2) Was endotracheal intubation done during the in-hospital stay?
    - No = 0
    - Yes = 1
- (3) Was central venous access done in the ED?
    - No = 0
    - Yes = 1
- (4) Was central venous access done during the in-hospital stay?
    - No = 0
    - Yes = 1
- (5) Was arterial lines placement in the ED?
    - No = 0
    - Yes = 1
- (6) Was arterial lines placement done during the in-hospital stay?
    - No = 0
    - Yes = 1
- (7) Was tube thoracostomy done in the ED?
    - No = 0
    - Yes = 1
- (8) Was tube thoracostomy done during the in-hospital stay?
    - No = 0
    - Yes = 1

- (9) Was thoracotomy done in the ED?
    - No = 0
    - Yes = 1
- (10) Was thoracotomy done during the in-hospital stay?
    - No = 0
    - Yes = 1
- (11) Was exploratory laparotomy done via ED admission?
    - No = 0
    - Yes = 1
- (12) Was exploratory laparotomy during the in-hospital stay?
    - No = 0
    - Yes = 1
- (13) Was any other procedure done via ED admission? Please specify
    - No = 0
    - Yes = 1
- (14) Was any other procedure done during the in-hospital stay? Please specify
    - No = 0
    - Yes = 1

21. Transfusion

We recorded the number of transfusion units during hospital course as a numerical variable that can take any natural number value. The variables upon which the assessment is based are:

- The number of blood unit transfused in the ED

- The number of blood unit transfused during in-hospital stay
- The number of platelet units transfused in the ED
- The number of platelet units transfused during in-hospital stay
- The number of fresh frozen plasma (FFP) units transfused in the ED
- The number of fresh frozen plasma (FFP) units transfused during in-hospital stay

22. Complications

We recorded the complications during the total hospital stay as categorical variables. The variables upon which the assessment is based are:

- (1) Did the patient sustain any kidney failure during the hospital course?
    - No = 0
    - Yes = 1
- (2) Did the patient sustain any shock during the hospital course?
    - No = 0
    - Yes = 1
- (3) Did the patient sustain any cardiac arrest during the hospital course?
    - No = 0
    - Yes = 1
- (4) Did the patient sustain any myocardial infarction during the hospital course?
    - No = 0
    - Yes = 1
- (5) Did the patient sustain any coagulopathy/disseminated intravascular

coagulation (DIC) during the hospital course?

- No = 0
- Yes = 1

- (6) Did the patient sustain any acute respiratory distress syndrome (ARDS) during the hospital course?
    - No = 0
    - Yes = 1
- (7) Did the patient sustain any wound infection during the hospital course?
    - No = 0
    - Yes = 1
- (8) Did the patient sustain any urinary infection during the hospital course?
    - No = 0
    - Yes = 1
- (9) Did the patient sustain any pneumonia during the hospital course?
    - No = 0
    - Yes = 1
- (10) Did the patient sustain any intra-abdominal abscess during the hospital course?
    - No = 0
    - Yes = 1
- (11) Did the patient sustain any sepsis during the hospital course?
    - No = 0
    - Yes = 1
- (12) Did the patient sustain any rebleed during the hospital course?

- No = 0
- Yes = 1

- (13) Did the patient sustain any gastritis during the hospital course?
    - No = 0
    - Yes = 1
- (14) Did the patient sustain any other complication during the hospital course? Please specify
    - No = 0
    - Yes = 1

23. Hospital Discharge Destination

We recorded hospital discharge destination as a categorical variable. The five categories of our variable are:

- Home = 1
- Dead = 2
- Transferred to another hospital = 3
- Other =4. Please specify
- Unknown destination = 5

F. Data Storage and Confidentiality

All data, when transcribed from the electronic health records (EHR), has been assigned a study number that makes it unidentifiable, and hence maintains confidentiality for patients. Computer systems inside AUBMC have been used for data entry, cleaning, management, and analysis. Physical forms of the collected data sheets have been stored in a safe place at the ED research unit accessed only by designated researchers

G. Analysis Plan

We entered data into a Microsoft Excel spreadsheet which has been designed specifically for this study. After that, data was transferred into the Statistical Package for Social Sciences (SPSS, version 24) which was used for data cleaning, management, and analyses.

We did a descriptive analyses by calculating the mean and standard deviation for continuous variables (age, ESI score at triage, ISS score, total acute cost, etc), and number and percentage for categorical ones (gender, nationality, marital status, class of admission, smoking status, insurance type, police informed, past medical history, discharge disposition, procedures done in ED, etc).

We did inferential statistics, mainly bivariate analyses using the Chi-square test for categorical variables and independent Student's t-test for continuous ones to assess any possible effect modifiers (for example the insurance type can affect the acute cost of care) or confounders/mediators (mechanism of injury such penetrating or blunt trauma can affect the ISS score and the cost of care).

For the primary objective, we studied the correlation between the continuous ISS score (range of 0-75) and the acute cost of care in United States Dollars (USD) via Pearson r correlation statistic assuming normal distribution (hence parametric distribution).

After that, a multivariate analysis was carried out to identify predictors while controlling for potentially confounding/moderator variables, more specifically, multivariate linear regression analyses was used with backward stepwise elimination.

The results will be reported using B, with the associated confidence interval. Backward stepwise elimination is a stepwise regression approach that begins with a full (saturated) model and at each step gradually eliminates variables from the regression model to find a reduced model that best explains the data. It starts with deleting the variable (if any) whose loss gives the most statistically insignificant deterioration of the model fit, and repeating this process until no further variables can be deleted without a statistically insignificant loss of fit (Hocking, 1976). In that matter, this regression removes the variable with the least significance at each level. In our model, we determined ($P<0.15$) to be the significant level to account for problems in stepwise regression that removes significant variables. The stepwise approach is useful because it reduces the number of co-variates, reducing the multicollinearity problem and it is one of the ways to resolve the overfitting. The goal of the model is to develop a predictive model for healthcare resources use especially for flow work in the ED.

Also, a subgroup analysis was performed to assess the relation of acute cost of care with the three categories of ISS (0-4: minor, 5-15: moderate, and ≥16 major trauma). P-values <0.05 will indicate statistical significance.

CHAPTER IV

RESULTS

A. Sample Characteristics

1. Demographic Data

The total Sample of the database from 2008 to 2013 included 431 patients with a mean age of 32.77 years. The youngest being 1 year and the eldest 98 years as shown in Table 1.1.

Figure 1.1 provides the histogram about the sample age distribution. More than 50% of the population are younger than 26 years. And almost quarter of the trauma patients are between 4 and 18 years of age.

Table 1.2 provides the basic demographics of sample. Male to female ratio was 1.6 times. Most of the patients were of Lebanese nationality (87%), one third were married (30.4%), and majority were not admitted to the hospital (88.2%). More than one third of trauma patients were self-payers (35%), while half of them were covered by private insurance (50%), and the rest were either covered by the hospital insurance scheme known as HIP or NSSF and other forms (15%).

2. Injury Description

The place of injury for 40% of trauma patients occurred at home (Table 2.1). Only 11.1 % of injuries occurred on motorways, and the rest were of very low percentages, or not documented where (38.7%). Police were informed in nearly 9% of the cases. Intentional injuries comprised a low percentage of 2.3%. Only 7.9% of patients arrived via EMS transport, while the majority presented by their private transportation.

Majority of the injuries occurred via blunt mechanism (65.4%) whereas 21% occurred via penetrating mechanisms, and almost 8% had a motor vehicle/bike involvement. For patients who need a form of immobilisation, only neck collar was used on nearly 2% of cases.

The ESI score, as noted in methods section, denotes the triage severity index with the highest number meaning less need of resources and hence less urgency. Only 0.5% of cases required immediate life-saving intervention (ESI 1). Nearly 8% of cases were involved in high risk situation, confused/lethargic/disoriented, or in severe pain/distress (ESI 2). 40% of cases required many resources (ESI 3), and almost 50% required one resource (ESI 4). 2.6% required no resource (ESI 5).

Table 2.2 shows the ESI score average, which was 3.45, hence required one or many resources.

3. Past Medical and Surgical History

Table 3.1 shows the history of medical and surgical diseases of the sample prior to trauma. Nearly 38% confirmed the existence of one or more medical or surgical problems. Of the total of 431 patients, the diseases prevalence was: HTN 13%, Diabetes 7%, CAD 5.8%, CHF 2.6%, myocardial infarction 0.2%, angina 0.5%, asthma 2.3%, COPD 0.7%, seizures 1.9%, stroke 0.2%, physical handicap 1.2%, kidney disease 0.7%, cancer 3.2%, psychiatric diseases 2.1%, bleeding tendency 0.5%, previous trauma 1.2%, osteoporosis 0.2%, dyslipidaemia 1.4%, and almost one third of the patients had a previous surgery (29%).

Table 3.2 shows the intake of blood thinners which was confirmed in 9% of cases. Aspirin was taken by 5.8% of patients, Vitamin K antagonists (Warfarin/ Coumadin/ Sintrom) 1.6%, NOACs (Plavix/ Clopidogrel/ Parasugrel/ Ticagrelor/ Pradexa) 8%, and no patients took heparin or any of its derivatives (Lovenox/ Innohep/ LMWH/ Heparin).

4. *ED Evaluation*

The ISS mean score of the sample was 6.399 (±7.794) (Table 4.1). The histogram shows that more than half of the total sample, 228 out of 431 patients, score between 4 and 6 on the ISS score (Figure 2.1). Table 4.2 displays ED evaluation items. Minor traumas with ISS ≤4 constituted 60.3%, moderate traumas with ISS 5-15 33.4%, and major traumas with ISS ≥16 6.3%.

Laboratory studies in ED were carried out on 12.8% of patients. X-rays were performed 45.2% of patients, with extremities receiving most of the share at almost 40% out of the total sample. CT imaging was performed on nearly 11% of the patients, with head scans being performed in most of these; 10% of total sample.

Majority of patients were discharged from ED to home (84.5%). Around 12 % of patients were admitted to the hospital either to ICU, OR or surgical floor. Only one death occurred in ED. Only 1.2% of patients received an invasive medical procedure in ED: Endotracheal intubation 0.5%, Foley catheter 0.7%, and OG line 0.2%.

5. *Hospital Evaluation*

Table 5.1 shows the procedures performed in the hospital. Of the 49 admitted patients, nearly half received an invasive procedure; a surgical intervention (48.9%), endootracheal intubation 4.1%, central venous access 2%, arterial line placement 4.1%, and tube thoracostomy 2.1%.

Complications were noted on 43% of the admitted patients, with urinary infection comprising 8.2%, similarly pneumonia 8.2%, kidney failure 6.1% and sepsis 4.1%.

6. Disposition and Outcome

Of the 49 admitted patients, the majority were discharged home (87.8%), 6.1% were transferred to another hospital, and 6.1% died (Table 6.1).

B. Covariates Affecting Acute Cost of Care

1. ISS and Acute Cost of Care

ISS, as the main predictor, was categorized into minor (1-4), moderate (5-15), and severe (>16). Relationship between numerical ISS (1-75) and cost was analysed. For all patients, we analysed the linear relationship between uncategorised ISS score and cost (Table 7.1). The result showed that there is a positive association between cost and ISS in statistically significant manner ($P<0.001$). ISS can explain 7.8 percent of the change in cost. Also, when ISS is grouped into three levels of severity, there was a positive association with cost for all patients (Table 7.2). Minor injuries cost on average $230, moderate injuries $982, and severe injuries $16431.

