Train accidents: Orthopaedic injuries and management at Groote Schuur Hospital, Cape Town, South Africa

by

CHRISTINA NIOVI KONTOGHIORGHE
KNTCHR006

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Under the supervision of Sithombo Maqungo, Associate Professor of Orthopaedics, Head of Orthopaedic Trauma

Division of Orthopaedic Surgery
University of Cape Town
Groote Schuur Hospital

Declaration

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Contents

Declaration 2

Abstract 5

Acknowledgements 7

List of figures and tables 8

Chapter 1 - INTRODUCTION 9
General background of the study 9
Problem statement 10
Professional significance of the problem 11
Overview of the methodology 11
Delimitations of the study 11
List of abbreviations 11

Chapter 2 - LITERATURE REVIEW 13
Research process 13
Review of literature 14
Literature on Cape Town 14
Literature on developing countries 15
Literature on developed countries 16
Literature on subways 21
Summary of literature 23
Research Gaps 24

Chapter 3 - AIMS AND OBJECTIVES OF THE STUDY 26
Methodology and aims 26
Study Design 26
Patients 26
Data analysis 26
Data safety 27
Methods 27

Chapter 4 - RESULTS OF THE STUDY 29
Results 29
All patients 30
Deaths 39
Orthopaedic patients 39
Orthopaedic injuries 42
Operations 46
Amputations 48

Chapter 5 - DISCUSSION 50
Statement of the problem 50
Review of the methodology 50
Summary of the results 51
Discussion of the findings/results 52
Interpretation of the results 52
Comparison of the current study results to previous findings 53
Limitations of the study 53

Chapter 6 - CONCLUSION AND RECOMMENDATIONS 55
Conclusions 55

References 56

Appendix 60
- Cape Town Rail Map
- Data collection proforma
- Human Research Ethics Committee approval letter

Abstract

Introduction

There is a high incidence of patient presentation at our hospital following train accidents. The literature describing the pattern of injuries and management following these accidents is sparse. In addition, the literature looking specifically at orthopaedic injuries and their management is lacking. The aim of this study was to investigate the demographics of patients sustaining traumatic injuries following train accidents and to specifically analyse injury patterns and management of orthopaedic injuries. Furthermore, the mortality rates and the effectiveness of advanced surgical care have also been evaluated and the outcomes of newer limb salvage techniques compared to amputation, which has been widely used in the past.

Methods

This is a retrospective observational study of patients presenting to a Level I Trauma Centre in Cape Town, South Africa. Prospectively collected data from January 2013 to July 2019 was reviewed retrospectively. All patients presenting with injury mechanism 'train casualty' or 'train-' were included in the study. Data was collected by one individual using a set proforma to ensure consistency. Patient folders were reviewed to ascertain specific details including mechanism of injury, types of injury and surgical intervention.

Results

Two hundred and twenty-two patients were identified through the trauma registers as presenting as train casualties to the Groote Schuur Hospital (GSH) trauma department; 48 patients were excluded, leaving a total of 174 patients included in the study; 92 of these were orthopaedic referrals. The average age was 32 years and males accounted for 87% of the patients. Fifty-four patients were involved in violence, 38 were accidental falls and 15 had been jumping on or off a train. Eight patients (4.6%) in total died in the trauma unit. Most accidents occurred between the hours of 20:00 h and 05:00 h. Of the orthopaedic referrals, males accounted for 89% of patients and the average age was 33 years. Forty- nine percent of patients sustained upper limb injuries and 49% sustained lower limb injuries. Spinal injuries were found in 27% of patients and pelvic injuries in 5%. Revised trauma score was calculable for 65 patients, with a mean score of 7.5. Each

orthopaedic patient had on average injuries to 1.74 body parts. Thirty-five patients sustained open fractures (38%). Non- operative management was undertaken in 32% of patients. Operative management took place in 68% of patients. A total of 61 patients had surgery for orthopaedic injuries. Each patient underwent on average 2.38 operations. There were 145 theatre encounters for 172 procedures. There were 19 amputation procedures for 12 patients; 10 of these patients had sustained traumatic amputations. There were 10 post-operative complications in total.

Conclusion

The findings of this retrospective descriptive study provide an insight into train accident victims and their orthopaedic injuries and management with a large sample size. As could be predicted from previous studies, the victims of these accidents are young males from poor socioeconomic areas. The victims who make it to hospital have a good chance of survival and even limb salvage. However, in this day and age, more needs to be done in terms of controlling and preventing railway violence. Similarly, increased health and safety measures need to be implemented in order to minimise accidental injuries on the railways in Cape Town. Further research into the long-term outcomes of these patients and their surgeries would provide further evidence into the role for limb salvage procedures.

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List of tables and figures

Table 1: Summary of literature review findings
Table 2: Patient demographics
Table 3: Stations where accidents occurred
Table 4: Patients' address
Table 5: Injuries and referrals
Table 6: Imaging in orthopaedic patients
Table 8: Orthopaedic injuries
Table 7: Operative versus non-operative management
Table 9: Orthopaedic operations
Table 10: Post-operative complications
Table 11: Orthopaedic injuries requiring amputation

Figure 1: Literature review process
Figure 2: Patients included in the study
Figure 3: Stations where accidents most frequently occurred
Figure 4: Map of patient addresses
Figure 5: Time of presentation to hospital
Figure 6: Number of cases by month

Chapter 1- INTRODUCTION

This chapter provides a brief introduction to the rationale behind the study of train accidents. It aims to provide a background to the current situation and an overview of the methodology chosen.

General background of the study

Railway transportation is a globally utilised method for travel. Whether in the developing or developed world, railway lines allow travel and commuting over long or short distances. Railway accidents are highly prevalent throughout the world. Although less frequently reported than motor vehicle accidents, they tend to confer more serious injuries and result in high numbers of fatalities. This is no less true in South Africa where trains are often overcrowded. Particularly in Cape Town, the trains pass through townships and carry commuters to their place of work. They are hotspots for crime and violence and the serious nature of the injuries associated with trains reflect this with high rates of morbidity and mortality. Pirie, in his paper in the Journal of Contemporary History, entitled 'Rolling Segregation into Apartheid: South African Railways, 1948-53' describes violence on the railways from the time of Apartheid where passengers were often involved in fights with the South African Railway (SAR) staff (Pirie, 1992). A wide spectrum of injuries result from train accidents and with access to trauma registers and the possibility of newer surgical techniques, this study set out to evaluate the orthopaedic injuries associated with train accidents.

In 2018-19, South Africa saw 641 fatalities and weighted injuries on their railway network (Railway Safety Regulator, no date). For a country with a population of around 57 million, this number is high in comparison to other places such as the UK which saw 318 fatalities in 2019-20, the European Union (EU) which saw 853 fatalities in 2018 (with a population over 7 times that of South Africa) and the United States of America (USA) which had 891 fatalities in 2019 (population more than 5 times that of South Africa) (Eurostat, 2020; Office of rail and road, 2020; U.S. Department of Transportation, Federal Railroad Administration, 2020).

Cape Town, one of the major cities of South Africa, has a population surpassing 3.7 million people. Up to a quarter of journeys are made using public transport (*Deloitte City Mobility Index Cape Town*, no date). According to the 'Transport for Cape Town' website, the city's railway network is made up of 118 stations and a total of 610 kilometres of railway line (*RAIL NETWORK*, no date). There are an estimated 621,833 journeys a day, mostly to and from the central business district (CBD), Bellville and Epping. The railway system is plagued by closures, delays and vandalism. A number of the city's main lines are currently non- operational and in need of refurbishment (Washinyira, 2020).

As per Matzopoulos et al. 1998, the railway system in Cape Town dates back to 1862 (Matzopoulos and Lerer, 1998). The first line, the Northern line, ran northwards to the diamond mining hub at the time. The Suburban line followed next, and during Apartheid, new lines connecting the Cape Flats to Cape Town were built to carry commuters from their homes into the city for work. Trespassing and proscribed pedestrians on the lines have been a major cause of accidents and death associated with the Cape Town rail network since its beginning. The rate of suicides has always been, in comparison, low on the railways. They noted a high rate of underreporting of fatal and non-fatal accidents, in particular concerning incidents relating to violence and robbery.

