The demographics of traumatic brain injury and in-patient costs in high dependency neurosurgical unit: a Cross-sectional study in a tertiary academic hospital

Researcher:

Dereje Gebrehiwot Mamo

Student number 700962

MMed Neurosurgery

Supervisor:

Dr John R Ouma

Academic Head of Department of Neurosurgery, University of Witwatersrand.

Head of Department of Neurosurgery, Chris Hani Baragwanath Academic Hospital.

DECLARATION

I, DEREJE GEBREHIWOT MAMO declare that this research report is my work. It is being submitted for the degree of MMed the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

……………………..

The service day of ……………., 2019

DEDICATION

I dedicate this research to my late brother MELAKU GEBREHIWOT MAMO for his contribution in my earlier education. I am a better person because of his positive influence.

ABSTRACT

The demographics of traumatic brain injury and in-patient costs in high dependency neurosurgical unit: a Cross-sectional study in a tertiary academic hospital

Background

This study looks at Traumatic brain injury (TBI) patient admission regarding the demographics, causes, bed occupancy and costs at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH).CMJAH runs one of the county's busiest trauma units, and TBI constitutes a significant neuro-surgical admission.

Methods

It is a retrospective descriptive study on Adult TBI patients admitted to CMJAH in 2015. Data including the demographic characteristics of the patient, date of admission, causes, and type of injury were collected from patient files. Bed occupancy rate of TBI patients was evaluated. Direct ICU and high care costs of TBI patient were calculated.

Results

A total of 254 cases of TBI were admitted. Most were young males (91.7%) between the ages of 17- 40 years. Blunt head trauma was the cause of 53% of the cases. About 50% of the cases had either acute subdural haemorrhage or acute

extradural haemorrhage, and 52% of cases had mild TBI. A neurosurgical intervention was performed in 65% of the cases.

A total of 145 TBI cases were admitted to ICU and 186 cases to high care with a bed occupancy rate of 33.4% and 21.8% respectively. The primary cost contributor was ICU stay. The total cost for all TBI patients was estimated to be nearly 16 million rands. The mean in-patient cost for mild, moderate and severe TBI was 48,709.24, R58 499.46 and R86 533.87 respectively. The severity of the injury and surgical intervention did increase the cost of care for individual patients in our study.

Conclusion

TBI affects younger male predominantly and is mainly caused by blunt trauma to the head. TBI patients occupy a significant proportion of neurosurgical bed. Health care costs for the management of TBI are high and need to be budgeted accordingly.

ACKNOWLEDGEMENT

I want to express my heartfelt gratitude to my mentor and supervisor Dr John ouma for his patience, kindness and wisdom toward the completion of this research as well as my training. You are an encouraging and enlightening voice inside a challenging field of medicine.

I also would like to express my appreciation to my friend Dr Woldemedhin T.Haile who contributed a lot to the formulation and statistical analysis of the study. I would like to thank for his feedback, cooperation and of course friendship.

I thank god for blessing me with a beautiful and supportive family. My wife Messay, you have been a pillar of the family during my years of study and beyond. I would not have done it without you. To my daughters Haldana and Edna, you have been very understanding and loving during my frequent absence from your life. Senay, you are blessing and a joy to watch and make me forget all the hardship.

TABLE OF CONTENTS

List of figures

List of tables

ABBREVIATIONS

AED	Acute extradural haemorrhage
ASD	Acute subdural haemorrhage
CDC	Centre for Disease Control
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
CHBAH	Chris Hani Baragwanath academic hospital
Deep skull #	Depressed skull fracture
ED	Emergency Department
GBD	Global Burden of Diseases
GCS	Glasgow coma scale
GSH	Gunshot to the head
Hem cont.	Haemorrhagic contusion
ICH	Intracerebral Haemorrhage
TBI	Traumatic brain injury

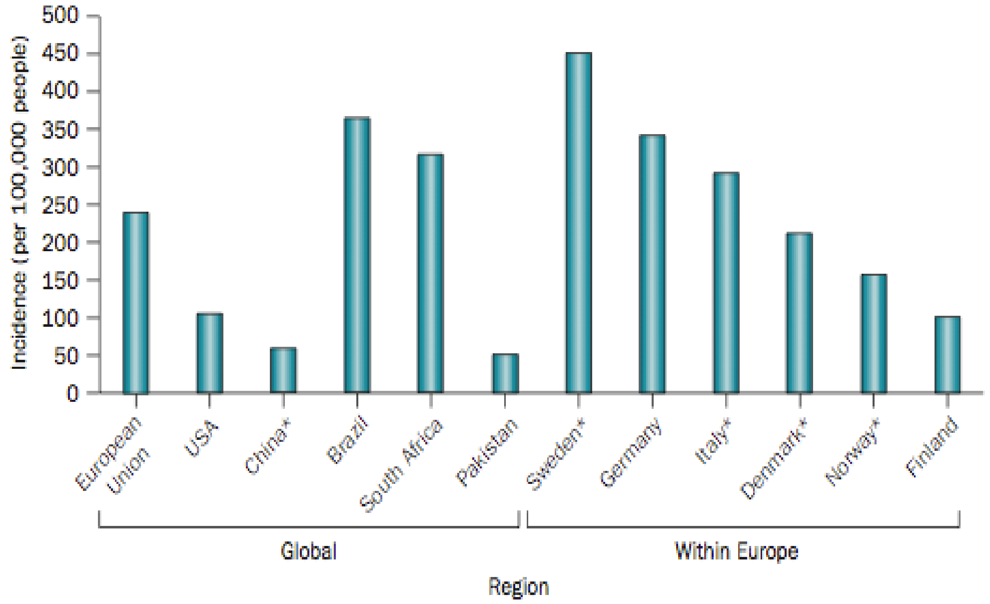
1. INTRODUCTION

Traumatic brain injury (TBI) is an insult to the brain from an external mechanical force causing reversible or permanent neurological dysfunction, which may result in impairment of cognitive, physical and psychosocial functions. The global incidence rate of TBI is estimated at 200 per 100 000 people per year in all age groups[1]. Population-based studies show that the incidence of TBI is between 180 and 250 per 100 000 population per year in the United States and 316 per 100 000 in South Africa[2]. An estimated 10 million people are affected annually by TBI worldwide[3]. TBI is a leading cause of disability in all regions of the globe. The Injury Expert Group within the Global Burden of Disease 2005 (GBD) Project attempted to provide better estimates of the incidence, prevalence and duration of TBI in each of the 21 GBD regions. A systematic literature review, as well as a country-specific hospital survey data, showed that the incidence of TBI in South Africa is estimated to be 1.5 to 3.5 times that of the global estimated rate. These numbers probably underestimate the actual incidence of TBI, because they typically refer to the TBI patients admitted to hospitals[1]. According to a CDC report about 78% of TBI patients get treated and discharged in the emergency department, and 19% require admission while 3% have immediate fatality[4].

The incidence of TBI worldwide is rising, mainly owing to injuries associated with the increased use of motor vehicles, particularly in middle and low-income countries. Due to the rapid surge in urbanisation, motorisation and economic liberation, many Asian countries have an increased risk of TBI. The number of road traffic accident fatalities on Africa account for 11% of all motor vehicle-related deaths in the world [.5] while developing countries have the lowest number of motor vehicles;

they have high road traffic accident mortality. In contrast, in developed countries, which own 60% of the world's motor vehicles, account for only 14% of global road traffic accident fatalities [6]. The burden of TBI is prominent in these countries as they have an ill-prepared health system to address the burden of TBI and its aftermath[3].

Figure 1: Estimates of the global incidence of traumatic brain injury



***Mean of results from two studies[7].**

Demographics:

The US department of health and human services centre for disease control (CDC) published a detailed report in 2010 for the years 2002-2006. The report found that in the US, children aged 0 to 4 years, older adolescents aged 15 to 19, and adults aged 65 years and older are most likely to sustain TBI. In a tertiary referral centre in Pakistan, a study by Muhammad et al. in 2016 showed out of a total of 1,056 patients the overall mean age was 27±16 years. Majority of patients 498(47.2%) belonged to 21-40 years age group [8]. In a study done in 2007 at trauma centre of New Delhi, the majority (34%) cases were of age up to 10 years; second highest (22%) were in age group 21-30 years followed by 14% cases of 30-40 years and 11% cases of 11-20 years respectively [9].