For patients who were admitted, a similar pattern was observed between ISS and cost (Table 7.3). The result showed that there is a significant positive association between cost and ISS ($P=0.036$). ISS can explain 9 percent of the change in cost. Also, when ISS is grouped into three levels of severity, there was a positive association with cost for admitted patients (Table 7.4). Minor injuries costed on average $751, moderate injuries $3,613, and severe injuries $23,007 (Figure 3.1).

2. Other Covariates and Acute Cost of Care

As well as ISS, which was the primary covariate investigated, univariate linear regression with coefficient factor (B) and P-value as a measure of significance was used to assess the individual relationship between cost and all other covariates (Table 8.1); results were recorded as unadjusted values. Statistically significant covariates (summarized in Table 8.2) (a cut-off p-value of 0.15 was used) were included in the final multivariate linear regression to explore the relationship between cost as a primary outcome and its association with the statistically significant covariates (using adjusted ORs). The reason we included results up to a significant level of P ≤0.15, is to make sure we don't miss any of the significant covariates that might affect the cost when we consider the full model.

Among all covariates, ISS, age, married status, class of admission, self-payment, home injury, EMS transport, ESI, history of hypertension, history of diabetes, history of CAD, history of COPD, history of cancer, history of previous surgery, intake of Aspirin, undertaking ED labs, receiving X-rays, receiving CT scans, receiving ED procedures, receiving hospital procedures, were associated positively with increase in cost in a statistically significantly manner (Table 8.2).

As mentioned earlier, in order to calculate distance to AUBMC, the location of injuries was transcribed into google maps using python language inputs. Python allowed the transcription of the words of location into coordinates on map. The accuracy of the location was checked manually. The distance was then calculated from site of injuries (home taken as the location) to AUBMC using google maps platform. Results of the map are displayed in Figure 4.1 and Figure 4.2 (link in Appendix F).

3. *Multivariate Linear Regression*

All the significant covariates identified from the univariate linear regression were included in the multivariate linear regression for cost (Table 8.3). The multivariate regression has identified ISS, class of admission, EMS transport, history of Diabetes, history of CAD, history of COPD, history of cancer, undertaking ED labs, receiving ED procedures, and receiving hospital procedures, as associated positively with increase in cost in a statistically significantly manner, when all co-variates are studied all-together.

4. *Confounders/Moderators and ISS*

As a second step, we also used univariate linear regression to explore the relationship between other clinically significant variables that might be associated with increase in ISS (as a continuous variable) Table 9.1. These variables were included to account for any change in cost that might be indirectly related to change in ISS. Hence, these variables are those that can potentially affect injury severity: age, gender, marital status, smoking status, alcohol consumption, distance to AUBMC, injury place, ESI, mechanism of injury, transport injuries, past medical/surgical history, and intake of blood thinners. Among these variables; the following were statistically significant (a cut-off p-value of 0.15 was used): age, gender, marital status, ESI, mechanism of injury, transport injuries, history of hypertension, history of diabetes, history of CAD, history of CHF, history of COPD, history of cancer, history of trauma, history of previous surgery, intake of Warfarin/Coumadin/Sintrome, and intake of Aspirin. They were summarized in Table 9.2 for clarity purposes.

5. *Final Multivariate Linear Regression Model for Cost with ISS*

Combing the significant variables that affect ISS (Table 9.2) with the covariates that affect the cost (Table 8.3), we did the final multivariate linear regression model that predicts the cost (using adjusted ORs). The use of adjusted ORs takes into consideration the effect of all co-variates on cost, rather than using the unadjusted ORs which assume a relationship with no other covariates. A backwards stepwise regression method was used to remove variables that were not significant in the model (Table 10.1).

In addition to ISS, the cost of care can be predicted using the below equation, based on the significant co-factors.

Final Equation that predicts cost of care: $Cost = 1878.08 - 2445\,(ISS\ category) + 9923.998\,(EMS\ Yes/No) + 6383\,(Class\ of\ Admission) + 8019.849\,(Diabetes\ Yes/No) + 7808\,(CAD\ Yes/No) - 14811.674(CHF\ Yes/No) - 15819.461(COPD\ Yes/No) + 19429.831(Cancer\ Yes/No) - 11692.474(ED\ Labs\ Yes/No) + 62535.428\,(Procedures\ ED\ Yes/No) + 10192.152\,(Procedures\ Hospital\ Yes/No)$

6. *ISS and Length of Stay (minutes)*

For all patients (N=403), we analysed the linear relationship between uncategorised ISS score and length of stay in ED (Table 11.1). The result showed that there is a positive association between cost and ISS in statistically significant manner ($P<0.001$). ISS can explain 9.8 percent of the change in length of stay in ED. Also, when ISS is grouped into three levels of severity, there was a positive association with length of stay in ED for all patients (Table 11.2). Minor injuries in ED stayed on average 88.72 minutes, moderate injuries 130.28 minutes, and severe injuries 497.56 minutes.

For patients who were admitted (N=49), a different pattern was observed between ISS and length of stay in hospital (Table 11.3). The result showed that there is very poor association between length of stay in hospital and ISS in statistically non-significant manner ($P=0.853$). ISS can explain 0.1 percent of the change in cost. Also, when ISS is grouped into three levels of severity, there was very poor association with length of stay for admitted patients (Table 11.4). Minor injuries stayed on average 2024 minutes (1.4 days), moderate injuries 23246 minutes (16.14 days), and severe injuries 16852 minutes (11.7 days).

CHAPTER V

DISCUSSION

A. Summary of Findings

The goal of this thesis was to examine the association severity of injury and the economic burden of trauma. We hypothesized that the increase in the severity of trauma would increase the cost of care and length of stay. Our findings suggest that there is a positive association between ISS and cost ($R=0.279$, $R^2=0.078$, $P<0.001$). ISS can explain 7.8 percent of the change in cost. Similarly, when ISS was grouped into three levels of severity, there was a positive association with cost for all subgroups. Minor injuries costed on average $230, moderate injuries $982, and severe injuries $1,6431 per admission. The use of EMS, class of admission, presence of specific comorbidities (diabetes, CAD, CHF, COPD, and cancer), performing ED labs, procedures in ED and procedures in hospital significantly affects the cost. It is important to note that the location of injury was not associated with the cost of care. There was a positive association between ISS and Length of Stay in ED ($R=0.313$, $R2=0.098$, $P<0.001$). ISS can explain 9.8 percent of length of stay in ED.

In (Hyp1), we hypothesized that the increase in the severity of trauma described as an increase in ISS score will be significantly associated with the increase in the acute cost of care of patients presenting to the hospital through ED. Our analysis shows that after controlling for effect modifiers and confounders, acute cost of care association with ISS was statistically significant. The association was similar to patients who were admitted or discharged from ED. Of significance was the finding that patient presenting via EMS and have past medical problems will sustain higher cost of care. We thus accept (Hyp1).

In (Hyp2), we hypothesized that the increase in the severity of trauma described as an increase in ISS score will be significantly associated with the increase in the length of stay of patients presenting to the hospital through ED. Our analysis shows that length of stay in ED association with ISS was statistically significant. Of significance finding is that patients who were admitted to the hospital had no association between length of stay and ISS. We thus accept (Hyp2).

Following are outlined the major findings comparing and contrasting to literature.

B. Sample Characteristics Comparison to Literature

The mean age of our sample was 33 years, indicating that trauma, in general, is a disease of the youth, similar to the conclusion derived by GBD study (2017). This finding is slightly different from the local data obtained from the study by Tamim et al. (2006) that indicated that the mean age was 44 years. Observing the histogram of our data (Figure 1.1), the number of injuries decreases with increasing age, except age group 20-24, where we have the highest frequency of cases holding 54 injuries. This pattern is again similar to the GBD study (2017) that noted age groups 20-24 and 25-29 as holding the highest frequency of injuries, and there is a similar gradual decrease over subsequent age groups as mentioned in the background section.

The male to female ratio in our study is 1.6. This finding is similar to the local data obtained by Tamim et al. (2006), and Tamim, Al Hazzouri, Mahfoud, Atoui & El-Chemaly (2008) that showed male to female ratio was 1.8. This consistent trend is similar to the global data that shows injuries are significantly more frequent in males than females (Roth et al. 2018).

More than half of the trauma patients (56.6%) who attended AUBMC were privately insured (private and HIP), while only 8.3 % had public insurance, and 35% were self-payers. Compared to the data from Tamim et al. (2006), the private coverage has increased slightly from 53.1%, while public insurance has decreased from 13.2% with increased contribution of out-of-pocket expenditure 23.2%.

C. Injury Description

Transport injuries comprised 8% of total injuries, while GBD data shows that 30% of injuries were due to transport. Local data is reported at 20.2% by Tamim et al. (2006) and 20.4% by Tamim, Al Hazzouri, Mahfoud, Atoui & El-Chemaly (2008). Blunt trauma and penetrating trauma constituted 65% and 21% respectively. Local data of trauma patients at AUBMC has reported that the striking majority of traumas (91%) are blunt, and only 8.9% are penetrating. These figures are the inverse of the numbers observed in trauma patients who attended AUBMC during the civil war, where penetrating injuries comprised most cases at 90%, and 9% of cases were blunt (Nassoura et al. 1991). Intentional injuries comprised 2.3% of cases, a modest number compared to the global figures of 30% (Roth et al., 2018).

Only 8% of total cases arrived via pre-hospital EMS service with 24% of these cases (1.9% of total cases) having cervical collar immobilisation.

ISS was available for the full sample of 431 patients. The mean ISS score was 6.399 , and standard deviation (SD) (7.8), indicating moderate injuries, a finding already supported in the literature where trauma patients at AUBMC had a mean score of 7.99 (SD 6.51) (Tamim et al., 2006). Minor traumas constituted 60.3 %, moderate traumas 33.4%, and major traumas 6.3%. These numbers are different than reported in literature as Tamil et al. (2006) report mild, moderate and severe injuries constituted 37.6%, 42.8%, and 12.1% respectively.

The number of deaths in our study was 3, and all patients sustained a major trauma (ISS≥16). No death was reported in lower severity injuries. This finding is in line with previous reports in the literature that showed that ISS is positively associated with mortality in different geographical areas and trauma settings (Bull, 1975; Threlfall, Stoner, & Galasko, 1981; Brismar & Bergenwald, 1982; Goris & Draaisina, 1982; Beverland & Rutherford, 1983, Copes at al., 1988; Foreman at al., 2007).

D. Covariates Affecting Acute Cost of Care

Our study has shown that there is a significant correlation between ISS and acute cost of care, with the former explaining 8% of the change in cost. This finding that cost increases with increasing severity of trauma (increase ISS) is in line with the literature (Chapter II, SectionB.3.a.iv). The average cost was $1496, with transport injuries costing on average $1078, and major traumas $16431. Compared to the developed world, the cost of major traumas falls below the median cost of major trauma of $22,448, but close to the UK that spends $18535 (Willenberg et al., 2012). For transport injuries, the mean cost falls below Jordan $4200, China $4330, and Thailand $3000, but above Vietnam that spends on average $365 on road traffic accident injuries. The average cost of injuries of $1496 constitutes 10% of the GDP per capita in Lebanon which is $14678 and is higher than the cost of healthcare per capita quoted as $1207 (Dieleman et al., 2017).