Whereas the World Health Organization (WHO) publishes information on global road traffic accidents, there is no such readily available publication for railway deaths (World Health Organization, 2015).

Problem statement

At GSH, train accidents are unfortunately a common presentation of patients to the trauma unit. A high proportion of these patients get referred to the orthopaedic team with extremity, pelvic and spinal injuries. We herein described the types of injuries referred and how the team managed these injuries.

Professional significance of the problem

The purpose of conducting this study was for a multitude of reasons. Firstly, there is limited literature on the topic of train accidents in general, but specifically in Cape Town and looking at orthopaedic injuries and their management. This information could become useful to trauma and orthopaedic departments so that they can have a greater understanding of the injury profile of train accident victims. In addition, it is hoped that this information could identify risk factors for those most commonly involved in train accidents in order to aid the enforcements of preventative measures targeted at these high-risk groups. This study aims to draw attention to the high prevalence and burden of train injuries in this developing world setting.

Overview of the methodology

The study was conducted retrospectively by studying trauma registers and medical folders to identify patients presenting as train casualties, their orthopaedic injuries and the management of these injuries.

Delimitations of the study

This study is limited by the fact that it was conducted at a single trauma centre in one city in South Africa. This is a developing world setting with a specific cohort of people using the rail network and presenting to this unit. The sample is dependent on adequate documentation from the trauma clerks as well as triage nurses and doctors. A number of the folders belonging to train accident victims were unavailable for review and this will have impacted on the sample size and reliability of the results.

List of abbreviations

GSH: Groote Schuur Hospital
UCT: University of Cape Town
RTS: Revised Trauma Score
ICU: Intensive Care Unit
GCS: Glasgow Coma Scale

CT: Computed Tomography

MRI: Magnetic Resonance Imaging

Ex- Fix: Uni/bi-planar external fixation

ORIF: Open Reduction Internal Fixation

MDT: Multi-Disciplinary Team

ACJ: Acromioclavicular joint

SIJ: Sacroiliac joint

TLSO: Thoraco-lumbar-sacral orthosis

AKA: Above knee amputation

TKA: Through knee amputation

BKA: Below knee amputation

MUA: Manipulation under anaesthesia

MESS: Mangled Extremity Severity Score

HREC: Human Research Ethics Committee

SD: Standard deviation

Chapter 2- LITERATURE REVIEW

The objectives of the literature review were primarily to gauge an understanding of what is known about the injuries sustained as a result of train accidents and how these are managed. The literature was searched for any publications which described the situation in Cape Town as well as other areas of South Africa. This search was then expanded and compared to train accidents in other developing countries and eventually developed countries. The aim was to understand if there is a high mortality rate associated with orthopaedic injuries and what the mainstay of treatments are for extremity injuries.

Research process

A literature search was carried out on MEDLINE (PubMed) and Google Scholar using the Boolean search terms as follows: railway accidents AND injuries; train accidents and orthopaedic injuries; railway OR railroad accidents AND orthopaedic injuries. These searches returned a number of results. Titles were screened for relevance. Titles not related to railway accidents were immediately excluded. Studies looking specifically at occupational accidents (railroad workers), electrical injuries (result of electrocutions), motor vehicles versus train accidents, train crashes, suicides and paediatric or children's injuries were excluded, as demographically the data from these results is skewed and not comparable to our study. Studies not in English (with no English translation) were excluded. These search terms returned thousands of results as shown in Figure 1. Following screening as above, 26 papers were deemed relevant for the purposes of this study and included in the literature review. The reference management software Mendeley (Elsevier) was used and the Harvard referencing system applied to acknowledge authors appropriately.

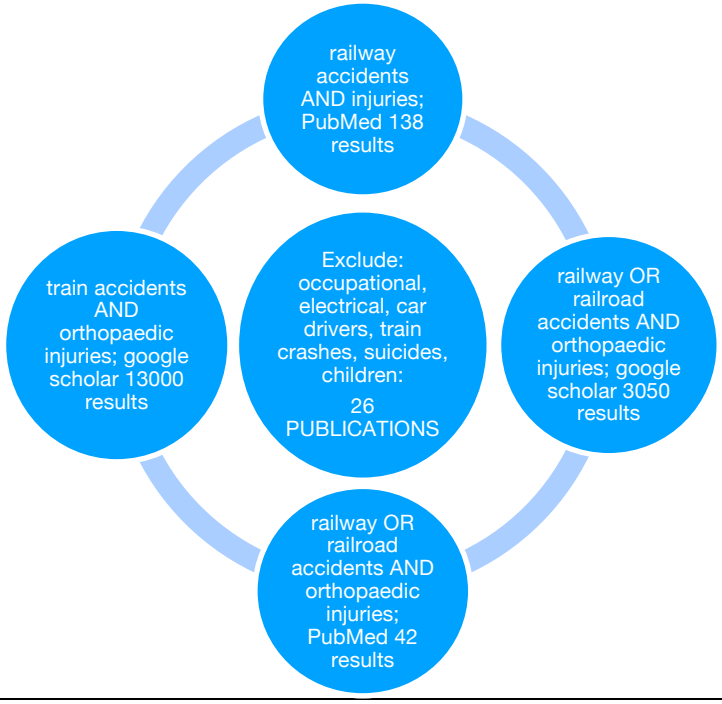

Figure 1: Literature review process. This figure shows the number of results for search terms in PubMed and Google Scholar and the final number of publications chosen after exclusions were applied as described in the main text.

Review of literature

Literature on Cape Town

In a study from Cape Town in 1988, Singer et al. described their experience of orthopaedic trauma following train accidents (Singer and Anderson, 1988). Between January 1984 and March 1986, 194 patients were admitted to GSH and 62 of these were referred to the orthopaedic department. The majority were males (59% versus 41%), employed and in most cases (68%) had suffered accidental injuries. Injuries occurred much less frequently on Sundays, suggesting commuters were mostly implicated. Sixty-eight percent of cases were due to accidental injury and 20% due to foul play. They described ninety orthopaedic injuries, including- amputations (N= 12), open fractures (N= 20), vertebral fractures, pelvic fractures and fracture dislocations. Associated major injuries included chest and abdomen. Average length of stay was 26 days. Three patients died. The authors suggested that with 2 train accident victims a week, the financial cost to the health system and emotional cost to victims' families was significant.

They urged that more awareness was required surrounding these types of accidents and preventative measures needed to be implemented.

In another study from Cape Town, Lerer and Matzopoulos published their work looking into the burden of train injuries from 1996-1998 (Lerer and Matzopoulos, 1996, 1997; Matzopoulos and Lerer, 1998). Their work was supported by the Medical Research Council. They found that there were 400 deaths as a result of train injuries per year in South Africa. Contributing factors to these accidents included an increasing number of commuters, violence and fare evasion. Falls from train or being struck by train were the most common mechanisms of injury. Most deaths occurred in those struck by train and those attempting suicide. They found that most accidents took place during peak morning and evening commuting hours (05:00 h- 09:00 h and 16:00 h- 20:00 h) and there was a link between alcohol consumption and pedestrian fatalities.

Literature on developing countries

In a study from New Delhi, India, 127 cases of train accidents were autopsied in one jurisdiction between 1996 and 2002 (Rautji and Dogra, 2004). Most cases were male (88%) and the most common age group was 21-30 years. They found upper and lower limb injuries in 26% and 23% of cases respectively. Over 10% of total victims required amputation and the majority of these were lower limb (69% versus 31% upper limb). The majority of accidents were from pedestrians crossing the tracks and over 30% of cases were commuters falling from trains. Alcohol was detected in over 17% of cases. There was only one documented case of suicide. Interestingly, the set-up in New Delhi is similar to that of Cape Town, with the railways passing through working class informal settlements where fences had been removed to be used as building materials, leaving the tracks exposed and open for pedestrians to use as crossings. Hence a large number of injuries occurred due to ‘trespassing’.