TBI rates are higher in males (78.8%) than in females (21.2%) in every age group in the US department of health and human services centre for disease control (CDC) 2010 report.[4] Of the 1056 TBI patients studied in a tertiary unit in Pakistan 805(76%) were males and 251(24%) female[8]. In a Similar study done in a trauma centre in New Delhi of 791cases 569 (72%) were males and 222 (28%) females[9]. In all 28 studies included in the European systemic review on the epidemiology of TBI, there was a male predominance: the male-to-female ratio ranged from 1.2:1.0[12]. In a national cohort study that was done in Norway on the incidence of hospital admitted severe TBI cases the gender ratio was male 77% and female23%[10]. In South Africa, the same trend towards sex differences has been reported for TBI in adults, with an estimated male to female ratio of 4:1[3]. Similar statistics were found in most of the epidemiological literature.[2, 11.]

In the US according to the CDC report falls were the most common reported cause of injury (35.2%) followed by motor vehicle crashes (17.3%) struck by/against (16.5%), assault 10% and unknown (21 %)[4]. In a systemic review of the epidemiology of TBI in Europe (2015) fall and road traffic accidents (RTA) were the two most frequent causes of TBI, with falls being reported more frequently than RTA. A cohort study in Norway transport accident contributed to 40% of admissions with fall 50%, assault only responsible for 5%[10.] The most common cause identified by Junaid et al. in a tertiary care referral centre in Pakistan were road traffic accidents 461(43.6%), followed by fall injuries 266(25%) and Bomb blast injuries were 60(5.6%)[8.] In the New Delhi (India) epidemiological study of traumatic brain injury (2015) majority (96%) cases were accidental TBI cases with only 4% cases of assault-related TBI [9.] In contrast, South Africa has the highest percentage of TBI-related outcomes as a result of violence and pedestrian-vehicle accident[7]. Worldwide, road traffic injuries are responsible for the highest injury mortality. In South Africa, road traffic injuries ranked second to interpersonal violence, but the road traffic fatality rate (39.7 per 100 000) was higher than for any WHO region and almost double the global average[14].

The cost burden of Traumatic Brain Injury (TBI):

Even though TBI constitutes 4.8% of all injuries in the Emergency Department (ED) visits it contributes to 15% of hospitalisation and 30% death of all injuries[4].For every death caused by traumatic brain injury at least two other people survive with permanent disability[2]. The sequelae include, among others, neurocognitive, neurophysical, neurobehavioral, psychological disorders, and these all have a significant socioeconomic impact. Patients with head injuries also consume massive proportions of neurosurgical resources. These resources include – ward costs (including ICU and high care), surgical costs (including theatre time and costs of specialist) among others.

In 2009, an internal audit conducted at Groote Schuur Hospital (GSH), Cape Town, Western Cape, revealed that of a total of 10,046 trauma patients admitted that year, approximately 24% were classified as head-injury patients, with 27% of those having a moderate to severe TBI. The total direct cost of these patients to the tertiary service in a public hospital in 2009 was R17, 448,756. This audit also found that the average length of stay in the hospital for a patient receiving neurosurgical intervention was 10.2 days[15].

A study done at the All India Institute of Medical Sciences in 2006 found that the total cost for a TBI patient on the ward was Rs 1062 ($15)/bed/day. The total cost of the ICU stay was Rs.3082 ($46)/bed/day. In the Indian study, the cost of time in ICU and the ward of severe and moderate head injury groups were higher compared to the patient with a minor head injury (P <.0001)[16]. The average intensive care cost of TBI per day and per stay in the ICU of a university hospital in Turkey was estimated at US$575 and US$4846, respectively in a retrospective review of the records of Trakya University Hospital's ICU from 2002-2006 [17]. The total cost per operation in India was Rs.11948 ($180), /operated patient.

The cost of TBIs in the United States is estimated at more than US$48.3 billion annually. Over US$31.7 billion in hospitalisation costs and another US$16.6 billion in costs associated with fatalities[4]. According to the US department of health and human services centre for disease control (CDC) published, a report in

2010 for the years 2002-2006 costs of hospitalisation averaged US$8,189 for moderate, US$14,603 serious, US$16,788 for severe and US$33,537 for critical TBI. Costs also varied by injury type, averaging US$20,084 for gunshot wounds, US$20,522 for motor vehicle crashes, US$15,860 for falls, and US$19,949 for blows to the head[4].

The immediate health care costs to treat TBI can be substantial, and there are no data collected in our setting in Johannesburg. TBI is one of the significant conditions faced in our day to day neurosurgical service requiring emergent and extended neuro-critical care as well as supportive allied care from physiotherapists, occupational therapists, speech therapists. There is a lack of research regarding TBI even though CMJAH runs one of the county's busiest trauma units. This review will help identify leading causes of TBI in our institution and hopefully indicate the national statistics which can be used in planning and implementing preventative measures. To date, no studies evaluating TBI burden on the cost of health services at large, in our hospital and neurosurgery in particular available. A better understanding of TBI's financial implication in the health system will help plan better resources allocation.

2. STUDY AIM AND OBJECTIVES

Aim

To investigate the service utilisation features and associated hospitalisation costs of TBI patient.

Objectives

1. To describe socio-demographic characteristics of admitted TBI patients.
2. To ascertain the causes and types of inpatient TBI cases and the time trend in their admissions.
3. To describe individual and total stay hours of TBI patients, disaggregated by ICU and high care stay and evaluate bed occupancy ratio.
4. To document/describe costs related to TBI patient hospital stay, including neuroimaging and procedure cost.
5. To compare costs with differing levels of severity of TBI.

3. METHODOLOGY

Study design

A descriptive cross-sectional study was conducted on patients admitted between January and December 2015. Data were collected retrospectively from patient admission files and the finance office on total expenditures related to each patient.

Site of study

Charlotte Maxeke Johannesburg Academic Hospital

Under the University of the Witwatersrand, there are two neurosurgical units namely Charlotte Maxeke Johannesburg academic hospital (CMJAH) and Chris Hani Baragwanath academic hospital (CHBAH). These two units serve a large part of Gauteng, Northwest Province and part of Mpumalanga as provincial neurosurgical units. These units are supplemented by numerous private hospitals which serve a tiny sector of society. The CMJAH neurosurgery unit has a total of 22 beds out of 800 total hospital beds where 8 are neurosurgical ICU beds equipped with ventilators, monitors, and ICU trained nurses and 16 high care beds for pre-and postoperative care. TBI referrals to the neurosurgical unit are made either via the trauma unit or referring hospitals and clinics in the catchment area. Due to a constant shortage of beds in the unit patients are kept in outlying wards and causalities for some days compromising medical care.

Study population

All Adult (≥16 years) TBI patients admitted to the neurosurgical ICU and high care wards during the study period.

Inclusion criteria

All adult TBI patients admitted under neurosurgical care during the study period.

Exclusion criteria

- TBI Cases where documentation was incomplete.

Variables and definitions

The key variables of interest included were:

Demographic characteristics of the patient (age and sex), date of admission, Causes of TBI (e.g., fall, assault, motor vehicle accident and pedestrian-vehicle accident), type of injury (skull fracture, extradural haemorrhage, subdural haemorrhage, contusion and diffuse axonal injury) and cost of inpatient stay.

Definitions of variables:

The following list defines the variables used, where they are not self-explanatory

- **Glasgow coma scale:** TBI is classified according to the Glasgow Coma Scale at arrival into: Severe: GCS ≤ 8, Moderate: GCS 9 – 12, and Mild GCS 13 – 15

Table 1: The Glasgow coma scale (adapted from ACS ATLS)

Eye opening(E)	Verbal response(V)	Motor response(M)
4. Opens spontaneously 3.Opens to voice 2.Opens to pain 1.None	5.Normal conversation 4.Disoriented conversation 3.words incoherent 2.incoprehensable sound 1.None	6.Normal 5.Localizes pain 4.Withdraws from pain 3.Decorticate posturing 2.decerebrate posturing 1.None

- **ICU bed occupancy rate was calculated as follows:**

Total ICU occupancy hours in 1year = 8 beds x 24hrs X 365d = 70080 potential ICU hrs. Per year.

TBI ICU occupancy rate = $\frac{\text{Total hr. TBI patient spent in ICU}}{\text{70080 ICU hrs.}}$ x100%

- **High care bed occupancy rate was calculated as follows**:

Total high care beds in one year = 16 beds x 365days = 5840 high care days

Total TBI occupancy rate = $\frac{\text{Total days occupied by TBI patients}}{\text{5880 high care}}$ x 100%

- **Cost during a stay in neurosurgery:**

Direct medical ICU and high care costs of TBI (such as a bed, medication, laboratory tests and diagnostic imaging, etc.) were calculated. All surgical procedure costs were added for each patient who underwent surgery during admission. (Appendix 2)

Total cost per patient = ∑ (ICU cost +High care cost+ theatre cost).

In government health sector patients are classified into three main groups for service fee determination:

A. full paying patients

B. subsidised patients

C. Free services.

Most of the patient in our unit are either getting free service or subsidised by the government. All patient costs were calculated as fully paying.