We have demonstrated that acute cost increases with ISS on all patients. This finding in a developing country like Lebanon validates the only study, to our knowledge, that addresses the trauma cost association with ISS in a similar developing country. Kaya, Ozguc, Tokyay & Yunuk (1999) have validated ISS in predicting trauma scores on 347 patients in Turkey. The cost of trauma care per patient was $1577, similar to our findings $1496. However, the study by Kaya, Ozguc, Tokyay & Yunuk (1999) did not address the effect of other cofounders and effect modifiers on cost.

One of the main objectives of our project was to find other predictors of the cost than ISS. We have clearly shown that, even after adjusting for cofounders, ISS is significantly associated with an increase in cost. For this reason, we analyzed the effect modifiers that affect the cost, then analyzed the confounders that affect ISS. The final step was to include the significant cofounders that affect the ISS in the multivariate analysis of cost that includes the significant effect modifiers.

The final model that predicts the cost has shown a significant association, in addition to ISS, of many other covariates. The use of EMS, class of admission, presence of specific comorbidities (diabetes, CAD, CHF, COPD, and cancer), performing ED labs, procedures in ED and procedures in hospital significantly affects the cost. The literature supports these results. Willenberg et al. (2012) did a comprehensive review about the use of ISS as a predictor of cost in high-income countries (US, Australia, Europe, and the UK) specifies ISS, surgical intervention, hospital and intensive care length of stay, polytrauma and age as predictors of cost. However, our equation shows a negative association of the cost with ISS category, history of CHF, history of COPD and ED labs performance. $\text{Expected Cost} = 1878.08 - 2445\ (\text{ISS category}) + 9923.998\ (\text{EMS Yes/No}) + 6383\ (\text{Class of Admission}) + 8019.849\ (\text{Diabetes Yes/No}) + 7808\ (\text{CAD Yes/No}) - 14811.674(\text{CHF Yes/No}) - 15819.461(\text{COPD Yes/No}) + 19429.831(\text{Cancer Yes/}$

No) – 11692.474(ED Labs Yes/No) + 62535.428 (Procedures ED Yes/No) + 10192.152 (Procedures Hospital Yes/No). This might seem to be counter-intuitive and even against our claim; however, the model predicts the cost while all factors affecting each other, while the individual effect of each significant variable on cost is in the positive direction (Table 8.2). To test our claims, we will use two examples in which these variables align with a reasonable clinical presentation of two hypothetical patients that are different in the severity of injury hence ISS category. The first patient has a minor injury as they sustained a wrist fracture and received admission for wrist manipulation and reduction; so the ISS category would be 1, EMS arrival would be no (0), had an admission to the hospital (1), Not diabetic (0), No CAD (0), No CHF (0), No COPD (0), No cancer (0), had ED labs (1), No procedures in the ED (0), and had procedures in the hospital (1). The expected cost would be $4316. The second patient has a severe injury. They sustained a fall, have significant comorbidities (CHF, COPD), required intubation and admission for OR; so the ISS category would be 3, EMS arrival would be yes (1), had an admission to the hospital (1), Not diabetic (0), No CAD (0), has CHF (1), has COPD (1), No cancer (0), had ED labs (1), had procedures in the ED (1), and had procedures in the hospital (1). The expected cost would be $41254.049. We have demonstrated that the cost also increases with ISS for admitted patients, with ISS explaining 9% of the change in cost. The average cost was $11075, with major traumas costing $23007. The cost is higher for each ISS category compared to all patients.

E. ISS and Length of Stay

One of the objectives of our study was to find the relationship between ISS and total LOS in hospital. So we divided the LOS into LOS in ED and LOS in the hospital.

To start with, we looked at the number of admission from each category of ISS. As mentioned earlier, from the total ED attendances (N=430), minor injuries constituted 260 cases (60.3%), 144 (33.4%) for moderate ISS, and 27 (6.3%) for major traumas. Of these 431 injuries, a total of 49 cases are admitted to the hospital (11.4%), distributed as 1 case for minor injuries (0.38% of total minor injuries), 29 for moderate (20.1% of total moderate injuries), and 19 (70.4% of total major injuries). This shows that major traumas are more likely to be admitted to the hospital.

We found that there is a significant increase in LOS in ED with an increase of ISS. ISS can explain 9.8% of the LOS in ED (Table 11.1). The model of relationship can be put as expected LOS in ED = 71.5+ 8.9 (ISS score). Hence a patient with ISS of 4, a minor trauma, is expected to stay 107.1 minutes in ED. The average is 88.7 minutes for minor trauma (Table 11.2). A patient with an ISS of 10, a moderate trauma, will stay 160.5 minutes, while the group average is 130.3 minutes for moderate trauma. A major trauma of ISS of 20 is likely to stay 249.5 minutes; the average for this group is 497.6 minutes. This finding aligns with the known literature that suggests ISS as a good predictor of LOS in trauma patients (Yousefzadeh chabok, Ranjbar taklimie, Malekpouri & Razzaghi, 2017; Ghag & Jagdale, 2018). Of significant finding in our study is that there is a very poor association between ISS and LOS in hospital (P=0.853). ISS can explain 0.1 percent of the change in LOS. Also, when ISS is grouped into three levels of severity, there was a very poor association with LOS for admitted patients (Table 11.4). Minor injuries stayed on average 2024 minutes (1.4 days), moderate injuries 23246 minutes (16.14 days), and severe injuries 16852 minutes (11.7 days). This could be explained due to the fact that severely injured patients have higher mortality in general, and in our study, the three mortalities that were sustained from 19 admitted patients (15.8%), were major traumas. This statistically significant compared to 0% in both minor and moderate injuries. Taking that into consideration, we can understand how moderate injuries stayed longer in hospital.

F. Strengths and Limitations

Our work has several strengths. We used homogeneous definitions of trauma in order to retrieve as much data from our systems as possible; ICD and WHO definitions. Also, we used homogeneous classification of trauma-based on the ISS that utilizes AIS. This has increased the comparability to the literature and allowed the quantification of the trauma burden to be more scientifically relevant. Moreover, the data collection was monitored for quality and cross-checked by the two data abstractors (Appendix E). Our study pioneers the use of geolocation of injuries to explore the association of location of the injury on the cost of care. Also, the use of a larger sample size than required to find the association of ISS and cost adds to the validity of our data. Furthermore, our work was able to affirm the known literature in the developed and developing country that demonstrates the association of ISS with the cost of care. However, our study, to our knowledge, is the first study in the developing world and the Middle East to comprehensively investigate the use of ISS and other covariates as a predictor of cost. We were able to detect the association of the use of EMS, pre-existing medical problems, hospital procedures, in addition to ISS in predicting the cost of care. This provides more solid information on the burden of trauma in Lebanon and provides key point interventions for health policymakers. This enabled us to develop a model that predicts the cost of care based on significant covariates.

However, our work has a number of limitations. First, the study is carried at a private medical center. Although the center is considered a tertiary care center, it does not resemble the full depth of the trauma burden in Lebanon. This conclusion stems from the map that shows most injuries were from Beirut district and surrounding (Figure 4.1 and Figure 4.2).

Second, the study did not incorporate LOS as a factor that affects cost. This is for multiple reasons. First, we wanted to check for covariates that affect cost without considering factors that affect each other, to avoid over fitting. Hence, we did not include LOS at the hospital to the final model because it is indirectly incorporated in other factors like the decision to admit, procedures in ED, and procedures in hospitals.

Third, the geolocation property of injuries was based on home location rather than the actual place of injury, as the injury location was not documented. This affects the generalizability of any finding related to location. Also, some cofactors like the age that are considered important in predicting the severity of trauma and cost were absent from the final model, although the univariate association with both ISS and cost was independently significant (Bull, 1975).

Fourth, the study is subject to some bias, the most important of which is non-response bias from missing data. However, our missing data of interest has never exceeded 10%, which makes all collected data eligible to use, and the imputation method was used to replace missing data (Wu & Ashton, 1997).

In addition, the use of the backward stepwise regression has some drawbacks. It does not guarantee to select the best possible combination of variables, and p-values and R^2 outputted by stepwise selection are biased and cannot be trusted. However, to account for that, we rerun the stepwise regression on different subsets of our data, and we noticed that we got the same variables each time.

Finally, since our work relied on retrospective chart review data, is unable to establish causality between ISS severity and cost. Also, at our model needs to be validated, and it cannot be applied to inpatient data, ss it had 49 subjects which is a very small number to base strong conclusions on. Validation in an independent sample that is retrospective would be reasonable. Validation in a prospective sample collected over time would be best. Future longitudinal prospective studies are needed to determine causality between injury severity and cost. However, we understand the limitations of the endeavor of any prospective study as it is impractical to address a potential trauma database in prospective study design (Worster &Haines, 2004).

CHAPTER VI

CONCLUSIONS

A. Implications

Our study has shown that trauma severity is associated with a substantial economic burden on the Lebanese population. The multifactorial effect of comorbidities and lack of appropriate EMS increase the burden, highlighting the need to design an approach that also targets other non-communicable diseases and improves trauma provision.

Trauma research from low-income and middle-income countries (LMICs) showed that injury remains a major public health problem globally, with 90% of all trauma deaths occur in LMICs, where resources to deal with this crisis are inadequate. There is a lack of population-based data to inform local policymakers, and preventive policies are not widely implemented. An efficient and effective trauma system has been found to be a key component.

Our study has shown that the use of EMS services for trauma patients is deficient, highlighting the need to establish a national prehospital system and design an interventional use of the existing volunteer-based systems of the ambulance systems. The EMS system in Lebanon faces numerous challenges with the absence of a lead agency that is statutorily charged with EMS oversight, planning, system assessment, policy development, and regulation (El Sayed & Bayram, 2012). A modest proposal would be the implementation of a single emergency access number similar to 911 in the US and 999 in the UK.

In addition, our study has shown that other NCDs like diabetes, CAD, CHF, and cancer increase the severity and cost of trauma, highlighting the need to have a holistic approach to tackle the trauma burden.

Our work has also provided further robust evidence about the use of ISS with sufficient precision and reproducibility that allows trauma centers to identify best practices that form the foundations of quality improvement programs. For instance, the use of the model suggested for the expected cost allows the billing department to provide patients and insurance companies with an estimated cost upon admission. This also enables patients and their families to prioritize and know expected health expenditure and healthcare-related decisions.

Besides, the use of ISS as a predictor of LOS in ED allows clinicians to make better service planning and carry the most efficient resource allocation. It also allows administration teams to expect better patients' LOS and turnover for bed capacity and availability management.

In its modest implementation, ISS has shown that it can provide a foundation for benchmarking and performance improvement in the arena of trauma care.

B. Future Research

Our work has highlighted the need for more comprehensive prospective studies for the burden of trauma. The need to shed light on the burden of morbidity and mortality of trauma mandates longitudinal prospective studies that tackle the DALYs, YLL, and secondary indirect costs of trauma. These indirect costs involve the loss of productivity after temporary or permanent disability, sick leaves, early retirement, police cost, judiciary inquiries, and claims for damages (Anders et al., 2013).

Longitudinal prospective studies targeting the use of pre-hospital systems, unified trauma protocols, and immobilization devices are needed.

Also, our research was performed at one medical center in Lebanon. There is a need to have more comprehensive data about trauma involving the whole nation's medical centers. This suggests pioneering a national trauma database that harbors all trauma-related data and provides baseline data for prevalence, incidence, and monitoring of trauma burden. This will allow policymakers to understand the burden of trauma better and compare our data morbidity and mortality to international data.