A study from Turkey, carried out at the Hacettepe University School of Medicine in the year 2000, retrospectively reviewed 41 cases over a 12-year period from 1985-1997 (Agalar, Cakmakci and Kunt, 2000). The authors suggested that the low safety standards in this developing country pertain to practices such as train

surfing. They found that 68% of the patients were male, with a mean age of 32 years. In terms of mechanism of injury, 59% had fallen from the train, 41% had been hit by a train and of these, 22% were suicide attempts. A total of 7 patients underwent 9 traumatic amputations and the majority of these were in the lower limb. There was a high mortality rate among traumatic amputees, with only 3 of the 7 patients surviving; the overall mortality rate was 17% and the majority of deaths occurred in the group 'hit by train'. Extremity fractures were present in 14 of the patients. Non-survivors had a statistically significant lower revised trauma score (RTS) of 3.6 versus 11.4. Sternum, clavicle and costal fractures were marginally more common than lower limb fractures, with upper limb much further behind.

In another study from Turkey, carried out in 2011, 10 years of records on train accidents at Hacettepe University Medical Center were analysed (Akkas *et al*., 2011). Between January 1998 and January 2008, 51 patients above 16 years of age were admitted due to railway accidents. Seven had missing records and were excluded from the study. Sixty-eight percent of the injured were male and the mean age was 31.8 years. The majority of accidents took place during the evening commute, 16:00 h- 19:00 h. The majority of patients were admitted to hospital in under 30 minutes. All bar 2 cases were train- pedestrian collisions; 8 of these were suicide attempts. Of the suicide attempts, 2 had alcohol in their blood and both were known to have a history of psychiatric illness. Overall, 5 patients had a history of psychiatric illness. There were 14 lower extremity fractures compared to 2 upper extremity fractures, with 12 lower limb versus 2 upper limb amputations. The mean RTS for all victims was 10.5; averaging 3 in deaths and 11.9 in survivors. There was a 16% mortality rate and all deaths occurred from accidents between 16:30 h- 19:30 h. Risk factors for mortality were alcohol involvement, recurrent suicide attempt, psychiatric illness and a low RTS.

Literature on developed countries

A study carried out in Tucson, USA in 1988 looked at railroad- related deaths between 1979 and 1986 through a retrospective review of the emergency medical services database (Spaite *et al.*, 1988). Of 41 patients analysed, the average age was 31.2 years and 90% were men. There were 10 deaths in total. Only one incident

occurred at night. Three cases were employees. Average hospital length of stay was 11.5 days. There was one suicide attempt (which did not lead to death). Five patients had amputations and all were injured by falling from a moving train. There was a total of 35 extremity injuries. Twenty-seven percent of patients had raised blood alcohol levels.

A study from Berlin in 1998 looked specifically at train surfing deaths (Strauch, Wirth and Geserick, 1998). Analysis of 14 deaths between 1989 and 1995 was made. The majority of victims were male and aged between 16 and 20 years. Nine cases suffered lower extremity and 6 cases upper extremity injuries. The most common cause of accident was collision with obstacles. Eight out of 9 cases recorded had alcohol in their systems.

A review which came out of Alabama in 1996 found 86 railway fatalities covering a 15-year period from 1981 to 1995 (Davis, Bruce Alexander and Brissie, 1997). A computer search was undertaken to retrospectively identify causes of death related to a train or taking place alongside a railway line. The average age of victims was 39 years and the majority were male. Sixty-four cases were accidental and 7 cases were due to suicide. Six of the deceased were railroad employees who died whilst at work. Forty-seven cases were trespassers and 42 were pedestrians on the tracks; 27 were in a motor vehicle. Of the 82 cases where toxicology analysis took place, 45% were found to be intoxicated with alcohol or drugs.

As with other studies, Shapiro et al. in 1994 found a correlation between raised blood alcohol levels (70% of patients had alcohol in their system) and train injuries in their study conducted in St Louis, USA (Shapiro *et al*., 1994). Their work came out of a level I trauma centre and covered a period of 7 years from June 1985 to September 1992. Twenty-three cases were analysed; 87% were male and the average age was 30.6 years. Nearly half of the injured were pedestrians. There were a total of 8 amputations, 6 lower limb and 2 upper limb. Three patients died. In contrast to other studies and also the South African model where most accidents happened during commuting hours, in this study, the majority of injuries (61%) happened during the night (23:00 h-07:00 h). Of note, there are no commuter trains in the Metropolitan St Louis area.

In another retrospective review from the USA, this time looking specifically at pedestrian-train accidents from the Carolinas Medical Center Trauma Service between August 1982 and May 1990, of 15 patients identified, all were male and the average age was 30 years (Moore, Wilson and Hartman, 1991). The majority of patients were trespassers; 2 were railroad employees. Traumatic amputation occurred for 10 extremities in 8 patients. Twelve of the 15 victims had raised alcohol blood levels. Four patients suffered open fractures. Overall, 59 surgical procedures were required in total, an average of 3.9 operations per patient. Average length of stay was 30 days. They found that the patients undergoing limb salvage surgery ended up requiring amputation, often as a result of bone loss and wound sepsis and suggested a role for primary amputation in this case.

In Texas, 1998, a study by Goldberg et al. found that 38% of 98 train related trauma patients required amputations (Goldberg, Mootha and Lindsey, 1998). Their study took place over 5 years from 1990 to 1995. The majority of cases were due to train-pedestrian accidents. Twenty-eight patients died altogether. Forty-five patients sustained extremity fractures.

Singer et al. (1994) carried out a retrospective review between February 1989 and February 1993 of train versus pedestrian accidents (Singer and Thordarson, 1994). They found that 24 of 30 patients presenting following a train injury required orthopaedic management. The most common injury was to the foot. There were a total of 19 lower limb and 2 upper limb amputations in 14 patients. The most commonly performed operation was debridement (most commonly in patients with traumatic amputations).

In an Austrian study from 2011, train- related injuries as a result of train surfing were compared to other high voltage injuries and their outcomes following fasciotomy, amputation and other soft-tissue operations (Lumenta *et al*., 2011). The authors conducted a retrospective review approved by the Medical University of Vienna over a 14-year period from January 1994 to December 2008. Thirty-seven patients in total were included in the study, and of these, 12 were train surfers (11 men and 1 woman). The average age of these train surfers was 15.8 years. The median length of stay was 52 days and on average 4 operations were carried out per patient. Six lower limb amputations were carried out in train

surfers and there was a fasciotomy rate of 71.4% in the train surfers group. Other injuries included closed fractures (33%) and brain injury. One patient from the train surfers group died as a result of multi-organ failure within one week of injury. The research group concluded that train surfing was not just attributable to lack of security and over-crowding, but in consideration of the demographic (young males), there was an element of thrill-seeking and a lack of sense of responsibility.

One study in 2007 described their experience of railroad injuries at the USA-Mexico border (Chattar-Cora *et al*., 2007). They studied a population who may have been trying to enter the USA illegally. The trauma registry of the University of Texas Health Sciences Center (level I trauma centre) was retrospectively searched from January 1996 to September 2003 for any victims of train-related trauma. Of a study group of 67 patients, mean age was 28.8 years and 61 were male. Sixty-one percent of patients were illegal immigrants. Most patients suffered injuries between 19:00 h and 07:00 h. Over half had fallen from a moving train. Others had jumped, fallen asleep on the tracks or been hit by the train. Thirteen patients had raised alcohol levels in their blood. An average of 2.97 operations were performed per patient. Thirty-eight patients had some kind of amputation and only 5 of these were upper limb. One death occurred in a 76-year-old male with multi-organ failure. There were 54 extremity fractures suffered in this group. The mean length of hospital stay was 16.48 days. The authors touched on the irony that young, fit men who were often travelling to find work (or commuting to work) could suffer such life-changing injuries which would render them unable to work in the future.