Sample size

The sample size was estimated using a one-sample comparison of the proportion of TBI patients to total neurosurgical admission. Using the percentage of TBI cases of 40% from previous data collected in the hospital, and assuming 32% prevalence for the study we estimated a sample size of 286, taking the level of significance at 0.05 and study power of 0.80. After accounting for an estimated 10% allowance for missing data, the total sample size would be 315.

Data collection

Data was collected over a two-month period from ICU and high care charts and estimate financial expenditure calculated and records using a structured data collection form (see Appendix A). Case report forms were generated where data was gathered. Anonymous-linked data was stored on a password protected files and maintained on a password-protected computer. Individuals involved with the data signed confidentiality agreements.

Ethics

Ethical approval was obtained from the Human Research Ethics Committee (medical) of the University of the Witwatersrand with clearance certificate no .M170272.

Data analysis

Each variable was explored for consistency and completeness (missing data).

The coding of categorical data and their labels were assessed and understood, and their categorisation was determined based on empirical assumptions. The distributions of quantitative variables were evaluated by looking at graphical distributions and statistics, such as percentiles, medians or means as appropriate.

Crude associations were assessed using chi-squared tests for categorical variables and t-tests for continuous ones.

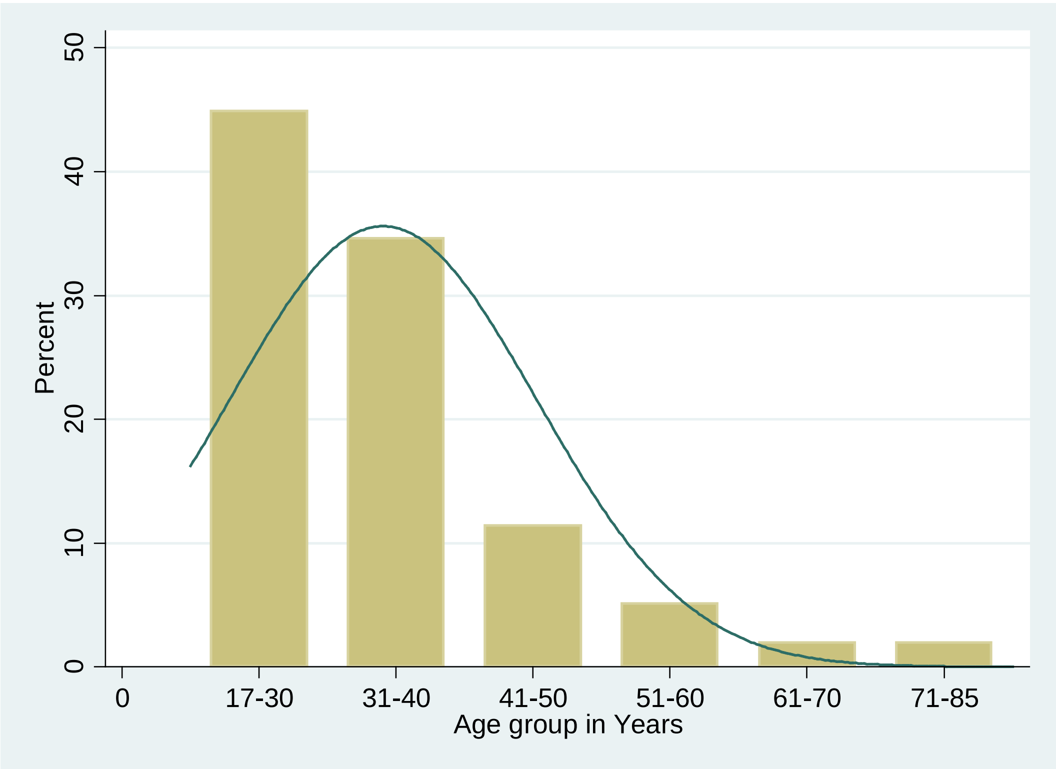
A two-sided p-value of 0.05 was used to determine statistical significance. Data entry and analysis was performed using STATA 12.

4. RESULTS

4.1 Characteristics of the study group

A total of 254 cases of traumatic brain injury patients who were admitted to the neurosurgical unit at CMJA hospital between January 01 2015 and December 31, 2015, were included in the study. The majority of the patients were males (91.7%) compared to females (8.3%). Age shows a left-skewed distribution as very few patients are above the age of 60 years. The median age was 31.5 years with a range of 17 to 83 years. More than 79% of the study participants were young adults between 17-40 years (Figure 2)

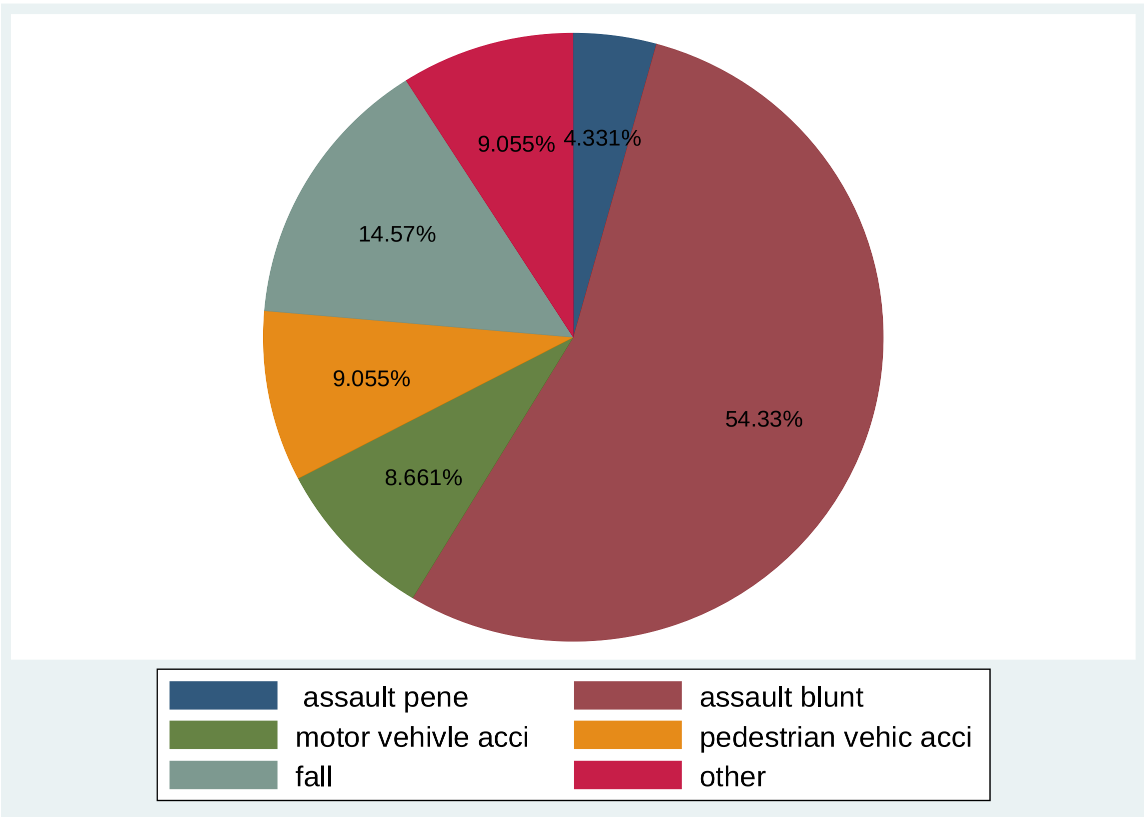
Figure 2: Age distribution of study participants (N=254)