ILLUSTRATIONS

Figure 1.1: Age histogram of the sample

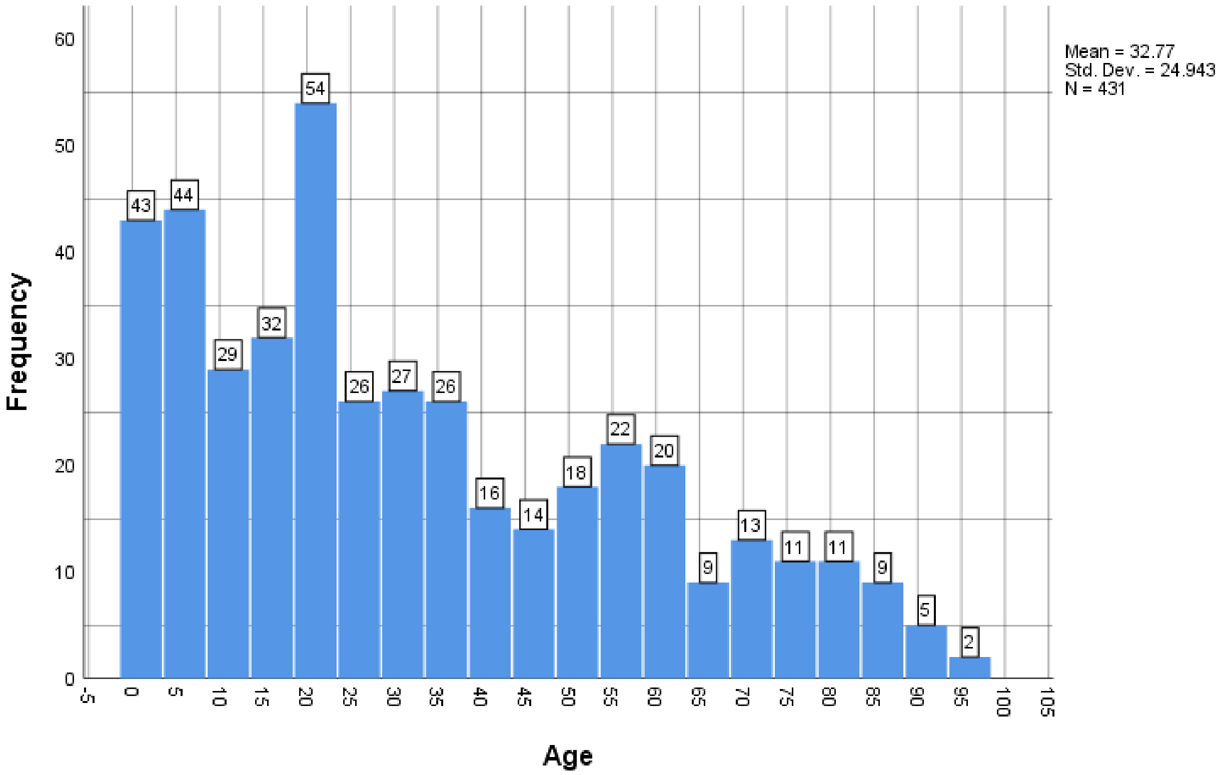


Figure 2.1: ISS histogram

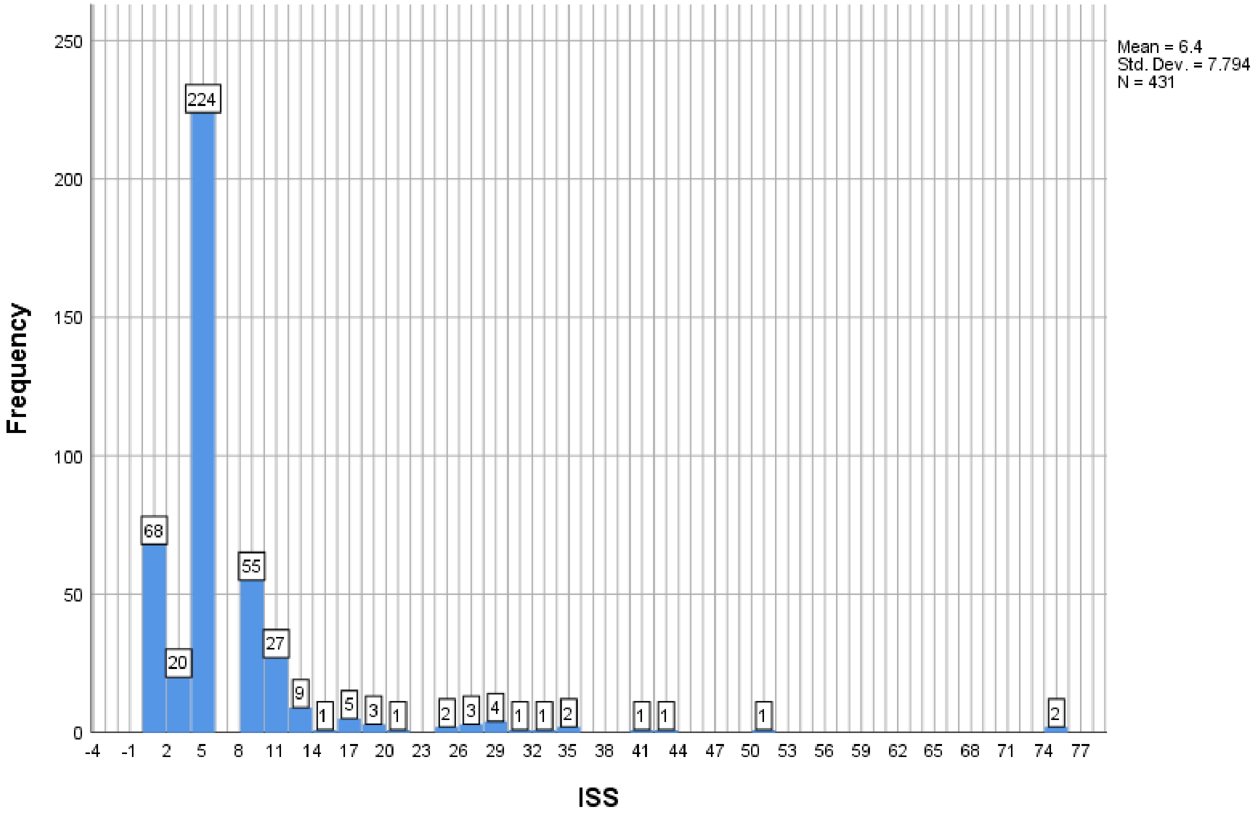


Figure 3.1: The mean cost of ISS Categories

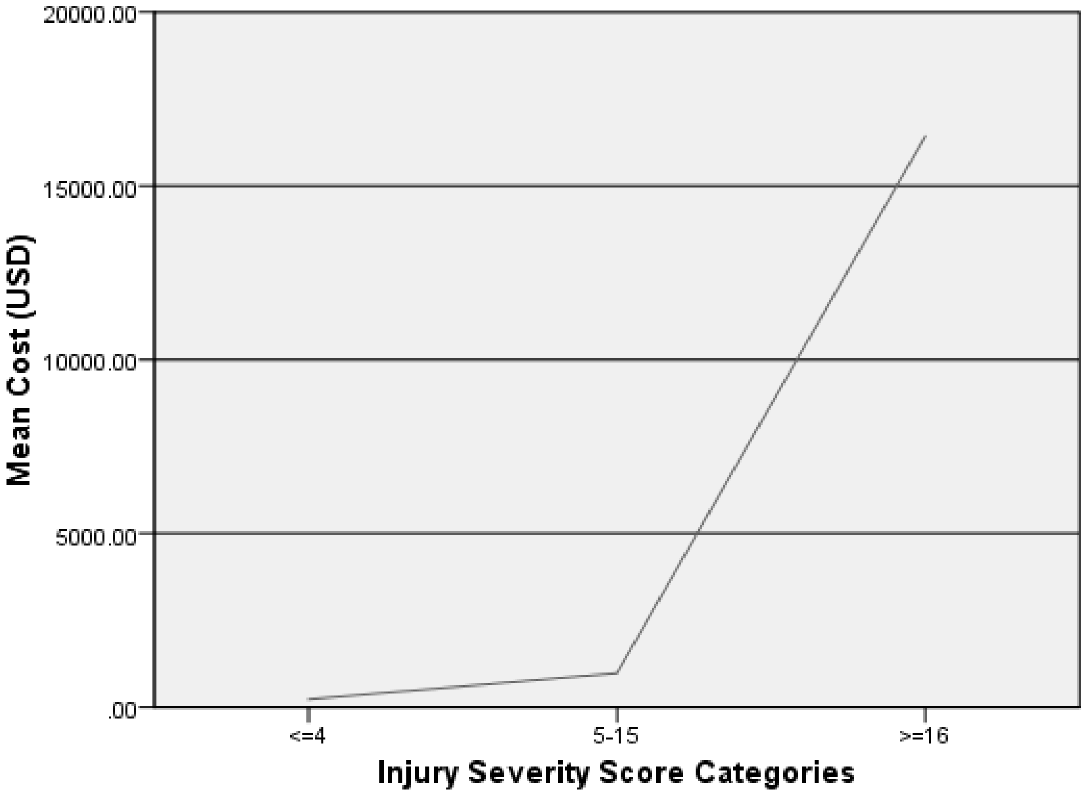


Figure 4.1: The geographical location of injuries on the Lebanese map

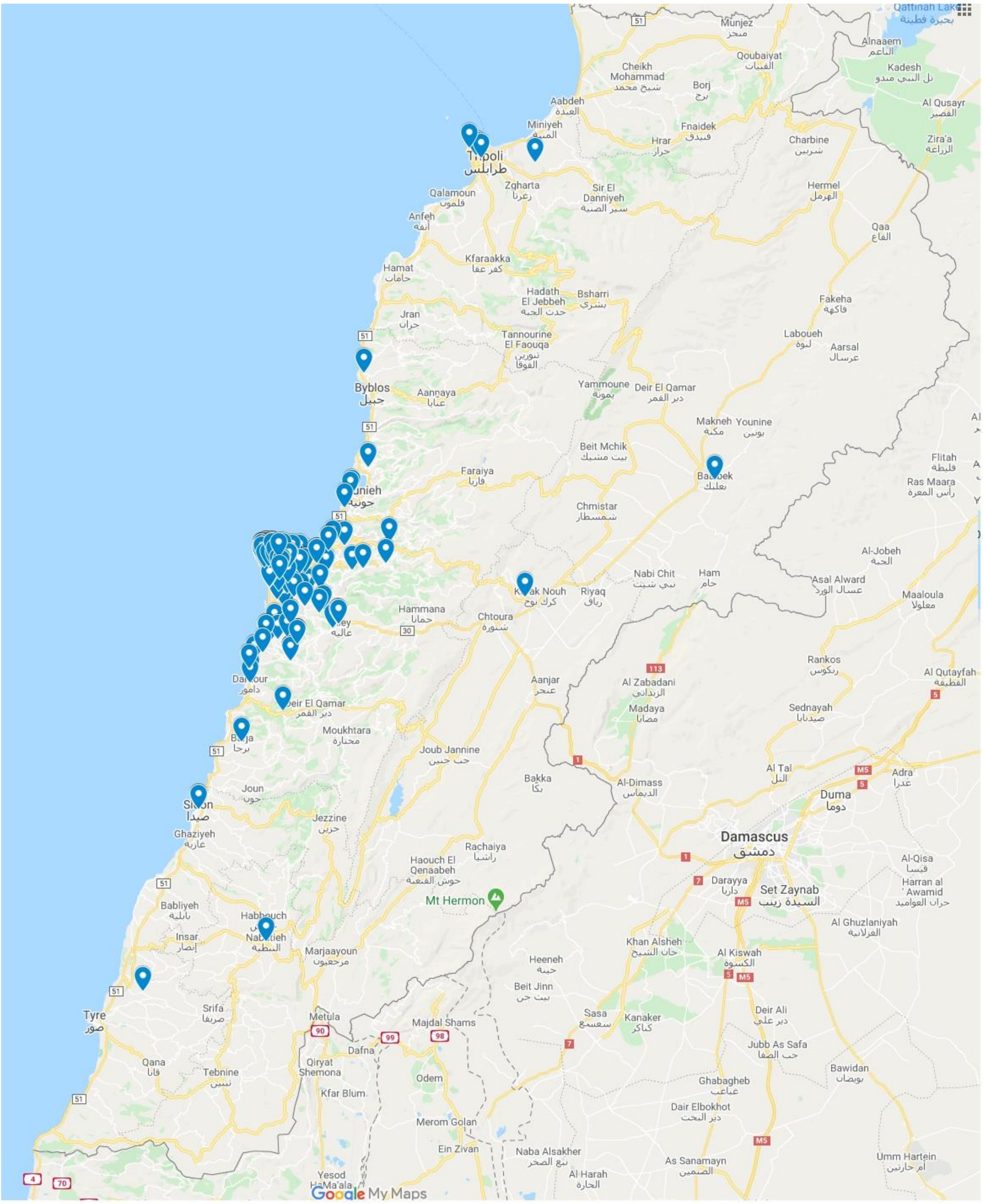
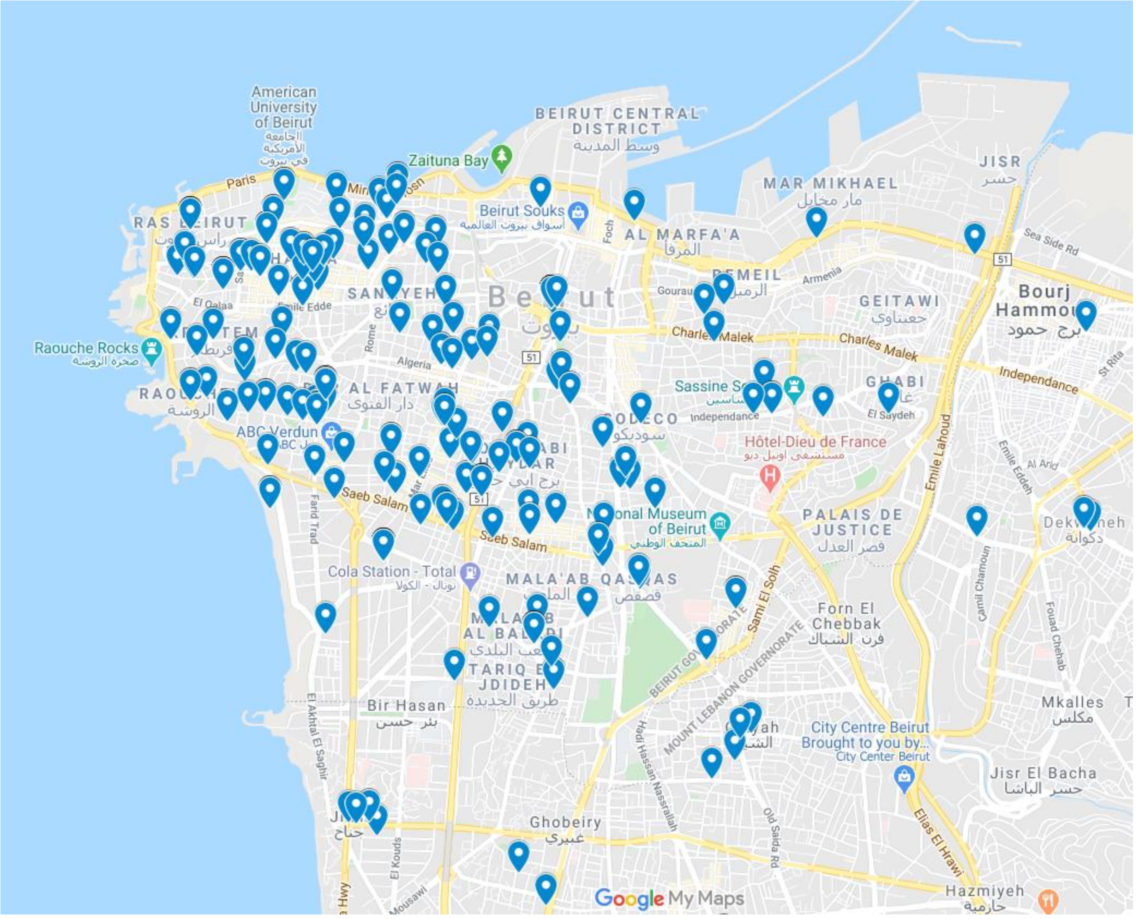


Figure 4.2: The geographical location of injuries on the Greater Beirut



TABLES

Table 1.1: Age characteristics of the sample

	N	Mean	Std. Deviation	Median	Minimum	Maximum
Age	431	32.77	24.943	26	1	98

Table 1.2: Basic demographic data of the sample

		Frequency	Percent
Age	0-3	43	10.0
	4-18	105	24.4
	19-65	228	52.9
	66+	55	12.8
	Total	431	100.0
Gender	Male	263	61.0
	Female	168	39.0
	Total	431	100.0
Nationality	Lebanese	375	87.0
	Non-Lebanese	56	13.0
	Total	431	100.0
Marital Status	Single	300	69.6
	Married	131	30.4
	Total	431	100.0
Class of Admission	First	26	6.0
	Second	13	3.0
	Third	12	2.8
	Not admitted to hospital	380	88.2
	Total	431	100.0
Smoking Status	Non-Smoker	330	76.6
	Smoker	101	23.4
	Total	431	100.0
Alcohol Intake	No	423	98.1
	Yes	8	1.9
	Total	431	100.0
Insurance Type	Private	220	51.0
	NSSF	1	.2
	Self	151	35.0
	Combination with NSSF	7	1.6
	HIP	24	5.6
	Other	28	6.5
	Total	431	100.0

Table 2.1: Injury description characteristics

		Frequency	Percent
Place of Injury	Industrial place	5	1.2
	Recreation/sport	28	6.5
	Street/Highway	48	11.1
	Public building	7	1.6
	Educational institution	2	.5
	Home/residence	172	39.9
	Nursing home	1	.2
	Hospital	1	.2
	Other/Unknown	167	38.7
	Total	431	100.0
Police Informed	No	393	91.2
	Yes	38	8.8
	Total	431	100.0
Cause of Injury	Intentional	10	2.3
	Unintentional	421	97.7
	Total	431	100.0
Mode of Transportation	EMS	34	7.9
	Private	392	91.0
	Walking	3	.7
	Others	2	.5
	Total	431	100.0
Mechanism of Injury	Blunt	282	65.4
	Penetrating	90	20.9
	Driver MVC	10	2.3
	Passenger MVC	10	2.3
	Driver MCC	9	2.1
	Pedestrian	6	1.4
	Domestic violence	1	.2
	Other	23	5.3
	Total	431	100.0
Immobilization	None	423	98.1
	Cervical collar	8	1.9
	Total	431	100.0
ESI	1	2	.5
	2	35	8.1
	3	173	40.1
	4	210	48.7
	5	11	2.6

	Total	431	100.0

Table 2.2: ESI index of the sample

	N	Mean	Std. Deviation	Median	Minimum	Maximum
ESI	431	3.45	0.7	4	1	5