In 2019, a retrospective cohort study looking at the orthopaedic injuries from elevated metrorail systems at a level I trauma centre in the US was published (Donnally *et al*., 2019). A total of 33 patients with a combined 104 orthopaedic injuries were included in the study. Seventy-five percent were male and mean age was 37.7 years. Mean length of stay for patients who survived was 24.7 days; 9 patients died. There were on average 1.2 operations per patient. Interestingly, there was a higher proportion of upper extremity injuries, with a total of 35%, compared to 31% lower extremity. Other injuries included vertebral and pelvic ring fractures. Open fractures occurred in over 60% of patients. Fifteen traumatic amputations were sustained in 9 patients; 9 lower limb and 6 upper limb. Patients

sustaining spinal injuries were statistically more likely to suffer a traumatic brain injury. Females were less likely to survive (38% versus 84% males). Over half of the patients (52%) had a history of psychiatric illness and this percentage was higher in patients with intentional injuries (79%). Alcohol was involved in 58% of cases. The presence of an open fracture significantly correlated with increased risk of death.

In 2001, a study from Sheffield, UK, looking at tram-related injuries was published (Cameron, Harris and Kehoe, 2001). Patients presenting to the emergency department at one hospital between April 1994 and November 1995 with injuries related to the tram system were analysed. Ninety patients were identified; 54 of these were male and the median age was 39 years. The largest group of patients was formed by cyclists (N= 41), followed by pedestrians (N= 23) and motor vehicle accidents (N= 12). Most accidents occurred in the evening and alcohol was involved in 10 cases. The upper limb was the most commonly fractured site (63%) and the majority group sustaining these injuries were cyclists. In total, 8 patients required surgery, with a total of 13 operations and length of stay 7.5 days. No amputations or deaths were mentioned in the study.

In 2014, a retrospective analysis based on autopsy reports of train-person collisions in Portugal from 2008-2012 was published (Sousa *et al*., 2015). Of the deaths related to train accidents in this study, over 60% were suicide and 30% were accidental (the remainder were indeterminable). They noted a significant decrease in fatalities after 2009, coinciding with a television campaign to reduce train- pedestrian fatalities. Sixty two percent of the victims were male and most victims fell into the age category of 40-59 years. Most accidents occurred in the winter and during rush hour. They found over 50% of patients to be under the influence of alcohol or other drugs.

A study in 1984 out of Queensland, Australia, reported on fatal and non-fatal accidents on the railways (Nixon *et al*., 1985). Two-hundred and eleven sequential accidents were retrospectively reviewed between 1978 and 1981 and a total population study was simultaneously carried out over a period of 5 years. There were 84 deaths in the study period. The top cause of death was occupational, closely followed by car-train collisions and drunk pedestrians. There were 10

suicides in the cohort. Thirty percent of people above the age of 17 years had alcohol detected in their blood. They found that mechanism of injury varied depending on the age group of the patient. Thirty-four patients (13.4%) suffered fractures, 3 patients (1.2%) had severed limbs and the same percentage had dislocations (body parts not specified). They suggested strategies for reducing accidents such as legislation, education and improved design for safety.

A total of 3506 patients were identified for a study looking specifically at non-motor vehicle railway accidents from the National Trauma Data Bank in the United States over an 8 year period of 2007 to 2014 (Schneble, Raymond and Loder, 2019). The average age was 38.6 years and 80.5% of patients were male. Over 44% of patients required an ITU admission with average length of stay of 8.6 days. The average total length of stay in the hospital was 12.1 days. Most injuries were as a result of colliding with rolling stock (38.6%), whereas 19.5% were injured following a fall within or from the train. Employees made up 12.5% of the casualties and alcohol or drugs were involved in over 40% of cases. The total number of fatalities was 6.4% and most of these were from the category 'hit by stock' which accounted for any number of injuries where there was direct impact of the victim with a moving object.

Another study from the USA in 1994 retrospectively analysed 25 train-pedestrian fatalities looking into manner of death (Cina, S.J., Koelpin, J.L., Nichols, C.A. and Conradi, 1994). A 10-year period from 1982 to 1992 was covered and data was taken from investigations at the Charlseton County Medical Examiners' Office, South Carolina. The mean age of the victims was 29 years and 96% were male. One off-duty railroad worker was struck by a train and died. The majority of incidents occurred overnight and 80% had raised alcohol levels in their system. There was one confirmed case of suicide.

Literature on subways

A study carried out in 2018 looking at patients who presented following injuries on the London Underground between June 2003 and July 2014, found that 90 out of 127 cases were due to deliberate injury (attempted suicide) (Virdee *et al*., 2018). This is in vast contrast to the picture in developing countries were cases are

mostly accidental or due to alcohol and violence. The most common injuries were to the chest and limbs. Thirty-two patients suffered lower limb amputations and 10 suffered traumatic upper limb amputations. The mean RTS was 4.27 for non-survivors versus 6.81 in survivors. The average length of hospital stay in survivors was 44.19 days. They found no significant difference in injury pattern between deliberate and accidental cases. They found traumatic lower limb amputation to be the most common injury to the extremities. Seventeen percent of patients died after admission to hospital.

In another subway study, this time in New York City, 2006, traumatic amputations were reviewed (Maclean *et al*., 2006). This retrospective analysis included 41 patients over a 14-year time period (1989-2003). The average age of patients was 37 years and 79% were male. Nearly a fifth of patients had prior psychiatric illness and two fifths had raised alcohol levels documented. Five patients had definitely attempted suicide, although this number could have been higher. Most of these injuries occurred between 18:00 h- 00:00 h. In cases with a documented mechanism of injury, patients most commonly fell onto the tracks. Other mechanisms included being pushed and attempted suicide (with equal prevalence) and also having a seizure. The majority of amputations were lower extremity (42 versus 14 for upper). On average, patients underwent 3 operative procedures each and average length of stay was 34 days. Limb salvage was unsuccessfully attempted in 8 patients (mostly due to wound infection). The overall mortality rate was 5%. The most common associated injury was chest. This paper emphasizes the psychological impact on victims, witnesses and also drivers as well as the social impact on return to employment or lack thereof, following this type of injury. Again, as with other studies, the authors recommended stricter preventative strategies taking into account how commonly patients had accidentally fallen onto the tracks.

A retrospective case series of 254 patients of subway related trauma over 15 years at a level I trauma centre in New York was published in 2018 (Rodier *et al*., 2018). The mean age of victims was 41 years and 80% were male. Interestingly, injury time was equally spread throughout the day, however seasonally, winter and spring saw more cases than summer. Seventeen percent of cases were suicides and 3 cases were due to assault. The mechanism of injury, in order of prevalence,

was: hit by train (49%), fall (44%) and pinned by train (3%). Thirty-eight percent of patients sustained long bone fractures, with 21% sustaining traumatic extremity amputations. None of the amputated limbs were deemed to be salvageable. Ninety-five patients (37%) required surgical intervention. Of the amputations, 64% were lower limb and 6% were both upper and lower limb. There was an equal mortality rate between those receiving amputation and those not requiring it. Over half of patients (55%) tested positive for alcohol. Seventeen percent of all cases were suicides. Mean length of stay was 11.9 days and overall mortality was 10%.

In 2009, another study looked at subway related fatalities in New York City (Lin and Gill, 2009). Death certificates between 2003 and 2007 were screened. Two hundred and eleven cases were identified. Suicide accounted for over 50% of cases, with accidents occurring in 76 cases. Average age was 44 years and men made up the majority of victims. The greatest number of accidents occurred between 04:00 h and 08:00 h and suicides between 08:00 h and 12:00 h. Interestingly, most accidents occurred around the time of bars closing in the city. Alcohol was detected in 42% of accidental deaths. In accidental deaths, extremity injuries occurred in 62% and amputations in 25%. Five deaths were in subway employees.

Summary of literature

As evidenced by the literature, train accidents have a high morbidity and mortality rate. There seems to be a high incidence of amputation when looking at musculoskeletal injuries. Risk factors for train injuries in general tend to be male gender in the 30-39 age group. Alcohol intake, attempted suicide and also occupation (railway employee) are additional risk factors. Lower limb amputations are more common than upper limb and limb salvage seems to be complicated by wound infections. There is a discrepancy in injury profile and cause of accident when comparing subways with railways and developed with developing countries. Developed countries see a much higher rate of injuries due to suicide whereas accidents in developing countries often happen to commuters. Time of accident also differs in these studies, with suicides taking place during

night-time hours and accidental injuries during daytime commuting hours. Table 1 shows a comparison of the major findings of these papers.