4.2 Mechanism of injury

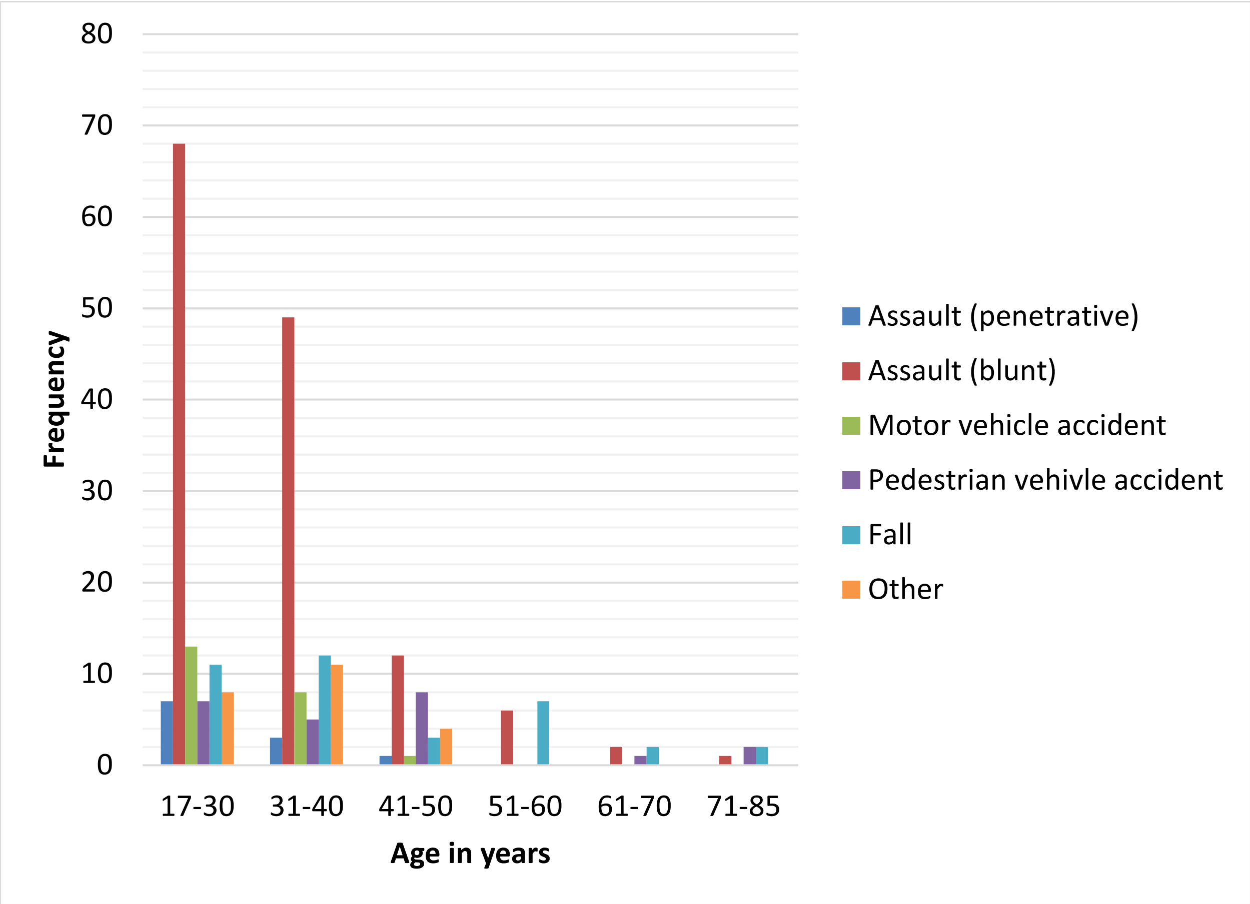
Blunt trauma to the head due to assault was the primary cause of TBI admission (53.3%) followed by falls, pedestrian-vehicle accidents, and motor vehicle accidents at 14.57%, 9.06%, and 8.67% respectively. Only a few admissions were due to penetrating head injuries (4.33%). Other causes of trauma including GSH and some with unknown mechanism together accounted for 9.06% of admissions (Figure 3).

Figure 3: Mechanism of injury (N=254)



The mechanism of injury was compared between different age groups. Assault and motor vehicle accident mostly affected younger people between the ages of 17 to 40yrs. Those who are older than 50 years are more likely to suffer from a fall and pedestrian-vehicle accident (Figure 4). A crude estimate of the effect of age group on the mechanism of injury also shows strong association (P<0.001).

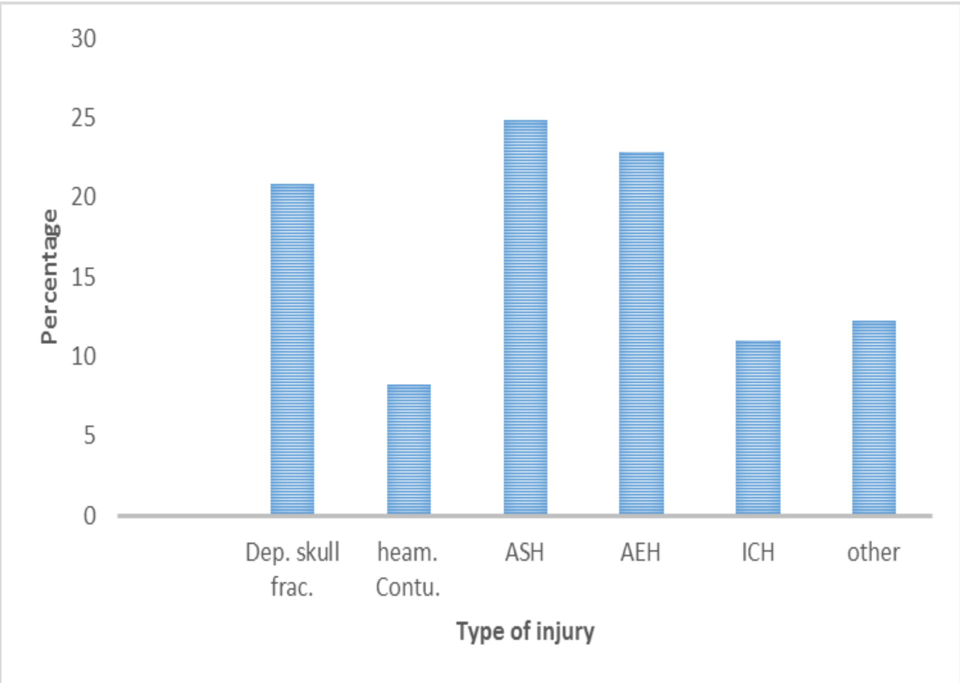
Figure 4: Mechanism of injury by age (N=254)



4.3 Types of Injury

Acute Subdural Haemorrhage (ASH) was the most substantial single pathology in 24.8% of cases followed by acute extradural haemorrhage (AED) and depressed skull fracture at 22.8%, and 20.87% respectively. A smaller proportion of cases were due to intracerebral haemorrhage (ICH) (11.2%) and hemorrhagic contusion (8.3%)(Figure 5). All other types of injuries constituted 12% of all cases which include GSH and unknown mechanism.

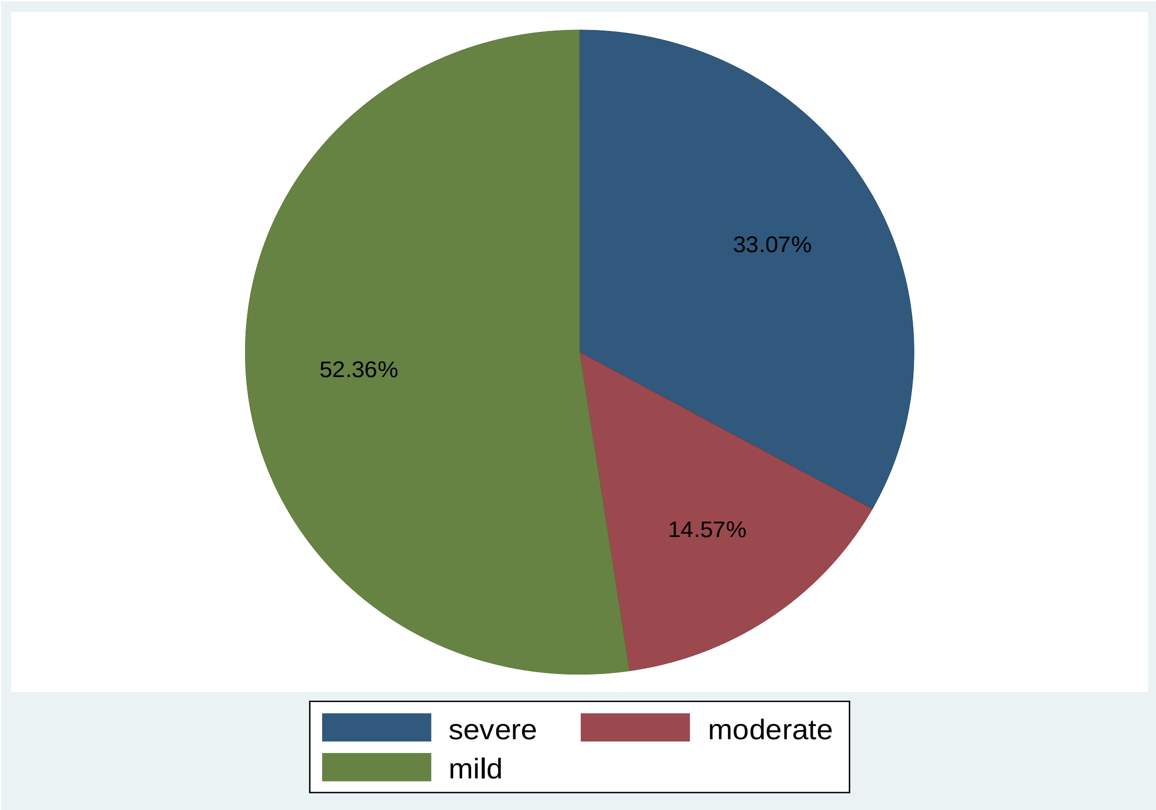
Figure 5: Type of TBI in patients admitted to CMJA hospital, Jan-Dec, 2015



4.4 Severity of Injury

Out of a total of 254 TBI patients included in the study 52.4% (134) patients sustained a mild injury, 14.5%(36) a moderate injury and 33.0 %(85) severe traumatic brain injury according to their initial GCS (Figure 6).