Table 3.1: Past medical and surgical history of the sample

		Frequency	Percent
Past Medical or Surgical disease (one or more)	Yes	164	38.1
	No	267	61.9
	Total	431	100.0
Hypertension	Yes	56	13.0
	No	375	87.0
	Total	431	100.0
Diabetes	Yes	30	7.0
	No	401	93.0
	Total	431	100.0
Coronary Artery Disease	Yes	25	5.8
	No	406	94.2
	Total	431	100.0
Congestive Heart Failure	Yes	11	2.6
	No	420	97.4
	Total	431	100.0
Myocardial Infarction	Yes	1	0.2
	No	430	99.8
	Total	431	100.0
Angina	Yes	2	0.5
	No	429	99.5
	Total	431	100.0
Asthma	Yes	10	2.3
	No	421	97.7
	Total	431	100.0
COPD/Emphesyma	Yes	3	0.7
	No	428	99.3
	Total	431	100.0
Seizures	Yes	8	1.9
	No	423	98.1
	Total	431	100.0
Stroke	Yes	1	0.2
	No	430	99.8
	Total	431	100.0
Physical Handicap	Yes	5	1.2
	No	426	98.8
	Total	431	100.0

Kidney Disease	Yes	3	0.7
	No	428	99.3
	Total	431	100.0
Cancer	Yes	14	3.2
	No	417	96.8
	Total	431	100.0
Psychiatric Problems	Yes	9	2.1
	No	422	97.9
	Total	431	100.0
Bleeding Tendency	Yes	2	0.5
	No	429	99.5
	Total	431	100.0
Previous Trauma	Yes	5	1.2
	No	426	98.8
	Total	431	100.0
Osteoporosis	Yes	1	0.2
	No	430	98.8
	Total	431	100.0
Dyslipidemia	Yes	6	1.4
	No	425	98.6
	Total	431	100.0
Previous Surgery	Yes	126	29.2
	No	305	70.8
	Total	431	100.0

Table 3.2: Intake of blood thinners

Anticoagulant Intake (one or more)	Yes	39	9
	No	392	91
	Total	431	100.0
Aspirin	Yes	25	5.8
	No	406	94.2
	Total	431	100.0
Warfarin/Coumadin/ Sintrom	Yes	7	1.6
	No	424	98.4
	Total	431	100.0
Lovenox/Innohep/LMWH /Heparin	Yes	0	0.0
	No	431	100.0
	Total	431	100.0
Plavix/Clopidogrel/ Parasugrel/ Ticagrelor/Pradexa	Yes	8	98.1
	No	423	1.9
	Total	431	100.0

Table 4.1: ISS characteristics of the sample

	N	Mean	Std. Deviation	Median	Minimum	Maximum
ISS	431	6.399	7.794	4	1	75

Table 4.2: ED evaluation items

		Frequency	Percent
ISS Category	≤4	260	60.3
	5-15	144	33.4
	≥16	27	6.3
	Total	431	100.0
ED labs	Yes	55	12.8
	No	376	87.2
	Total	431	100.0
Radiology	Yes	223	51.7
	No	208	48.3
	Total	431	100.0
Xray	Yes	195	45.2
	No	236	54.8
	Total	431	100.0
	Extremity	171	39.7
	Chest	28	6.5
	Pelvis	15	3.5
	Spine	10	2.3
	Cervical	6	1.4
CT	Yes	46	10.7
	No	385	89.3
	Total	431	100.0
	Head/Neck	43	10.0
	Abdomen/Pelvis	5	1.2
	Chest	4	0.9
	MRI	1	0.2
	CT Angio	1	0.2
Procedure done in ED	Yes	5	1.2
	No	426	98.8
	Total	431	100.0
	Endotracheal intubation	2	0.5
	Foley catheter	3	0.7
	OG line	1	0.2
	Home	364	84.5