Research Gaps

The last study on train accidents to come out of Cape Town was over 20 years ago. With an ever-changing economic landscape, increased commuting and ongoing violence in the Western Cape, it is of significant importance to study the behaviours on the railways and whether there has been any change since the last study. There are a number of related papers from the developing world and also a number of papers looking at fatalities; however, few studies describe orthopaedic injuries, apart from amputation, and none of these studies describe in detail the orthopaedic management of extremity injuries.

Table 1: Summary of literature review findings. Salient points are noted including year of publication, country/ city, whether this is a developed or developing country, authors, number of patients in the study, mean age, percentage male, suicide attempts, mortality rate, amputation rate, intoxication rate, percentage of patients requiring intensive care admission and average length of stay (days).

Year	**Country**	**City**	**Developed country? (Y/N)**	**Author**	**No. patients**	**Age (yr)**	**Male %**	**Suicide attempts %**	**Deaths %**	**Amputations %**	**Intoxicated %**	**ITU %**	**LOS (days)**
2020	*South Africa*	*Cape Town*	*N*	*Kontoghiorghe et al.*	*174*	*31.8*	*87.4*	*0*	*4.6*	*6.9*	-	*8.8*	*14.9**
2019	USA	Miami	Y	Donnally III et al.	33	37.7	75.8	35.7	27	27	-	42.4	24.7
2019	USA	-	Y	Schneble et al.	3506	38.6	81	-	6.4	-	40.7	44.6	12.1
2018	UK	London	Y	J Virdee et al.	127	41	73	71	19	33	-	57	44.19
2018	USA	New York	Y	Rodier et al.	254	41.3	80	17	10	21	55	-	11.9
2015	Portugal	Northern region	Y	Sousa et al.	97	40-59	62	60.8	-	-	50	-	-
2011	Austria	Vienna	Y	Lumenta et al	37	-	97.3	-	5.4	16.1	-	-	-
2011	Turkey	Hacettepe	N	Akkas et al.	44	31.8	68	18	16	31.8	4.5	-	15.7
2009	USA	New York	Y	Lin et al.	211	44	83	52.6	-	30	42	-	-
2007	USA	San Antonio	Y	Chattar-Cora et al.	67	28.8	89.7	-	1.5	56.7	19.4	-	16.48
2006	USA	New York	Y	Maclean et al.	41	37	79	18.5	5	56	39	-	-
2004	India	New Delhi	N	Rautji et al.	127	21-30	88.2	-	-	10.2	17	-	-
2001	UK	Sheffield	Y	Cameron et al.	90	39	60	-	-	-	18.5	-	7.5
2000	Turkey	Hacettepe	N	Agalar et al.	41	32	68	22	17	9.8	17	-	-
1998	United States	Texas	Y	Goldberg et al.	98	30.1	-	-	31	38	-	-	-
1998	South Africa	Cape Town	N	Matzopoulos et al.	827	-	-	7.9	45.2	-	-	-	-
1998	Germany	Berlin	Y	Strauch et al.	41	16-20	93	-	44	-	50	-	-
1997	USA	Jefferson County	Y	Davis et al.	86	39	88	8.1	-	-	45	-	-
1997	South Africa	Cape Town	N	Lerer et al.	379	-	85	8	-	-	40	-	-
1996	South Africa	Cape Town	N	Lerer et al.	884	-	-	10.6	42.9	-	-	-	-
1994	USA	St Louis	Y	Shapiro et al.	23	30.6	87	-	14	34.8	70	-	-
1994	USA	California	Y	Singer G et al.	30	21	-	-	-	52	-	-	-
1994	USA	Charleston	Y	Cina et al.	25	29	96	4	-	-	80	-	-
1991	USA	North Carolina	Y	Moore et al.	15	30	100	-	-	53.3	80	-	30
1988	South Africa	Cape Town	N	Singer et al.	194	20-29	59	-	1.5	6.2	-	-	26
1988	USA	Arizona	Y	Spaite et al.	41	31.2	90	2.4	24	4.9	27	2.4	-
1984	Australia	Queensland	Y	Nixon et al.	295	-	80	12	28	1.2	30	-	-

*from 92 person sample

Chapter 3 – AIMS AND OBJECTIVES OF THE STUDY

This chapter describes the aims of the study and the methods used to carry out the analysis.

Methodology and Aims

There is a high incidence of patients presenting to GSH following train accidents. The literature describing the pattern of orthopaedic injuries and management following these injuries is sparse. The literature looking specifically at orthopaedic injuries and management is lacking. There are some publications from Cape Town, however, these are over 20 years old (Singer and Anderson, 1988; Lerer and Matzopoulos, 1996, 1997; Matzopoulos and Lerer, 1998). This study aims to evaluate how train accidents occurring in the present day and their associated injuries are managed, as well as assessing the mortality rates of these patients presenting to the trauma unit. In particular, with rapidly advancing surgical care, the operative management of orthopaedic injuries is specified and the indications for amputation are investigated.

Study Design

This is a retrospective descriptive study of patients and their injuries presenting to GSH- a level I trauma centre in Cape Town, South Africa. As this is a descriptive analysis of our findings, there was no null hypothesis.

Patients

The study population included all patients presenting to GSH, Cape Town, Trauma Department having been involved in a train accident between January 2013 and July 2019.

Data analysis

As this is a descriptive study, no power calculations were carried out. Categorical data is presented in the form of frequencies and percentages. Continuous data is

reported as the mean and standard deviation. Due to the sample size, analysis between groups was not undertaken as this was not deemed to be able to return statistically meaningful results.

Data safety

All data was collected in line with the hospital and university data collection policies. All patient-identifiable data was omitted. Ethical approval from both GSH Department of Research Ethics Committee and the University of Cape Town Human Research Ethics Committee was sought and granted; DRC REF 2019/068, HREC REF: 419/2019.

Methods

The trauma registers from the trauma unit at GSH, a level I trauma centre in Cape Town, South Africa, were reviewed retrospectively for prospectively entered data between January 2013 and July 2019. All patients presenting with mechanism 'train casualty' or 'train-' were included. Data was collected by one individual on a set proforma to ensure consistency. Hospital number, age or date of birth, date of admission, mechanism of arrival and disposal were all noted onto data collection forms. Hospital numbers were used to search the medical records department for the patients' folders. The folders were then used to ascertain specific demographic and clinical details.

Demographic data collected included: date of admission, date of birth/ age, gender, occupation: employed, unemployed, student, disabled, pensioner, unknown; referring hospital, time of arrival, patient's home neighbourhood, station where the incident occurred, method of arrival: ambulance, self, other; mechanism of accident and disposal: admit, discharge, death. Mechanism of accident was noted as either: 1) jumping on or off the train (purposeful), 2) fall from the train (accidental), 3) crossing the railway line (pedestrian), 4) suicide attempt, 5) train surfing, 6) violence (including being pushed), 7) injured on the train, 8) other, 9) not available.

Clinical data collected included: if the patient was haemodynamically stable, types of injuries sustained, vital observations, Glasgow Coma Scale (GCS), investigations undertaken, blood transfusion, outcome of resuscitation (survival versus death) and which teams were involved in the care, including admission to the Intensive Care Unit (ICU).

For any patient referred to the orthopaedic team or presenting with orthopaedic injuries, the details of the injuries were noted as well as details of conservative or operative management, length of stay and any complications. The RTS was also calculated for the orthopaedic patients. A questionnaire was completed for each patient and the data was then uploaded onto a Microsoft Excel (Microsoft Corporation, 2018) spreadsheet. Any patient for whom a folder was not found was excluded from the study. Other exclusions were any patient for whom the mechanism of injury did not fit the criteria of a train accident when reviewed in the notes, any patient presenting later than the date of injury and any patient with insufficient notes in their files. Patients presenting with injuries from the train station which did not involve being on a train or injured by a train were also excluded.