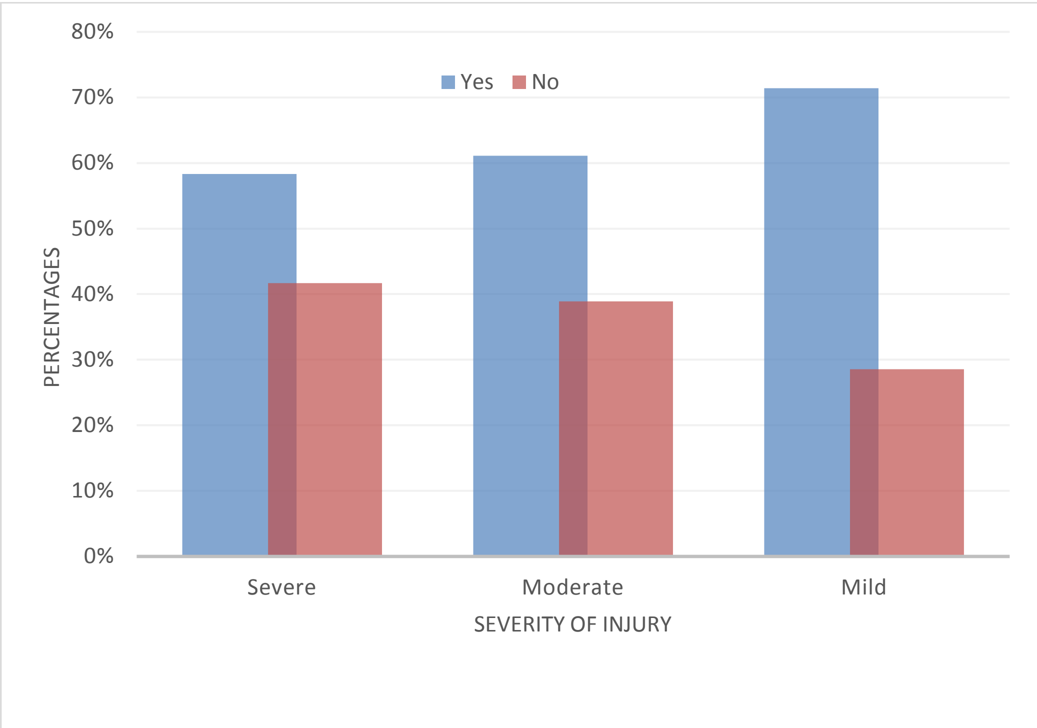
Figure 6: Severity of injury of TBI patients admitted to CMJA hospital between Jan-Dec 2015



4.5 Need for Neurosurgical Intervention.

From the total of 254 patients, 65.7%(167) required neurosurgical intervention. In the different severity category cases, 71.4%(95) of mild TBI patient required surgical intervention while 62.1%(22) and 58.3%(49) of moderate and severe TBI cases required neurosurgical intervention respectively (Figure 7).

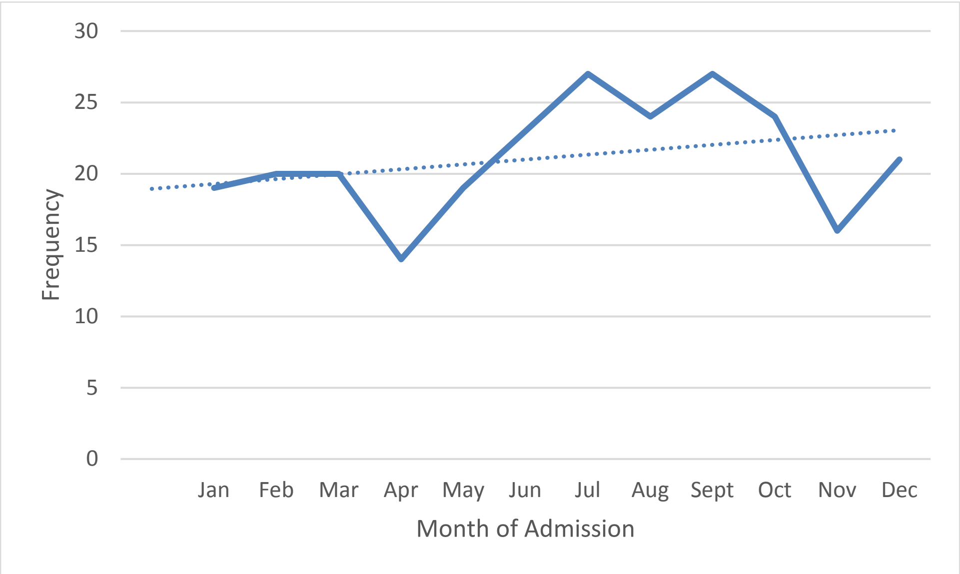
Figure 7: The number of cases requiring neurosurgical intervention by the severity of the injury



4.6 Monthly Admission Trend.

The frequency of monthly admission is depicted in figure 8 below which shows July and September showing the highest peak in the number of monthly admissions.

Figure 8: The number of cases requiring neurosurgical intervention by the severity of the injury



4.7 Hospital stay

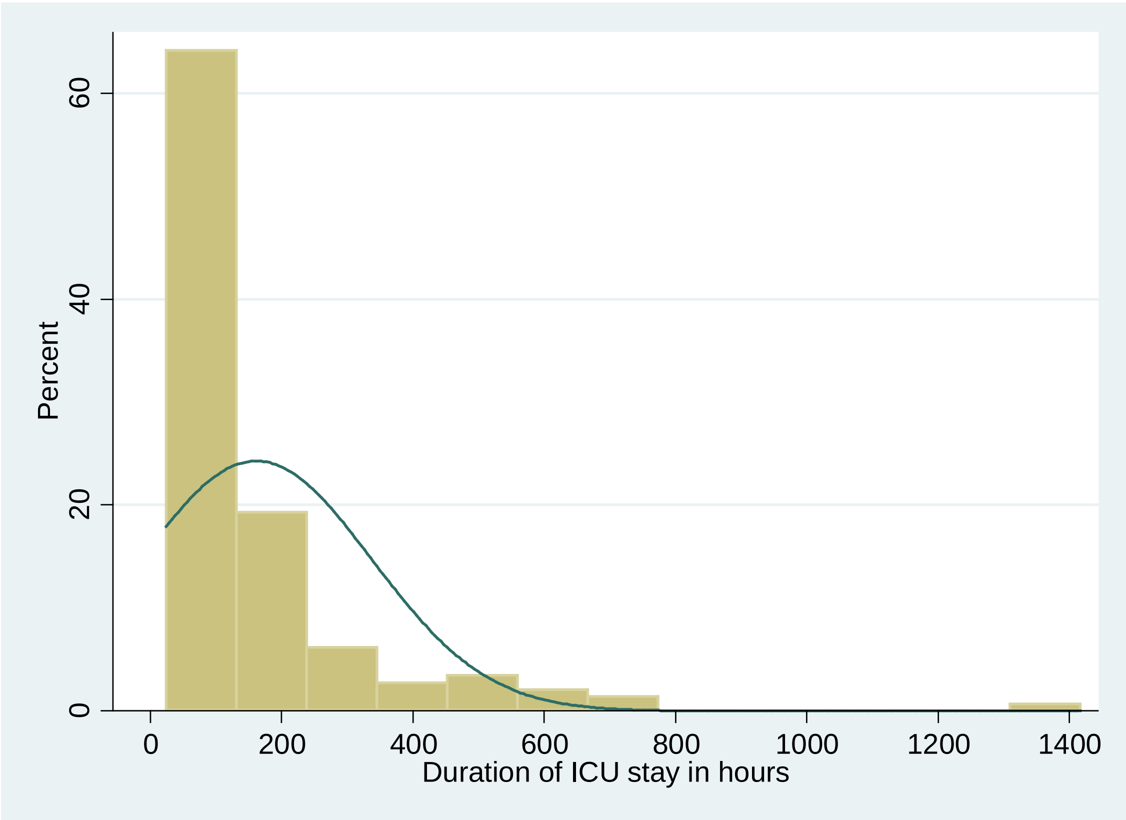
4.7.1 ICU

A total of 145 TBI cases were admitted in the neurosurgical ICU during the study period. The range of ICU stay was from 1 to 59 days with a median value of 5 days. Most of the patients (90%) of the patient stayed in ICU for less than

15 days (Figure 9). A significant ICU stay period was occupied by 15 patients remaining a total period of 365 days cumulatively.