ED Discharge Disposition	Left against medical advice	10	2.3
	Transferred to another hospital	7	1.6
	Admitted to ICU	9	2.1
	Admitted to OR	10	2.3
	Admitted to Floor	30	7.0
	Death in ED	1	.2
	Total	431	100.0

Table 5.1: Hospital evaluation items

ISS Category	≤4	1	2.0
	5-15	29	59.2
	≥16	19	38.8
	Total	49	100.0
Procedure done in Hospital	Yes	24	48.9
	No	25	51.1
	Total	49	100.0
	Endotracheal intubation	2	4.1
	Central venous access	1	2.0
	Arterial lines placement	2	4.1
	Tube thoracostomy	1	2.1
	Surgical intervention	24	48.9
Complications	Kidney failure	3	6.1
	Shock	1	2.0
	Cardiac arrest	2	4.1
	Coagulopathy	1	2.0
	Wound infection	2	4.1
	Urinary infection	4	8.2
	Pneumonia	4	8.2
	Sepsis	2	4.1
	Rebleed	1	2.0
	Other (SVT, AKI)	1	2.0
	None	28	57.1

The analysis of the complications was done for patients who were admitted to ICU or to floor or to OR (Total of 49 patients)

Table 6.1: Hospital discharge destination

		Frequency	Percent
Hospital Discharge Destination	Home	43	87.8
	Dead	3	6.1
	Transferred to another hospital	3	6.1
	Total	49	100.0

The analysis of the discharge destination was done for patients who were admitted to ICU or to floor or to OR (Total of 49 patients)

Table 7.1: Cost as function of ISS for all patients

Model	R	R Square	Sig.
1	0.279	.078	.000

Model		Standardized Coefficients	Sig.
1	(Constant)	-2065.178	0.027
	ISS	556.518	.000

Table 7.2: Cost as function of ISS groups for all patients

			Lower CI	Upper CI	Between Groups Sig.
≤4	260	229.920	209.986	249.855	0.00
5-15	144	981.716	309.042	1654.391	
≥16	27	16431.046	-7481.493	40343.587	
Total	431	1496.020	24.555	2967.486	

Table 7.3: Cost as function of ISS for admitted patients

Model	R	R Square	Sig.
1	0.300	.090	.036

Model		Standardized Coefficients	Sig.
1	(Constant)	-6497.403	0.530
	ISS	1025.049	.036

Table 7.4: Cost as function of ISS groups for admitted patients

			Lower CI	Upper CI	Between Groups Sig.
≤4	1	750.910	.	.	0.348
5-15	29	3613.116	296.459	6929.772	
≥16	19	23007.225	-11493.180	57507.630	
Total	49	11074.868	-1955.369	24105.105	

Table 8.1: Univariate linear regression for all covariates in relation to Cost:

		B	P-value	Lower CI	Upper CI
ISS		556.518	<0.001	374.795	738.241
ISS Category	N	Mean Cost			
≤4	260	229.921	<0.001	209.986	249.855
5-15	144	981.717		309.043	1654.39
≥16	27	16431.020		-7481.493	40343.587
Distance to AUBMC		-0.009	0.795	-0.080	0.061
Age		73.683	0.014	14.966	132.400
Age Category	N	Mean Cost			
0-3	43	311.107	0.030	207.062	415.152
4-18	105	540.162		140.368	939.957
19-65	228	751.730		389.943	1113.517
66+	55	1496.020		-4273.069	18938.368
Male Gender		1227.780	0.424	-1790.643	4246.203
Lebanese Nationality		1036.382	0.642	-3344.049	5416.812
Married Status		3081.553	0.058	-107.942	6271.048
Class of Admission		-2050.036	0.031	-3912.399	-187.672
Admission Category	N	Mean Cost			
First	26	2493.092	<0.001	912.803	4073.382
Second	13	3665.408		267.471	7063.345
Third	12	35890.347		-21014.95	92795.649
Not admitted	380	267.447		245.120	289.774
Smoking Status		-461.210	0.794	-3938.843	3016.424
Alcohol Consumption		-1032.896	0.853	-11947.38	9881.589
Distance to AUBMC		-0.009	0.795	0.080	0.061
Insurance Type		282.954	0.561	-672.243	1238.152
Insurance Type Category	N	Mean Cost			
Private	220	594.011	0.767	310.124	877.898
NSSF	1	416.270		.	.
Self	151	3104.591		-1086.172	7295.354
Combination with NSSF	7	2107.260		-1323.828	5538.349
HIP	24	222.467		153.469	291.465
Other	28	885.821		-361.308	2132.950
Self-Payers		2476.049	0.115	-602.935	5555.034
Length of Stay in ED (minutes)		1.380	0.702	-5.697	8.458
Length of Stay in Hospital (minutes)		0.005	0.955	-0.169	0.178
Injury Place		597.669	0.109	-134.436	1329.775
Injury Place Category	N	Mean Cost			

Nursing Home	1	100.000	0.946	.	.
Hospital	1	201.820		.	.
Industrial Place	5	336.827		-138.413	812.067
Recreation	28	349.165		162.344	535.986
Others	167	373.024		168.630	577.420
Education	2	573.660		-1232.654	2379.974
Street	48	813.337		181.060	1445.614
Public Building	7	1490.305		-853.046	3833.656
Home	172	3023.880		-663.304	6711.065
Home Injury		2524.121	0.098	-471.724	5519.996
Police Informed		-554.322	0.834	-5749.801	4641.157
Cause of Injury		-796.881	0.873	-10582.35	8988.593
EMS transport		12902.075	<0.001	7575.847	18228.303
ESI		-3265.877	0.002	-5350.592	-1181.162
Mechanism of Injury		-182.642	0.592	-852.383	487.099
Mechanism Category	N	Mean Cost			
Blunt	282	1879.053	0.999	-362.630	4120.737
Penetrating	90	782.368		171.978	1392.758
Driver MVC	10	294.853		87.873	501.833
Passenger MVC	10	2319.328		-927.465	5566.120
Driver MCC	9	990.475		278.486	1702.463
Pedestrian	6	445.249		-119.805	1010.302
Domestic violence	1	155.172		.	.
Other	23	286.779		176.661	396.897
Past Medical/Surgical History		2602.562	0.091	-421.669	5626.794
HTN		6800.925	0.002	2467.181	11134.669
Diabetes		12453.723	<0.001	6786.644	18120.803
Coronary Artery Disease		13876.603	<0.001	7704.171	20031.035
Congestive Heart Failure		4510.741	0.343	-4820.911	13842.392
Myocardial Infarction		-1195.494	0.939	-31815.04	29424.049
Angina		-444.498	0.968	-22121.11	21232.116
Asthma		-1006.381	0.840	-10791.68	8778.920
COPD		13859.896	0.124	-3810.803	31530.595
Seizure		-1117.396	0.841	-12031.81	9797.013
Stroke		-1225.655	0.937	-31845.19	29393.878
Physical Handicap		-955.470	0.891	-14712.88	12801.94
Kidney Disease		-809.823	0.928	-18529.24	16909.589
Cancer		23151.668	<0.001	15137.292	31166.045
Psychiatric Disease		-1094.276	0.835	-11396.63	9208.076

Bleeding Tendency	-12.955	0.934	-322.226	296.316
Trauma	14.615	0.807	-103.111	132.342
Osteoporosis	-1430.339	0.927	-32049.79	29189.113
Dyslipidemia	-1296.064	0.840	-13869.24	11277.114
Previous Surgery	3319.989	0.044	96.425	6543.554
Intake of Blood thinners	9523.332	<0.001	4468.240	14578.424
Warfarin / Coumadin / Sintrome	-778.966	0.896	-12433.51	10875.577
Aspirin	15087.75	<0.001	8950.182	21225.318
Plavix / Clopidogrel / Parsugrel / Ticagleror / Pradaxa	578.498	0.917	-10336.29	11493.285
ED Labs	9698.225	<0.001	5379.901	14016.55
Xray	2488.657	0.098	-461.707	5439.022
CT scan	7756.41	0.001	3042.337	12470.482
ED Procedures	72914.057	<0.001	61022.933	84805.181
Hospital Procedures	18156.644	<0.001	11967.595	24345.693

Table 8.2: Significant co-variates for Cost

			B	P-value	Lower CI	Upper CI
ISS			556.518	<0.001	374.795	738.241
ISS Category		N	Mean Cost			
	≤4	260	229.921	<0.001	209.986	249.855
	5-15	144	981.717		309.043	1654.39
	≥16	27	16431.020		-7481.493	40343.587
Age			73.683	0.014	14.966	132.400
Age Category		N	Mean Cost			
	0-3	43	311.107	0.030	207.062	415.152
	4-18	105	540.162		140.368	939.957
	19-65	228	751.730		389.943	1113.517
	66+	55	1496.020		-4273.069	18938.368
Married Status			3081.553	0.058	-107.942	6271.048
Class of Admission			-2050.036	0.031	-3912.399	-187.672
Admission Category		N	Mean Cost			
	First	26	2493.092	<0.001	912.803	4073.382
	Second	13	3665.408		267.471	7063.345
	Third	12	35890.347		-21014.95	92795.649
	Not admitted	380	267.447		245.120	289.774
Self-Payers			2476.049	0.115	-602.935	5555.034
Home Injury			2524.121	0.098	-471.724	5519.996
EMS transport			12902.075	<0.001	7575.847	18228.303
ESI			-3265.877	0.002	-5350.592	-1181.162
Past Medical/Surgical History			2602.562	0.091	-421.669	5626.794
		HTN	6800.925	0.002	2467.181	11134.669
		Diabetes	12453.723	<0.001	6786.644	18120.803
		Coronary Artery Disease	13876.603	<0.001	7704.171	20031.035
		COPD	13859.896	0.124	-3810.803	31530.595
		Cancer	23151.668	<0.001	15137.292	31166.045
		Previous Surgery	3319.989	0.044	96.425	6543.554
		Aspirin	15087.75	<0.001	8950.182	21225.318
ED Labs			9698.225	<0.001	5379.901	14016.55
Xray			2488.657	0.098	-461.707	5439.022
CT scan			7756.41	0.001	3042.337	12470.482
ED Procedures			72914.057	<0.001	61022.933	84805.181
Hospital Procedures			18156.644	<0.001	11967.595	24345.693

Table 8.3: Multivariate Linear regression for Cost:

	B	P-value	Lower CI	Upper CI
(Constant)	3548.296	.454	-5766.287	12862.879
ISS Category	-1968.133	.141	-4589.507	653.242
Age	-47.641	.224	-124.563	29.281
Marital Status	1768.156	.307	-1631.375	5167.686
EMS or Self	8118.157	.004	2601.915	13634.398
ESI	-419.646	.690	-2485.849	1646.556
Hypertension	-1081.038	.651	-5768.840	3606.764
Diabetes	8970.905	.001	3514.675	14427.134
Coronary Artery Disease	5303.476	.121	-1407.163	12014.116
COPD/Emphysema	-22201.502	.007	-38170.930	-6232.075
Cancer, specify	19351.473	.000	11958.631	26744.314
Previous surgery	-217.696	.889	-3280.907	2845.514
Aspirin	-1045.544	.766	-7959.744	5868.655
ED Labs	-12381.734	.000	-18773.524	-5989.943
ED Procedures	63096.322	.000	50983.835	75208.810
Hospital Procedures	12026.145	.001	4917.368	19134.923
Class of Admission	5884.324	.000	2655.965	9112.684
Home Injury	562.181	.659	-1944.159	3068.522
Self-Payers	791.245	.542	-1760.050	3342.541
XRAY	-339.734	.809	-3095.418	2415.950
CT scan	1281.678	.593	-3422.689	5986.046