Chapter 4- RESULTS

In this chapter an overview of the patients presenting secondary to train accidents to the trauma department at GSH was prepared. Data analysed included age, gender and other patient characteristics for all patients. Furthermore, a description of the orthopaedic injuries resulting from train accidents was prepared and evaluation of the non-operative versus operative management was undertaken.

Results

Ten trauma registers were available for review for the selected period January 2013 to July 2019. A total of 51 months of admissions to the trauma unit spanning 7 years were analysed. Two hundred and twenty-two patients were identified through the trauma registers as presenting as train casualties to the GSH trauma department. Forty-eight patients were excluded as per the exclusion criteria above, leaving a total of 174 patients included in the study; 92 of these were orthopaedic referrals (Figure 2).

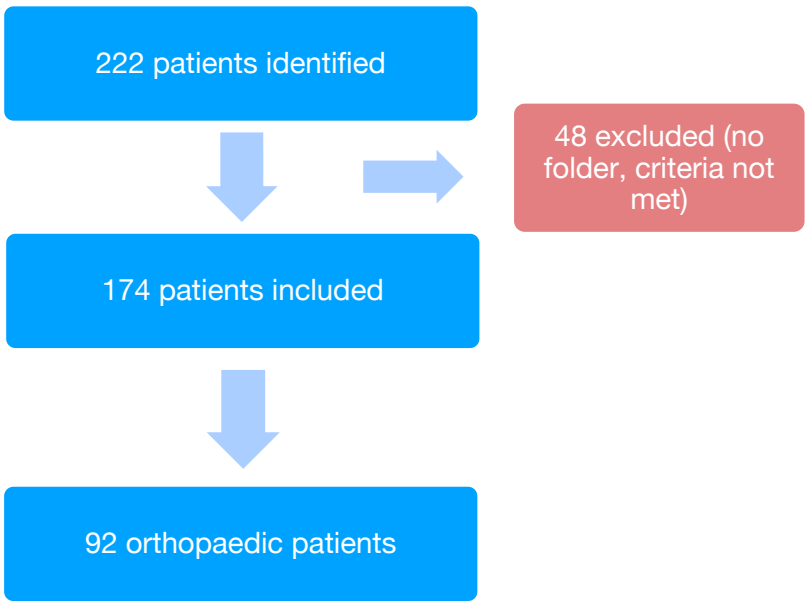

Figure 2: Patients included in the study. Two-hundred and twenty-two patients initially identified, 48 excluded; a total of 174 patients were included in the study and 92 of these were referred to the orthopaedic team.

Summary of all patients

Eighty-seven percent of all train injury patients were male. The average age was 31.8 years (range 12-83; SD 13.0). Seventy-one patients were unemployed; 43 were employed; 48 were unknown and the remainder were students (N= 9), pensioners (N= 2), disabled (N= 1). The top three home neighbourhoods for train victims were Khayelitsha (N= 26), Mitchell's Plain (N= 26) and Guguletu (N= 23). For a number of patients, stations where the accident took place were unknown (N= 66), however Salt River (N= 9), Woodstock (N= 8) and Langa (N= 8) had high rates of accidents (Tables 2, 3, 4; Figures 3, 4). Eighty-four percent (N= 145) of patients were brought in by ambulance, while the rest came in by themselves (N= 13), by alternative methods (N= 13) or the arrival method was not documented (N= 3). The highest reported mechanism of injury was through violence (N= 54). Other mechanisms in order of frequency were fall (N= 38), not available (N= 34), other (N= 21), jumping on or off (N= 15), train surfing (N= 5), and injured on train (N= 1). Seventy-four percent of patients were admitted, 22% were discharged and 3.4% (N= 6) died in the trauma unit. Two further patients died shortly after admission, bringing the total number of deaths to 8 (4.7%)

Table 2: Patient demographics. Presentation of data showing the baseline characteristics of all patients and orthopaedic patients.

	ALL PATIENTS N (%)	**ORTHOPAEDIC PATIENTS N (%)**
SEX		
MALE	152 (87.4)	82 (89.1)
FEMALE	22 (12.6)	10 (10.9)
MEAN AGE (YEARS)	31.8 (SD 13.0)	33.4 (SD 13.7)
EMPLOYMENT		
EMPLOYED	43 (24.7)	-
UNEMPLOYED	71 (40.8)	-
STUDENT	9 (5.2)	-
DISABLED	1 (0.6)	-
PENSIONER	2 (1.1)	-
UNKNOWN	48 (27.6)	-
REFERRING HOSPITAL		
NONE	95 (54.6)	-
NEW SOMERSET	4 (2.3)	-
MITCHELL'S PLAIN	7 (4.0)	-
VICTORIA	1 (0.6)	-
DAY HOSPITAL	8 (57.1)	-
FALSE BAY	1 (0.6)	-
GENERAL PRACTITIONER	1 (0.6)	-
HEIDEVELD	3 (1.7)	-
NOT SHOWN	54 (31.0)	-
MECHANISM		
JUMPING ON/OFF TRAIN	15 (8.6)	12 (13.0)
FELL	38 (21.8)	14 (15.2)
INJURED ON TRAIN	1 (0.6)	0 (0.0)
CROSSING RAILWAY LINE	8 (57.1)	5 (5.4)

SUICIDE	0 (0.0)	0 (0.0)
VIOLENCE	52 (29.9)	27 (29.3)
TRAIN SURFING	5 (2.9)	3 (3.3)
UNKNOWN	34 (19.5)	21 (22.8)
OTHER	21 (12.1)	10 (10.9)
TIME OF ARRIVAL		
05:00-09:00 H	27 (15.6)	-
09:00-16:00 H	47 (27.1)	-
16:00-20:00 H	42 (24.3)	-
20:00-05:00 H	57 (32.9)	-
MECHANISM OF ARRIVAL		
SELF	13 (7.5)	-
AMBULANCE	145 (83.3)	-
OTHER	3 (1.7)	-
NOT SHOWN	13 (7.5)	-
DISPOSAL		
ADMITTED	128 (73.6)	82 (89.1)
DISCHARGED	38 (21.8)	9 (9.9)
DIED	6 (3.4)	1 (1.1)
UNKNOWN	2 (1.1)	0 (0.0)
TOTAL DEATHS	8 (4.6)	2 (2.2)

Table 3: Stations where accidents occurred. Presentation of data showing number of casualties at each metrorail station where this was available in the documentation.

STATION	**N (%)**
ALPHEN HILL	1 (0.6)
BEACH ROAD	1 (0.6)
BERMAN DRIVE	1 (0.6)
BONTEHEUWEL	7 (4.0)
CAPE TOWN	3 (1.7)
CENTURY CITY	2 (1.1)
DIEP RIVER	1 (0.6)
FISH HOEK	1 (0.6)
GREEN POINT	1 (0.6)
GUGULETU	4 (2.3)
HANOVER PARK	2 (1.1)
HEIDEVELD	5 (2.9)
KHAYELITSHA	1 (0.6)
KOEBERG	1 (0.6)
LANGA	8 (4.6)
LENTEGEUR	2 (1.1)
MAITLAND	4 (2.3)
MANENBERG	1 (0.6)
MUTUAL	1 (0.6)
NDABENI	1 (0.6)
NETREG	6 (3.4)
NOLUNGILE	1 (0.6)
NEW SOMERSET HOSPITAL	1 (0.6)
NYANGA	5 (2.9)
PHILLIPI	7 (4.0)
PINELANDS	6 (3.4)
RONDEBOSCH	2 (1.1)
ROSEBANK	2 (1.1)
SALT RIVER	9 (5.2)
SOUTHFIELD	1 (0.6)
STELLENBOSCH	1 (0.6)

STEURHOF	1 (0.6)
STRAND	1 (0.6)
UNKNOWN	66 (37.9)
WETTON	2 (1.1)
WOODLANDS	1 (0.6)
WOODSTOCK	8 (4.6)
YSTERPLAAT	3 (1.7)