Traumatic brain injury cases occupied a total of 23,429 ICU hours for the year studies out of a possible 70,080 neurosurgical ICU hours of the year with a bed occupancy rate of 33.4%.

Figure 9: Distribution of ICU length of stay for TBI patient at CMJA Hospital during 2015

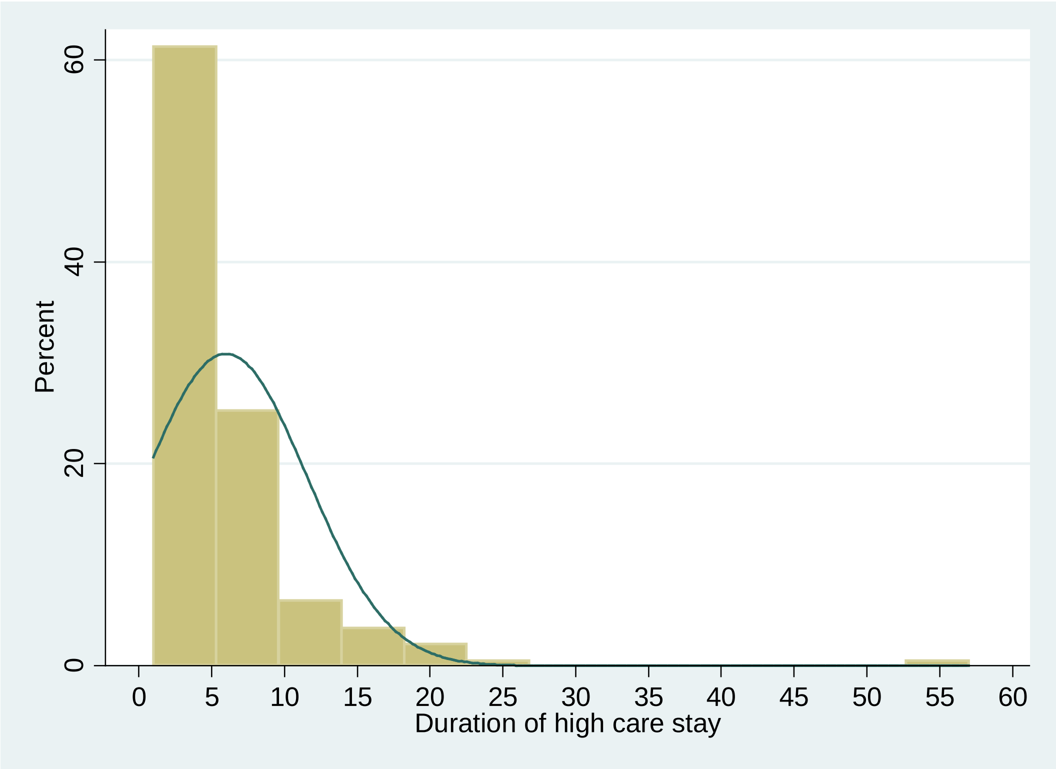


4.7.2 High care

A total of 186 TBI patients were admitted to the neurosurgical high care unit with a length of stay ranging from 1 to 57 days with a median stay of 5 days (Figure 10).

The majority of patients (90%) of patients stayed less than 11 days. With 5113.5 potential high cares bed days available for the year a total of 1113 amount of HC bed days were utilised by TBI cases making the occupancy rate 21.8%.

Figure 10: Distribution of length of high care stay in days for TBI patients admitted during 2015 at CMJA hospital.



4.8 In-patient Cost of TBI in the Unit.

The major contributor to cost in the acute management of TBI is ICU stay with a total estimated value of 8,306, 698 rands followed by high care cost which was estimated at 4,202, 685 rands. Other expenses include surgical, imaging and laboratory cost at 2, 753, 474 rands,431, 633 rands and 217,164 rands respectively. The total cost was estimated to be 15,911,654.

The average inpatient cost of for mild, moderate and severe TBI cases was 48,709.24, 58,499.46 and 86,533.87 respectively. The median in-patient cost for mild, moderate, and severe TBI cases was 40,244, 62,712 and 64,134.5 respectively. (Table2)

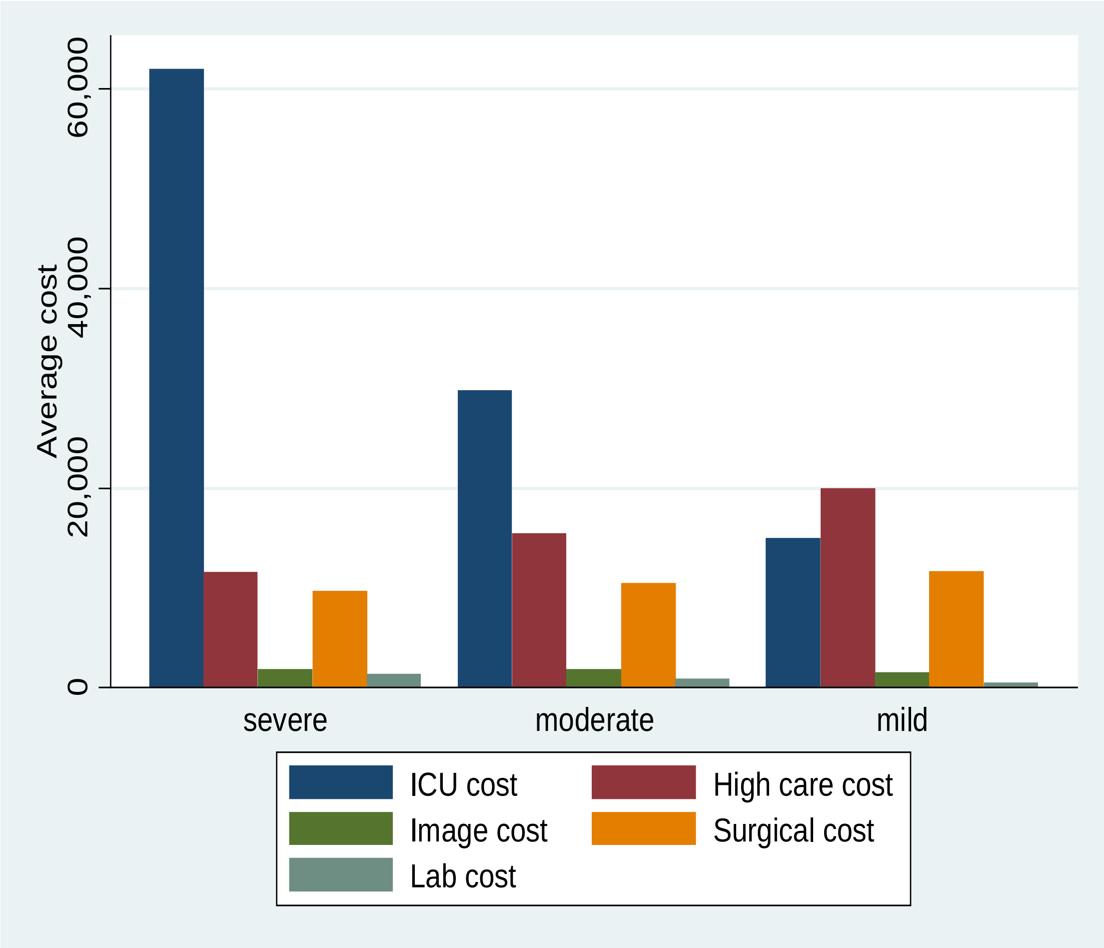
Assuming normal distribution of total inpatient cost, we ran a simple linear regression analysis to quantify the relationship between cost and degree of severity of the injury. The F test shows strong association (P<0.001) which indicates that the level of severity of injury explains significant variation in the cost of health care for TBI patients.