Table 9.1: Univariate Linear regression for confounders/mediators for ISS:

	B	P-value	Lower CI	Upper CI
Age	0.053	<0.001	0.024	0.082
Gender	-1.190	0.122	-2.701	0.320
Marital Status	1.510	0.064	-0.089	3.110
Smoking Status	-1.129	0.203	-2.870	0.612
Alcohol Consumption	0.103	0.971	-5.370	5.576
Distance to AUBMC	7.082×10^{-6}	0.688	0.000	0.000
Injury Place	0.255	0.174	-0.113	0.622
ESI	-5.599	<0.001	-6.513	-4.685
Mechanism of Injury	0.310	0.069	-0.024	0.645
Transport Injuries	6.818	<0.001	3.941	9.695
Past Medical/Surgical History	2.082	0.007	0.574	3.591
HTN	4.405	<0.001	2.248	6.562
Diabetes	4.336	0.003	1.462	7.210
Coronary Artery Disease	10.065	<0.001	7.052	13.077
Congestive Heart Failure	9.573	<0.001	4.977	14.168
Myocardial Infarction	-1.402	0.858	-16.756	13.951
Angina	7.134	0.197	-3.715	17.983
Asthma	0.718	0.774	-4.189	5.624
COPD	9.333	0.039	0.491	18.174
Seizure	-0.916	0.742	-6.389	4.557
Stroke	2.607	0.739	-12.745	17.959
Physical Handicap	-0.201	0.954	-7.100	6.697
Kidney Disease	3.290	0.467	-5.590	12.171
Cancer	9.037	0.000	4.959	13.115
Psychiatric Disease	-0.294	0.911	-5.460	4.872
Bleeding Tendency	-0.023	0.774	-0.178	0.132
Trauma	0.109	<0.001	0.051	0.167
Osteoporosis	-5.412	0.489	-20.757	9.934
Dyslipidemia	0.271	0.933	-6.034	6.576
Previous Surgery	2.666	0.001	1.062	4.270
Intake of Blood thinners	4.354	0.001	1.812	6.896

Warfarin / Coumadin / Sintrome	8.017	0.007	2.222	13.811
Aspirin	7.177	<0.001	4.091	10.263
Plavix / Clopidogrel / Parsugrel / Ticagleror / Pradaxa	2.777	0.319	-2.689	8.244

Table 9.2: Summary of significant variables that affect ISS:

.	B	P-value	Lower CI	Upper CI
Age	0.053	<0.001	0.024	0.082
Gender	-1.190	0.122	-2.701	0.320
Marital Status	1.510	0.064	-0.089	3.110
ESI	-5.599	<0.001	-6.513	-4.685
Mechanism of Injury	0.310	0.069	-0.024	0.645
Transport Injuries	6.818	<0.001	3.941	9.695
Past Medical/Surgical History	2.082	0.007	0.574	3.591
HTN	4.405	<0.001	2.248	6.562
Diabetes	4.336	0.003	1.462	7.210
Coronary Artery Disease	10.065	<0.001	7.052	13.077
Congestive Heart Failure	9.573	<0.001	4.977	14.168
COPD	9.333	0.039	0.491	18.174
Cancer	9.037	<0.001	4.959	13.115
Trauma	0.109	<0.001	0.051	0.167
Previous Surgery	2.666	0.001	1.062	4.270
Intake of Blood thinners	4.354	0.001	1.812	6.896
Warfarin / Coumadin / Sintrome	8.017	0.007	2.222	13.811
Aspirin	7.177	<0.001	4.091	10.263

Table 10.1: Final Multivariate Linear Regression for Cost:

	B	Sig	Lower Bound	Upper Bound
(Constant)	1878.080	.271	-1473.745	5229.905
ISS Category	-2345.664	.053	-4726.249	34.921
EMS or Self	9923.988	.000	4699.420	15148.557
Diabetes	8019.849	.001	3187.024	12852.673
Coronary Artery Disease	7808.075	.015	1511.802	14104.348
Congestive Heart Failure (CHF)	-14811.674	.002	-24192.493	-5430.855
COPD/Emphysema	-15819.461	.057	-32106.784	467.862
Cancer	19429.831	.000	12444.002	26415.659
ED Labs	-11692.474	.000	-17427.737	-5957.211
ED Procedures	62535.428	.000	50840.206	74230.649
Hospital Procedures	10192.152	.003	3380.560	17003.744
Class of Admission	6383.052	.000	3291.004	9475.101

Table 11.1: Length of stay in ED as function of ISS for all patients

Model	R	R Square	Sig.
1	0.313	.098	.000

Model		Standardized Coefficients	Sig.
1	(Constant)	71.537	0.000
	ISS	8.793	0.000

Table 11.2: Length of stay in ED as function of ISS groups for all patients

			Lower CI	Upper CI	Between Groups Sig.
≤4	243	88.72	71.78	105.65	0.00
5-15	135	130.28	103.87	156.69	
≥16	25	497.56	250.35	744.77	
Total	403	128	106.18	149.83	

Table 11.3: Length of stay in hospital as function of ISS for admitted patients

Model	R	R Square	Sig.
1	0.027	.001	.853

Model		Standardized Coefficients	Sig.
1	(Constant)	17646.406	0.337
	ISS	156.755	0.853

Table 11.4: Length of stay in hospital as function of ISS groups for admitted patients

			Lower CI	Upper CI	Between Groups Sig.
≤4	1	2024.000	.	.	0.936
5-15	29	23246.276	-13809.173	60301.725	
≥16	19	16851.684	2329.820	31373.549	
Total	49	20333.633	-1716.478	42383.743	

APPENDICES

Appendix A: Interpretation of Cohen's Kappa

Table 3.

Interpretation of Cohen's kappa.

Value of Kappa	Level of Agreement	% of Data that are Reliable
0–.20	None	0–4%
.21–.39	Minimal	4–15%
.40–.59	Weak	15–35%
.60–.79	Moderate	35–63%
.80–.90	Strong	64–81%
Above.90	Almost Perfect	82–100%

McHugh, M. (2012). Interrater reliability: the kappa statistic. *Biochemia Medica*, 276-282. doi: 10.11613/bm.2012.031

Appendix B: Kappa value for the reproducibility of the severity scores

TABLE 4. Frequency of Injuries in Body Regions and Severity Scores Distributed on Correlation Between CT and AU: Relative and Absolute Numbers of Individuals Where CT Gave the Same, a Higher or a Smaller Severity Score Than Autopsy Did and Kappa Values for Reproducibility of Severity Scores in Traffic Fatalities Investigated at the Institute of Forensic Medicine, University of Southern Denmark, February 2006 to May 2007

	Injury Present		Severity Scores				
Body Region	**CT (%)**	**AU (%)**	**CT = AU**	**CT > AU**	**CT < AU**	**TOTAL**	**Kappa Values for Reproducibility of Severity Scores**
Head and neck							
Facial skeleton	37	25	83% (43)	17% (9)	0% (0)	100% (52)	0.65
Cranium	52	56	88% (46)	2% (1)	10% (5)	100% (52)	0.84
Cerebrum	54	54	81% (42)	12% (6)	8% (4)	100% (52)	0.73
Cerebellum	14	21	85% (44)	2% (1)	13% (7)	100% (52)	0.56
Brain stem	4	8	96% (50)	0% (0)	4% (2)	100% (52)	0.65
Meninges	52	50	96% (50)	4% (2)	0% (0)	100% (52)	0.97
Neck organs	12	33	79% (41)	0% (0)	21% (11)	100% (52)	0.45
Cervical column	21	25	96% (50)	0% (0)	4% (2)	100% (52)	0.81
Thorax							
Ribs	79	81	90% (47)	2% (1)	8% (4)	100% (52)	0.88
Lungs	59	73	65% (34)	17% (9)	17% (9)	99% (52)	0.54
Heart	21	27	90% (47)	0% (0)	10% (5)	100% (52)	0.81
Aorta	8	33	75% (39)	0% (0)	25% (13)	100% (52)	0.40
Pleural cavities	60	54	81% (42)	19% (10)	0% (0)	100% (52)	0.72
Pericardial sac	21	23	96% (50)	0% (0)	4% (2)	100% (52)	0.90
Thoracic column	31	31	100% (52)	0% (0)	0% (0)	100% (52)	1.0
Abdomen							
Liver	39	48	87% (45)	2% (1)	12% (6)	101% (52)	0.77
Spleen	25	37	85% (44)	2% (1)	13% (7)	100% (52)	0.68
Kidneys	8	23	81% (42)	0% (0)	19% (10)	100% (52)	0.39
Gastrointestinal	0	6	94% (49)	0% (0)	6% (3)	100% (52)	0.39
Peritoneal cavity	11	11	100% (52)	0% (0)	0% (0)	100% (52)	1.0
Lumbar column	6	4	100% (52)	0% (0)	0% (0)	100% (52)	1.0
Extremities							
Humerus	10	10	98% (51)	2% (1)	0% (0)	100% (52)	0.89
Radius and ulna	11	11	100% (52)	0% (0)	0% (0)	100% (52)	1.00
Hand bones	4	4	100% (52)	0% (0)	0% (0)	100% (52)	1.00
Pelvis	39	40	88% (40)	19% (10)	4% (2)	100% (52)	0.66
Femur	25	23	98% (51)	2% (1)	0% (0)	100% (52)	0.95
Tibia and fibula	29	31	91% (47)	8% (4)	2% (1)	100% (52)	0.79
Foot bones	4	4	100% (52)	0% (0)	0% (0)	100% (52)	1.00

Leth, P., & Ibsen, M. (2010). Abbreviated Injury Scale Scoring in Traffic Fatalities: Comparison of Computerized Tomography and Autopsy. *The Journal Of Trauma: Injury, Infection, And Critical Care*, *68*(6), 1413-1416. doi: 10.1097/ta.0b013e3181b251b8

Appendix C: Data collection sheet/Questionnaire form

Trauma Registry Form (Hospital Questionnaire)

Demographic Data

Study ID #: [__[__[__[__]

Discharge Diagnosis: ________________________

ICD 9 code: ________________________

Gender: 1. Male 2.Female

Age: [__[__]

Nationality: 1. Lebanese

2. Non Lebanese

Marital Status: 1. Single

2. Married

3. Separated/Divorced

4. Widowed

Residence Address:

City ________________________

Street ________________________

Class of Admission (Only if patient was admitted): 1. First 2. Second 3. Third 4. Not admitted to the hospital

Smoking Status: 1. Smoker

2. Non-smoker

3. Ex-Smoker

Insurance type:

1. Private
2. NSSF
3. Self
4. Combination with NSSF
5. HIP
6. Others (specify) __________________

Alcohol Consumption: 1. Yes

Injury Description

Date of ED admission: [__[__]/[__[__]/[__[__] Time of ED admission: [__[__]: [__[__]
d m y

Date of ED discharge: [__[__]/[__[__]/[__[__] Time of ED discharge: [__[__]: [__[__]
d m y

Date of injury: [__[__]/[__[__]/[__[__] Time of injury: [__[__]: [__[__]
d m y

Place of injury:

1. Industrial place	2. Recreation/sport	3. Street/Highway	4. Public building	5. Educational institution	6. Air port	7. Home/residence
8. Nursing home	9. Residence/Institution	10. Physician office/clinic	11. Hospital	12. Jail	13. Other, specify	