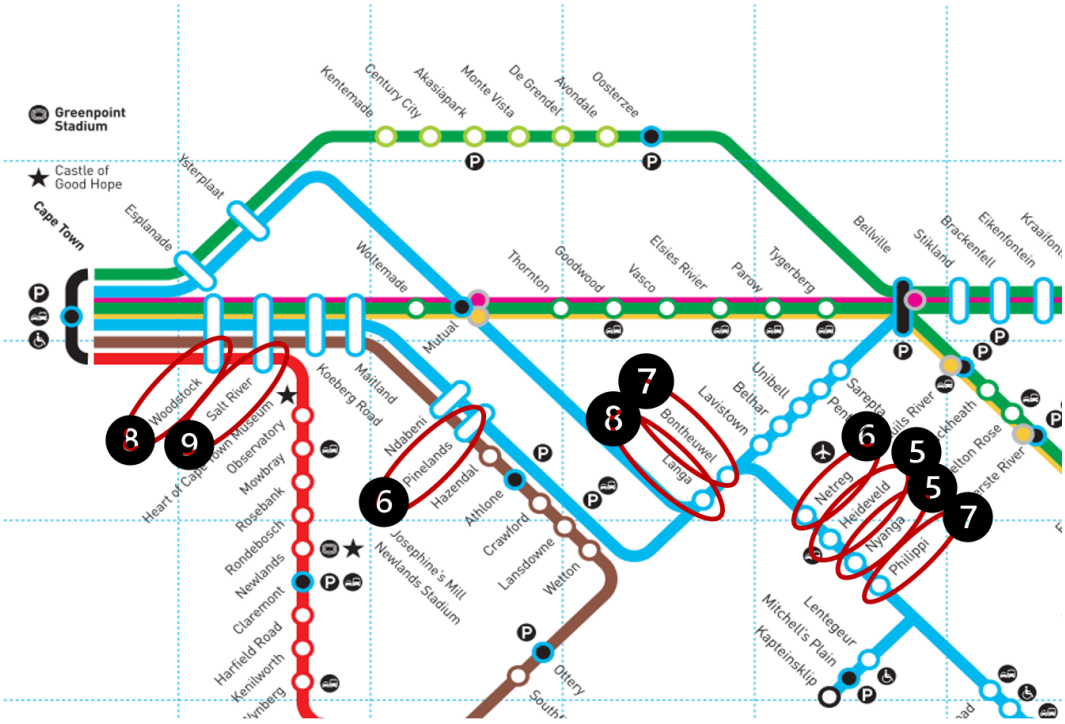

Figure 3: Stations where accidents most frequently occurred. Based on the Cape Town rail map depicting stations with 5 or more cases documented during the study period.

Table 4: Patients' address. Presentation of data showing number of patients from each residential area where this was available in the documentation.

PATIENT'S ADDRESS	**N**
ATHLONE	6 (3.4)
BELHAR	2 (1.1)
BRACKENFELL	1 (0.6)
CLAREMONT	2 (1.1)
DELFT	1 (0.6)
DIEP RIVER	1 (0.6)
EERSTERIVIER	7 (4.0)
ELSIES RIVIER	3 (1.7)
FISH HOEK	2 (1.1)
GATESVILLE	9 (5.2)
GOODWOOD	1 (0.6)
GRASSY PARK	1 (0.6)
GUGULETU	23 (13.2)
HANOVER PARK	2 (1.1)
HEIDEVELD	1 (0.6)
KHAYELITSHA	26 (14.9)
KRAAIFONTEIN	5 (2.9)
KUILS RIVER	2 (1.1)
LANGA	7 (4.0)
LANSDOWNE	2 (1.1)
LAVISTOWN	1 (0.6)
LENTEGEUR	1 (0.6)
MAITLAND	3 (1.7)
MANENBURG	1 (0.6)
MATROOSFONTEIN	1 (0.6)
MELKBOSSTRAND	1 (0.6)
MITCHELL'S PLAIN	26 (14.9)
MUIZENBERG	3 (1.7)
NYANGA	5 (2.9)
OBSERVATORY	2 (1.1)
OTHER	1 (0.6)

PAROW	2 (1.1)
PHILLIPI	4 (2.3)
PINELANDS	1 (0.6)
PLUMSTEAD	2 (1.1)
RETREAT	2 (1.1)
STEENBERG	1 (0.6)
STELLENBOSCH	1 (0.6)
TAFELSIG	1 (0.6)
THORNTON	1 (0.6)
UNKNOWN	5 (2.9)
WOODSTOCK	3 (1.7)
WYNBERG	2 (1.1)

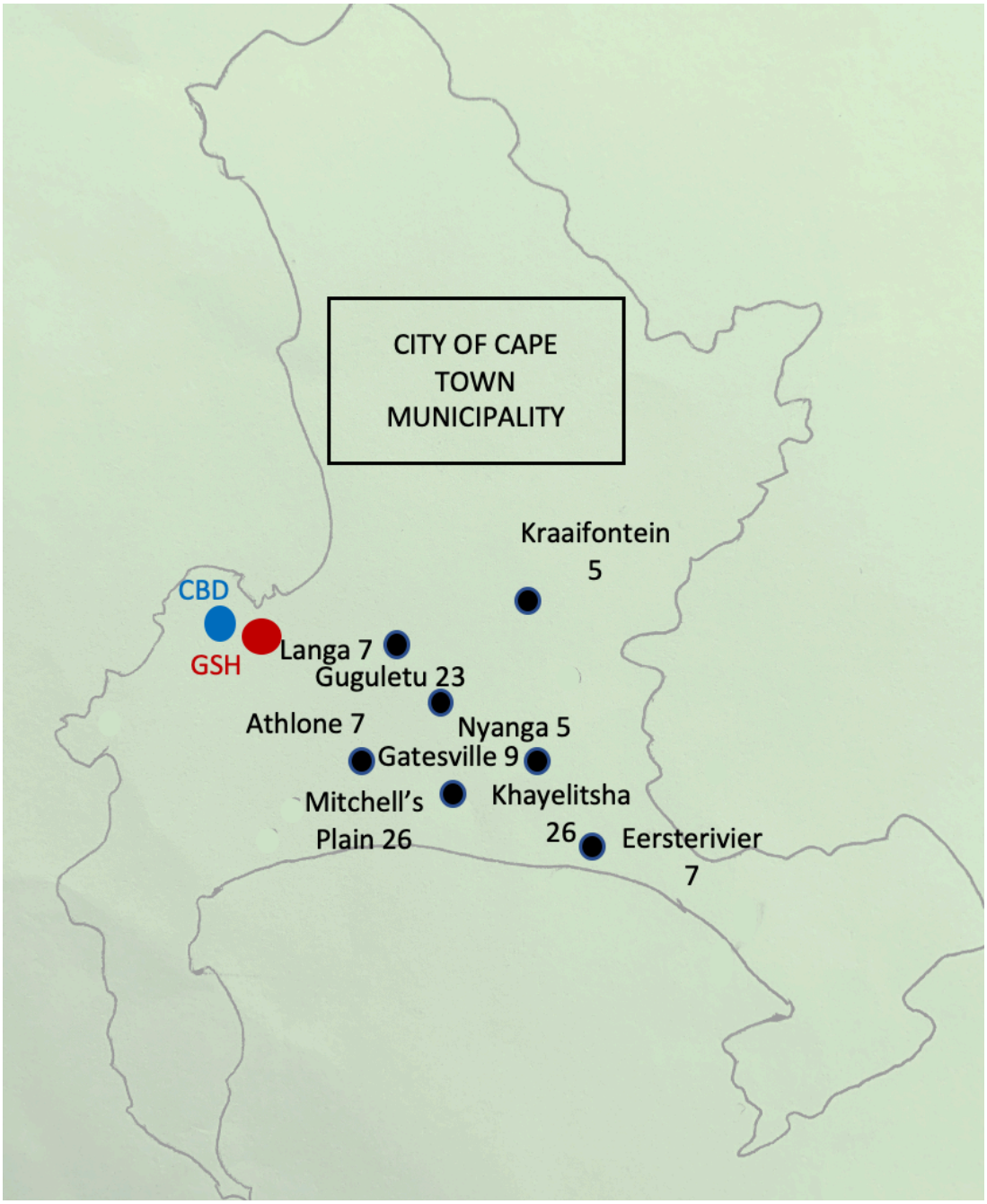

Figure 4: Map of patient addresses. This figure shows the most common places of residence for patients involved in train accidents. The figure depicts locations with 5 or more cases.