Table 2: Average and median in-patient cost for TBI patients admitted between January-December 2015 (N=254)

	N0. of patients	Mean cost	Median cost
Severe	84	86,533.87	64,134.5
Moderate	37	58,499.46	62,712
Mild	133	48,709.24	40,244

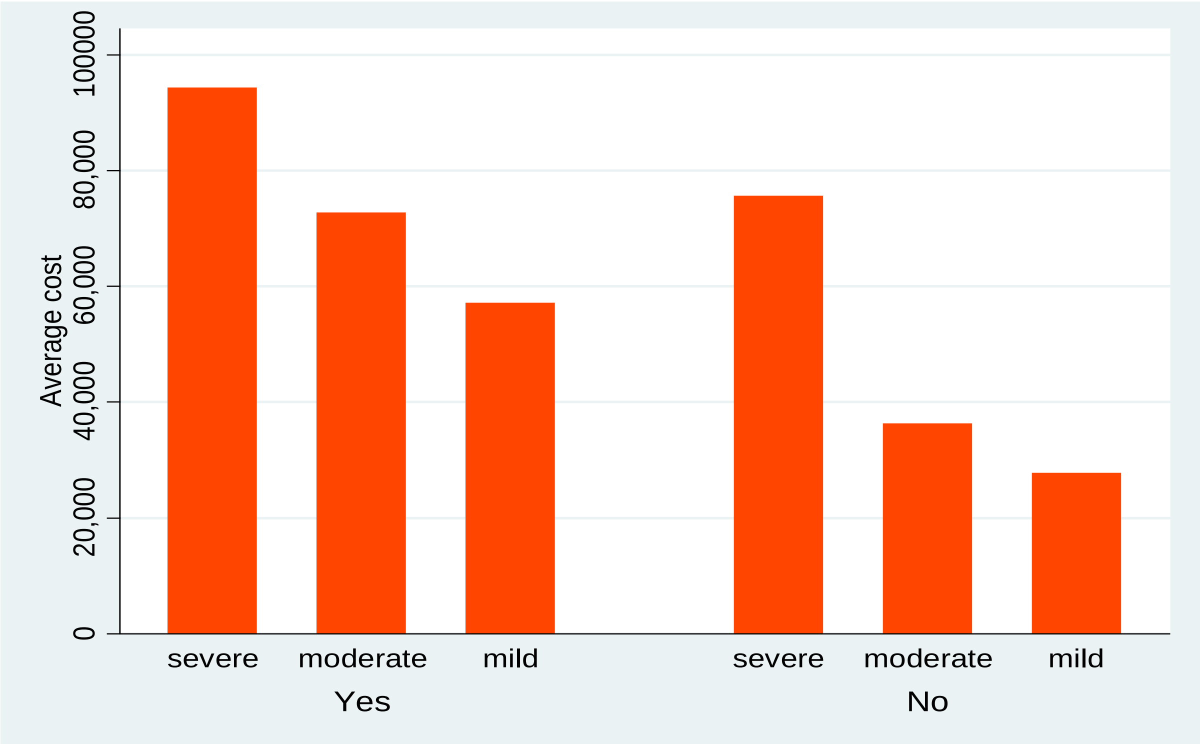
The average hospital stay cost broken down into the different category of components is depicted below (Figure 11). It illustrates that severe TBI patients primary cost is ICU stay while mild TBI patients are high care.

Figure 11: Average TBI patient hospital stay costs by the severity of the injury



We also compared average prices across severity on those with or without surgical intervention. Patient requiring surgical intervention had a higher average cost than those who do not require surgical intervention across all categories of severity (Figure 12).

Figure 12: TBI patients' average total hospital stay cost by the degree of severity of the injury and surgical intervention



5. DISCUSSION

Summary of result

A total of 254 cases of TBI were admitted at CMJA hospital neurosurgical unit in 2015. Most of the patients were young males between the ages of 17- 40 years. Blunt head trauma contributed to about half of the total cases. About 50% the cases had either ASH or AED predominantly. Half of the cases had a mild TBI. A neurosurgical intervention was performed in 65% of cases in the group with mild TBI.

The range of cases per month was between 14 and 27 Cases. The bed occupancy rate was 30% throughout the year in ICU and 25% bed occupancy in high care. A significant contributor to cost was ICU stay with an estimated half of all expenditure. The severity of the injury and surgical intervention did increase the cost of care for individual patients in our study.

Limitations

Since it is a retrospective study, some information was missing which may have resulted in an underestimation of the cost. We only included a subset of adult TBI who needed admission which may have biased the sample. Information on Overall department expenditure was not available.

Discussion of results

Our study demonstrated that traumatic brain injury predominantly occurs in males correlates with most studies done in adult populations. Males consistently show a higher incidence in numerous studies with ratios ranging from 1.5:1 in the US to 2.5:1 in rural China. Approximately 1.4 times as many TBIs Occurred among males as among females, in the U.S. Department of health and human services centres for disease control and prevention 2010 report for the years 2002–2006[4]. In the New Delhi study (2007) of 791cases, the ratio was 569 (72%) were males and 222 (28%) females[9]. Of the 1056 TBI patients investigated in the tertiary unit in Pakistan (2016), 805(76%) were males and 251(24%) female[8]. The incidence of male to female ratio is much higher in our study than other studies which might be because our study included only admitted cases excluding minor TBI cases discharged or referred to other facilities from emergency unit. A similar cohort study done in Norway on the incidence of hospital admitted severe TBI the gender ratio was male 77% and female23%[10,] This might suggest that males sustain more serious TBIs than females, but this claim needs further investigation.

The study also showed that young male adult between the ages of 17 to 40 years sustains significant TBI injury requiring neurosurgical management constituting about 80% of our admission.

Assault due to blunt trauma and PVA are the leading causes of head injury in our study which confirms the findings from previous studies. The injury burden profile for South Africa has been shown to differ from most regions of the world as intentional injuries exceed un-intentional injuries[1]. In contrast, in the developed countries falls and MVA are the leading causes of TBI[2.] Traffic safety education and the enforcement of road traffic laws should be strengthened to reduce TBI. Prevention of inter-personal violence should be made a public health priority.

The use of ICU and high care beds by patients with a TBI is also of concern. In 2009-2009 South Africa had 4 719 ICU/HC beds, with 75% (3533) in the private sector and 25% (1 186) in the public sector. The majority of ICU beds were located in 3 provinces: Gauteng (49%, 2 311 beds), KwaZulu-Natal (14%, 672 beds) and Western Cape (15%, 719 beds[18.] We mainly admitted patient requiring neurosurgical intervention or specialised care in our unit due to a limited number of ICU and HIGH care bed. The significant Bed occupancy rate of ICU and high care of TBI cases at 33.4% and 21.8% respectively needs further study to investigate its impact on other neurosurgical cases.

In this study, 65% of the patients required neurosurgical intervention which is high compared to other studies where 75% of admissions were treated none operatively[19.] The limited numbers of bed available compel the unit at CMJAH to admit mainly patients who are requiring neurosurgical intervention.

The cost of brain injury is immense involving acute hospital care, rehabilitation costs, loss of income and lifetime emotional and financial burden on the individual and the society. Our cost analysis is not designed to evaluate the full impact of TBI, but a particular portion of the cost that is incurred on to the individual or mainly to the state since most of our patients are subsidised. In 2009 internal audit conducted at Groote Schuur Hospital (GSH), Cape Town, Western Cape, revealed that of a total of 654 patients having a moderate to severe TBI required neurosurgical admission. The direct cost of these patients to the tertiary service in

2009 was R17 448 756 with an average cost of 26 680 per patient (T King, Coma Care Trust audit, 2010 – unpublished) [15.] Our study showed the escalation of this cost with an estimated total cost of 15,911,654 rands for 254 patients with an average cost of 62 644 rands per patient. The average daily cost per day in T King, Coma care Trust audit was 2 615 rands while our study showed to be 12 528 rands with an increase of about 500 per cent, possibly due to the high health inflation cost over the years.

The High care and ICU cost in our study were 3, 784($270) and 8,608($615) rands respectively which is much higher than a 2006 study in India where ward stay was Rs 1062 (15$)/bed/day and Rs 3082 (40$)·The average surgical cost of the 2006 survey in India was Rs 11948 (180$) wherein our study the mean surgical cost was 16 487 rands(1268$)[16].

The ICU cost is comparable to a review of records of Trakya University Hospital's ICU in turkey from 2002-2006 which was 575$ compared to 615$ in our study[17]. Total cost per patients increased according to the severity of injury similar to the US CDC report in 2010. In the CDC report, the total average cost was much higher than our findings with moderate TBI cost $8189 (vs $4 516), serious $14603, severe $16788 (vs $6 656) and critical $33,537 respectively .[4]

6. CONCLUSION

We have demonstrated that TBI primarily affects the younger productive members of the society predominantly caused by assault with a blunt object as well as PVA. Educating pedestrians in road traffic laws needs to be strengthened as the present campaigns are mainly focused on motorists. The importance of prevention of crime and interpersonal violence cannot be overemphasised as the majority of cases in our study are as a result of an intentional injury.