Police Informed 1. Yes 0. No

Was the accident work-related? 1. Yes 0. No 2. Not applicable 9.Unknown

Cause of injury: 1. Intentional Alcohol Intake 1. Yes 0. No 9. Unknown
2. Unintentional If yes, was the patient intoxicated 1. Yes 0. No 9.Unknown
9. Unknown

Mode of Transportation: 1. EMS If Ambulance Transport:
2. Private Immobilization: 1. Yes 0. No 9.Unknown
3. Walking If yes: 1. Cervical Collar 2. Back Board
4. Others ______________________

ESI (Emergency Severity Index) at triage: __________

Mechanism of Injury: 1. Blunt 2. Penetrating 3. Driver MVC 4. Passenger MVC 5.Driver MCC
6. Passenger MCC 7. Pedestrian 8.War-related trauma 9.Domestic violence 10.Other, specify __________

For accident-related injuries, please check all that apply:
1. Helmet 2. Seat-belt 3. Air bag 4. Infant car seat 5. Others, specify:__________

Patient related Data

Past Medical and Surgical History

	Disease	

1	Hypertension	0. No 1. Yes 9. UNKNOWN
2	Diabetes	0. No 1. Yes 9. UNKNOWN
2	Coronary artery disease (CAD)	0. No 1. Yes 9. UNKNOWN
3	Congestive Heart Failure (CHF)	0. No 1. Yes 9. UNKNOWN
4	Myocardial infarction	0. No 1. Yes 9. UNKNOWN
5	Angina	0. No 1. Yes 9. UNKNOWN
6	Asthma	0. No 1. Yes 9. UNKNOWN
7	COPD/ Emphysema	0. No 1. Yes 9. UNKNOWN
8	Seizures	0. No 1. Yes 9. UNKNOWN
9	Stroke	0. No 1. Yes 9. UNKNOWN
10	Physical handicap, specify	0. No 1. Yes 9. UNKNOWN
11	Kidney problems/failure	0. No 1. Yes 9. UNKNOWN
12	Cancer, specify	0. No 1. Yes 9. UNKNOWN
13	Psychiatric problems (schizophrenia/MDD/…)	0. No 1. Yes 9. UNKNOWN
14	Bleeding tendancy	0. No 1. Yes 9. UNKNOWN
15	Previous trauma	0. No 1. Yes 9. UNKNOWN
16	Previous Surgeries If yes, please specify: ___________________________ ___________________________ ___________________________ ___________________________ ___________________________	0. No 1. Yes 9. UNKNOWN

Home medications: (options to be listed: anticoagulants,...) (put 1. Yes 0. No)

- Warfarin / Coumadin / Sintrome /
- Lovenox / Innohep / LMWH / Heparin
- Aspirin
- Plavix / Clopidogrel / parsugrel / ticagleror / pradaxa
- Others, please specify below:

  ____

  ____

ED evaluation

Physical Examination:

Tick (✓) if the description is satisfied

	Body region	Region is Injured	Abbreviated Injury Score
1.	Head		[__]
	Neck		[__]
	Vertebral column		[__]
2.	Face		[__]
3.	Chest		[__]
4.	Abdomen & Pelvic contents		[__]
5.	Upper extremities		[__]
	Lower extremities		[__]
6.	External, Burns, and others		[__]

Highest 3 AIS sc

AIS 1: [__]

AIS 2: [__]

AIS 3: [__]

ISS: [__][__]

Vital signs **(If missing from charts write unknown)**	
Height: [__[__[__] cm	Weight: [__[__[__] Kg
Temperature	[__[__][__]
Pulse rate	[__[__[__]
Respiratory rate	[__[__]
BP	[__[__[__]/[__[__]__]
GCS	[__]__]
Revised Trauma Score	[__]__]

ED Labs and Radiological Workups on arrival **(Put "ND" if the bood test was not done)**

HCT ___________ RBC _________ WBC _________

SODIUM ___________ POTASSIUM _________ CREATININE ________

1ST ABG: pH ___________ pCO_2 __________ HCO_3^- _________ PO_2 _____

Base Deficit ___________ LACTATE __________ ETOH _________

X-RAY: CHEST PELVIS CERVICAL SPINE EXTREMITY

CT SCANS: HEAD/NECK CHEST ABD/PELVIS FAST MRI

CT ANGIO: _______________

OTHER: ____

ED Discharge disposition:

1. Home
2. Left against medical advice

3. Transferred to another hospital
4. Admitted to ICU

   ICU admisison date: [__[__]/[__[__]/[__[__]
   d m y

   ICU discharge date: [__[__]/[__[__]/[__[__]
   d m y

5. Admitted to OR
6. Admitted to Floor
7. Death on arrival
8. Death in ED

Hospital Course

Procedures

		Procedure done in ED 0. No 1. Yes	Procedure done in hospital 0. No 1. Yes
1.	Endotracheal intubation		
2.	Central venous access		
3.	Arterial lines placement		
4	Tube thoracostomy		
5.	Thoracotomy		
6.	Exploratory Laparotomy		
7.	Others, please specify below:		

Transfusions

	No. of Units (ED)	No. of Units (Hospital)
Blood		
Platelets		
FFP		

Medications used

		0. No	1. Yes
1.	Amino caproic acid		
2.	Factor VII		
3.	Others, please specify below:		
4.			
5.			
6.			
7.			

Complications

Tick if the condition is satisfied

1.	Complication	0. No	1. Yes
2.	Kidney failure		
3.	Shock		
4.	Cardiac arrest		
5.	Myocardial Infarction		
6.	Coagulopathy / DIC		
7.	ARDS		
8.	Wound infection		
9.	Urinary infection		
10.	Pneumonia		
11.	Intra-abdominal abscess		
12.	Sepsis		
13.	Rebleed		
14.	Gastritis		
15.	Others, please specify below:		

Disposition and outcomes

Hospital Discharge information

Discharge destination:

1. Home
2. Dead
3. Transfer to hospital (specify:___________________________________)
4. Other, specify: ____
5. Unknown destination

Date of discharge/death: [__[__]/[__[__]/[__[__]　　　Time of discharge/death: [__[__]: [__[__]

d　　m　　y

Total charges[3] (LBP): ____

Total collections[4] (LBP):____

Appendix C: Questionnaire

[3] Total charges is equal to both ED & hospital charges

[4] Total collections is equal to the total amount (of total ED & hospital charges)

Appendix D: Kendall or Spearman correlations for sample size calculation

TABLE 1.
Accuracy of Sample Size Approximation

			Pearson		Spearman		Kendall	
$\tilde{\theta}$	w	α	Eq. 5	Correct n	Eq. 5	Correct n	Eq. 5	Correct n
.10	.1	.05	1507	1507	1517	1517	661	661
.10	.1	.01	2601	2601	2614	2614	1139	1139
.10	.2	.05	378	378	382	382	168	168
.10	.2	.01	650	650	653	653	269	269
.10	.3	.05	168	168	169	169	77	77
.10	.3	.01	288	288	290	290	129	129
.30	.1	.05	1274	1274	1331	1331	560	560
.30	.1	.01	2198	2198	2297	2297	963	963
.30	.2	.05	320	320	334	334	143	143
.30	.2	.01	550	550	574	574	243	243
.30	.3	.05	143	143	149	149	65	65
.30	.3	.01	245	244	255	255	110	110
.40	.1	.05	1086	1086	1173	1173	448	448
.40	.1	.01	1874	1874	2024	2024	822	822
.40	.2	.05	273	273	295	295	122	122
.40	.2	.01	469	469	507	507	208	208
.40	.3	.05	123	123	132	132	57	57
.40	.3	.01	209	209	226	226	94	94
.50	.1	.05	867	867	975	975	382	382
.50	.1	.01	1495	1495	1682	1682	656	656
.50	.2	.05	219	219	246	246	99	99
.50	.2	.01	376	376	422	422	167	167
.50	.3	.05	99	99	111	111	46	46
.50	.3	.01	168	168	189	189	76	76
.60	.1	.05	633	633	746	746	280	280
.60	.1	.01	1091	1091	1287	1287	480	480
.60	.2	.05	161	161	189	189	73	73
.60	.2	.01	276	276	325	325	123	123
.60	.3	.05	74	74	86	86	35	35
.60	.3	.01	125	125	146	146	57	57
.70	.1	.05	404	404	503	503	180	180
.70	.1	.01	696	696	866	866	307	307
.70	.2	.05	105	105	129	129	49	49
.70	.2	.01	178	178	221	221	81	81
.70	.3	.05	49	49	60	60	24	24
.70	.3	.01	82	82	101	101	39	39
.80	.1	.05	205	205	269	269	93	93
.80	.1	.01	352	352	463	463	157	157
.80	.2	.05	56	56	72	72	27	27
.80	.2	.01	94	93	122	122	44	44
.80	.3	.05	28	28	36	35	15	15
.80	.3	.01	46	45	59	59	23	23
.90	.1	.05	63	62	87	86	30	30
.90	.1	.01	106	105	147	147	49	49
.90	.2	.05	21	20	28	27	12	11
.90	.2	.01	34	33	46	45	18	17
.90	.3	.05	13	12	18	16	8	8
.90	.3	.01	21	20	28	25	11	11

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Appendix E: Email exchanged for cross data review between data abstractors

From: Mohammad Nasser
Sent: Thursday, February 9, 2017 1:54 PM
To: Reem Al Assaad (Alumni)
Subject: Data Comparison

Dear Dr. Al-Assaad,

Attached is the review form of your 35 charts of 1-250 data sheet entered.
Errors are corrected in reverse color
Best,

Mohamad

Name of Person Reviewing: Reem AL Assaad

	Study Number	Area of Error	Data Collection Personnel Notified (Mohammad Nasser)
1.	501	Mode of transport ESI at triage missing	
2.	505	Class of admission missing AIS score Home medications missing	
3.	507	Smoking status Home medications missing	
4.	509	ESI score missing Home medications missing Was the accident work related	
5.	529	Discharge diagnosis incomplete Class of admission (patient admitted) Was the accident work related Cause of injury Mode of transport Hospital course section missing	
6.	533	Time of ED discharge missing Was the accident work related AIS score	
7.	535	Discharge diagnosis	
8.	539	Mechanism of injury missing Was the accident work related	
9.	540	Discharge diagnosis Was the accident work related	
10.	547	Was the accident work related	
11.	549	Was the accident work related RTS score	
12.	554	none	
13.	560	none	
14.	569	EM sheet not scanned ED admission date/time	
15.	569	duplicate	
16.	572	Medications used in hospital Transfusions in hospital Procedures done in hospital Time of discharge from hospital Discharge destination from hospital	
17.	576	none	
18.	576	duplicate	
19.	581	none	
20.	586	none	
21.	594	Time of Ed discharge Place of injury	
22.	633	none	
23.	643	none	
24.	645	none	
25.	658	Questionnaire Not found	
26.	658	Questionnaire Not found	
27.	660	Questionnaire Not found	
28.	665	Questionnaire Not found	
29.	665	Questionnaire Not found	
30.	670	Questionnaire Not found	
31.	675	Questionnaire Not found	
32.	678	None	
33.	680	None	
34.	681	Marital status	
35.	694	none	

Appendix F: Hyperlink to the map of distribution of injuries in Lebanon

https://www.google.com/maps/d/u/0/viewer?mid=1D43Gp53QB_hxlhMrL8cuQTDd24MF0W4S

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