Few ICU/HIGH care bed are available in the provincial hospital to serve a large number of the critically ill patient. In our unit priorities are given to TBI cases because of the emergent nature of the condition. The high percentage of bed occupancy rate is indicative of its impact on other neurosurgical conditions. We have shown that our unit is capable of using the referral system with high admission /surgery ratio of 67% and turnover with a median stay of 5 days. The significant TBI bed occupancy rate in the unit needs serious consideration not to impel further the academic unit to be a primary neuron- trauma servicing unit. The recent development by the department to open satellite neurosurgical units and step down rehabilitation centres needs to be reinforced.

Future studies should investigate the actual impact of TBI on other neurosurgical services with a focus on delays in admission and a surgical waiting period of none TBI neurosurgical patients. Other crucial factors like delays in the investigation of cases especially neuroimaging and theatre allocation time needs to be investigated separately as neurosurgical procedures take a longer operating time compared to most surgical disciplines.

We have shown the escalation of health care costs over the years and the high cost of TBI for short in hospital stay (5 days). The cost of managing TBI compared to another developing world like India is more expensive being equivalent to a country like Turkey and is much lower than developed nations like America. Where health delivery is under constraints and sharing of resources with epidemics like HIV and Tuberculosis is a reality, the consequences of TBI in our society is not entirely understood and hence is underfunded. Our study looked only at a subset of TBI patients and their management in our unit. Much broader research is needed to understand the impact on health care provision fully. As the healthcare costs escalate, the old idiom holds true "Prevention is better than cure" since TBI leaves many financial, physical and psychological scars on our society especially since a cure in a significant number of cases is not possible.

APPENDIXES

Appendix1. Patient Data Collection Format

Serial number: ___________

1. Patient identification and demographic information

1.1 Patient unique identifier: _____________

1.2 Age in years: _____________

1.3 Sex: 1. Male 2.Female

2. Admission information

2.1 Duration of total ICU stay (hours):________

2.2 Duration of total high care stay (days): ______

3. Clinical information

3.1 Cause of injury

1. Assault (penetrating)
2. Assault (Blunt)
3. Motor vehicle accident
4. Pedestrian vehicle accident
5. Others, specify: ____

3.2 Severity of injury (using Glasgow Coma Scale)

1. Severe: GCS < 8
2. Moderate: GCS 9-12
3. Mild: GCS 13-15

3.3. Type of injury

1. Depressed skull fracture
2. Haemorrhagic contusion
3. Acute subdural haemorrhage
4. Acute extradural haemorrhage

5. Intracerebral haemorrhage

6. Others, specify: ____________________________________

3.4 Surgical intervention done

1. Yes, 2. No

3.5 If yes, type of surgery done: ______________________

4. Patient care cost information in Rand

ICU stay cost: _______________

High care stay cost: _____________

Neuro Imaging cost: ______________

Medication cost: _________________

Surgical procedure cost: ________________

Laboratory investigation cost: ________

Other cost, Specify: ________________________

____

Total cost: _______________

Appendix 2: Patient Cost Estimates

Patient Cost Estimates	Level of care	12hrs (Rands)	24hrs (Rands)	Amount (Rands)
Hospital stay	**ICU stay**			
	specialist fee Inclusive of a facility fee	4304	8608	
	High care stay			
	specialist fee Inclusive of a facility fee	1892	3784	
surgical cost	**Craniotomy for acute subdural haemorrhage:**			14557
	Specialist Fee			1919
	Anaesthetic			1802
	Craniotomy for evacuation of acute extradural haemorrhage			14557
	Specialists fee			1919
	Anaesthetic			1802
	Craniotomy for evacuation of intracerebral haemorrhage			14557
	Specialists fee			1919
	Anaesthetic			1802
	Debridement of depressed skull fracture:			
	Procedure 1			2183
	Specialist Fee			266
	Anaesthetic			514
	Procedure 2			5687
	Specialist Fee			724
	Anaesthetic			514
Imaging cost	**CT Brain**			
	Uncontrasted			981
	Anaesthetic			559

	Specialist Fee			1695
	Contrasted			491
	Anaesthetic			559
	Specialist fee			848
	CXR			75
	Specialist fee			123
	Skull x-ray			75
	Specialist fee			123
Lab test / test (varies)	**Drawing of blood (daily cost)**			33
	FBC			50,25
	ABG			46,9
	U+E			73,87
	CRP			84,87

Are the costs for blood tests from the NHLS 2015 price list [22, 23.]

REFERENCES

1. Bryan-Hancock C, Harrison J. The global burden of traumatic brain injury: preliminary results from the Global Burden of Disease Project. Injury Prevention. 2011; 16(Supplement 1): A17-A.

2. Norman R MR, Bradshaw D. The high burden of injuries in South Africa. 7505 Tygerberg, South Africa: bull world health organ; 2007 [695–702].

3. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. NeuroRehabilitation. 2007; 22(5):341-53.

4. Faul M, Xu L, Wald MM, Coronado VG. Traumatic brain injury in the United States: emergency department visits, hospitalisations, and deaths. Centres for Disease Control and Prevention, National Center for Injury Prevention and Control. 2010:891-904.

5. Jacobs G., Aeron-Thomas A., Astrop, A. and Britain G (2012) A review of global road accident fatalities http://trid.trb.org/view.aspx?id=658322

6. Saidi H, Mutiso B.k, Ogendo J. Mortality after road traffic crashes in a system with limited trauma date capability. Journal of Trauma Management and outcome, 2014; volume 8 Article 4.doi:10.1186/1752-2897-8-4

7. Roozenbeek B, Maas AI, Menon DK. Changing patterns in the epidemiology of traumatic brain injury. Nat Rev Neurol. 2013;9(4):231-6

8. Muhammad J, Afeera A, Mamoon-ur R, Ayesha T, Syed S B, Anisa K. Changing spectrum of traumatic head injuries: Demographics and outcome analysis in a tertiary care referral centre jpma.org.pk.

9. Chandra S, Laxmi N G, Ishwar C P, Madhu S, and Jugal K An epidemiological study of traumatic brain injury cases in a trauma centre of New Delhi (India) Journal of emergencies, trauma, and shock: 2015;8 (3): 131-139

10. Andelic N. · Anke A. · Skandsen T. · Sigurdardottir S. · Sandhaug M.· Ader T. · Roe C. Incidence of Hospital-Admitted Severe Traumatic Brain Injury and In-Hospital Fatality in Norway: A National Cohort Study. Neuroepidemiology. 2012; 38(4):259-67. Doi: 10.1159/000338032. Epub 2012 Jun 5

11. Puvanachandra P, Hyder, A A. The Burden of Traumatic Brain Injury in Asia: a Call for Research. Pak J Neurol Sci. 2009; 4(1):27-32.

12. Peeters W, van den Brande R, Polinder S, Brazinova A, Steyerberg EW, Lingsma HF, Maas AI.Epidemiology of traumatic brain injury in Europe.Acta Neurochir (Wien). 2015 Oct; 157(10):1683-96. Doi: 10.1007/s00701-015-2512-7. Epub 2015 Aug 14.

13. Naidoo D. Traumatic brain injury: The South African landscape. S Afr Med J. 2013:613-4.

14. Christopher J L, Alan D L, Colin D M, Claudia S. The Global Burden of Disease 2000 project: aims, methods and data sources. Global Programme on Evidence for Health Policy Discussion Paper No. 36 World Health Organization November 2001 (revised) Global burden of disease 2000, Version 1 estimates. Available at: http://www.who.int/healthinfo/bodgbd2000v1/en/index.html

15. Webster J, Taylor A, Balchin R. Traumatic brain injury, the hidden pandemic: A focused response to family and patient experiences and needs. S Afr Med J. 2015; 105(3):195-8.

16. Singh M, Vaishya S, Gupta S, Mehta VS. Economics of head injuries. Neurol India. 2006; 54(1):78-80.

17. Sut N, Memis D. Intensive care cost and survival analysis of traumatic brain injury. Ulus Travma Acil Cerrahi Derg. 2010; 16(2):149-54.

18. Naidoo K, Singh J, Lalloo U.Critical analysis of ICU/HC beds in South Africa: 2008-2009 S Afr Med J. 2013 Sep 3;103(10):751-3. Doi: 10.7196/samj.6415.

19. Schuhmann M U, Rickels E, Rosahl S K, Schneekloth C G, Samii M. Acute care in neurosurgery: quantity, quality, and challenges. J Neurol Neurosurg Psychiatry 2001; 71:182-187

20. Humphreys I, Wood R L, Phillips C J, Macey S.The costs of traumatic brain injury: a literature review ClinicoEconomics and Outcomes Research 2013; 5: 281–287.

21. Thomas K, Jeyaseelan L, Yadav B, John KR. Cost of intensive care in India international journal of technology assessment in health care, 32:3(2016) DOI: 10.1017/S0266462316000398

22. NHLS State Price List 2015

23. Provincial Gazette vol. 21 Pretoria, 9 September 2015 No 397

.