Thirty-three percent of the accidents happened between 20:00 h and 05:00 h; 27% occurred between 09:00 h and 16:00 h; 24% between 16:00 h and 20:00 h and 16% between 05:00 h and 09:00 h (Figure 5). Ninety-five patients presented directly to GSH, 8 patients were referred from the day hospital, 7 patients from Mitchell's Plain hospital, 4 patients from New Somerset Hospital, 3 patients from Heideveld hospital, 1 patient each from the General Practitioner, False Bay hospital and Victoria hospital and this information was not stated in 54 patient records. Figure 6 shows the number of cases by month. The cases vary throughout the year. January saw the fewest cases (N= 7) compared to May which had the most cases (N= 22).

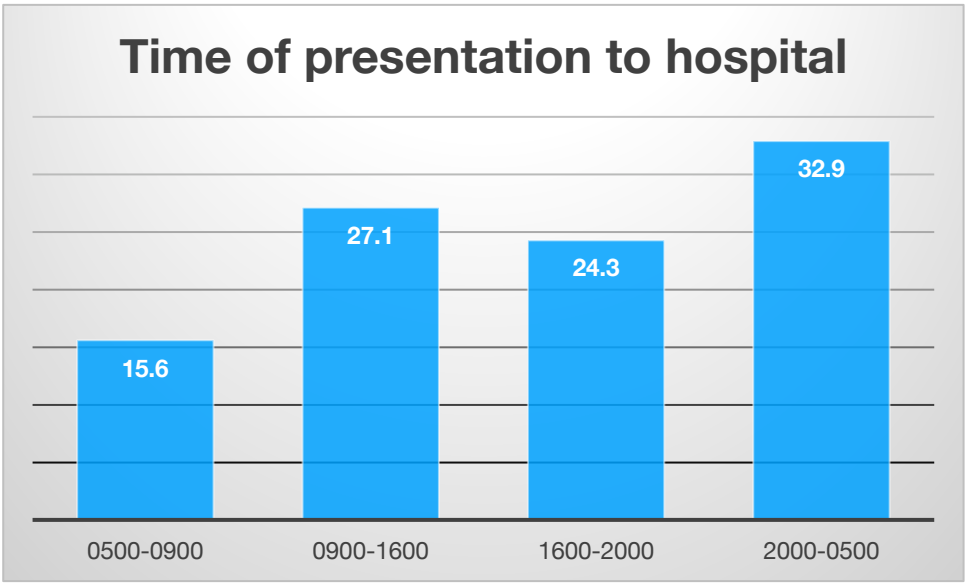

Figure 5: Time of presentation to hospital. Presentation of data showing the percentage (%) number of patients presenting during each time period throughout the day.

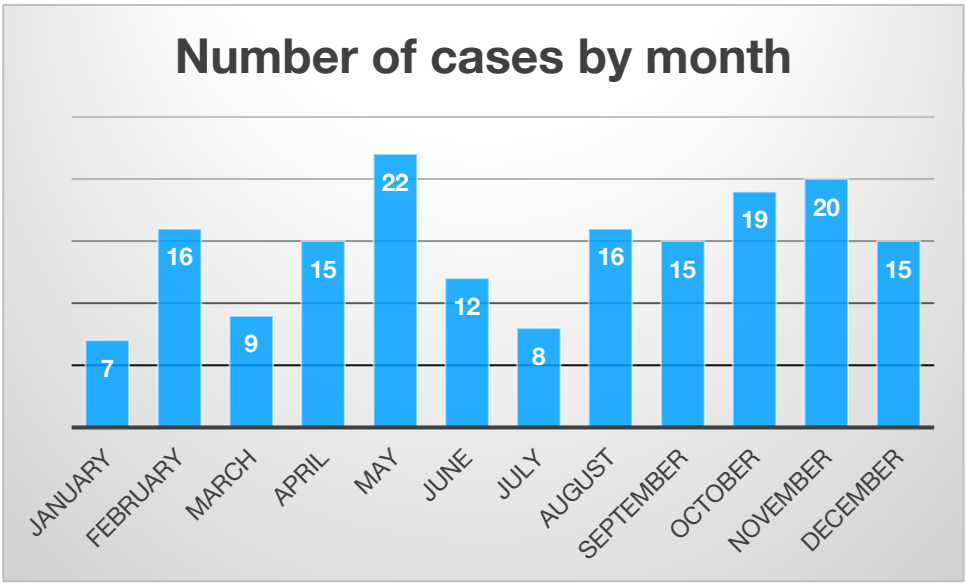

Figure 6: Number of cases by month. Presentation of data showing the actual number of train accident patients presenting to GSH trauma department each month throughout the study period.

Deaths

Eight patients in total died from their injuries. Seven of these were male and the average age was 44.9 years (range 24-77; SD 21.3). Only 1 patient was stable on presentation to the trauma department. Seven patients had head injuries. There was 1 facial injury, 3 thoracic injuries, 1 abdominal injury, 3 spinal, 1 upper limb and 1 lower limb injury. RTS was available for 5 of the patients and the mean score was 5.8 (range 4-7; SD 1.1). Two patients were admitted to ICU and length of stay was 4 and 6 days. Three patients suffered orthopaedic injuries, although one presented in cardiac arrest so was not referred to the orthopaedic team. This patient had fractures in the right femur and right humerus. The other 2 patients had C-spine fractures, namely: C5-C6 facet fractures, left transverse process fracture C7 and linear fracture of the C5 spinous process. The other patient suffered C5-6 bi-facet dislocation.

Orthopaedic patients

Ninety-two patients were referred to the orthopaedic department. Males accounted for 89% of patients and the average age was 33.4 years (range 12-83; SD 13.7). Mechanism of injury was most commonly violence (N= 27), followed by fall from

train (N= 14), jumping on or off the train (N= 12), crossing the railway line (N= 5) and train surfing (N= 3). The mechanism was 'other' in 10 patients and 'not shown' in 21. The majority of patients were stable on presentation (86%). Forty-nine percent of patients sustained upper limb injuries and 49% sustained lower limb injuries. Spinal injuries were found in 27% of patients and pelvic injuries in 5%. Most commonly associated non-orthopaedic injuries were head (41%), thorax (21%) and abdomen (13%). Neck and vascular injuries were each found in 1% of patients. Imaging carried out for initial diagnosis and assessment included full body digital X-ray (63%), chest X-ray (27%), cervical spine (C-spine) X-ray (13%), pelvic X-ray (8%), limb X-ray (27%), Computed Tomography (CT) head/ C-spine/ brain (62%), Magnetic Resonance Imaging (MRI) (1%), angiogram (0%) and other (1%). Eleven patients required blood transfusion with an average of 2 units (range 1- 4). RTS was available for 65 patients, mean 7.5, mode/ median 8 (range 3-8; SD 1.05). Of the orthopaedic referrals, 82 patients were admitted, 9 were discharged and 2 died. Nine percent of patients were admitted to ICU. Other teams involved in their care included trauma (31%), neurosurgery (27%), plastic surgery (4%), maxillofacial (18%), otolaryngology (1%), spinal (2%), hands (7%), ophthalmology (8%) and other (4%). Mean length of stay was 15 days (range 1-89; SD 18.2) (Table 5, 6, 7). Eighty-six percent of patients had outpatient follow-up.

Table 5: Injuries and referrals. Presentation of data showing the frequency of injured body parts for all patients and orthopaedic patients and which teams these patients were referred to.

	ALL PATIENTS N (%)	**ORTHOPAEDIC PATIENTS N (%)**
INJURY		
HEAD	88 (50.3)	38 (41.3)
FACE	35 (20.2)	16 (17.4)
NECK	1 (0.6)	1 (1.1)
THORAX	35 (20.2)	19 (20.7)
ABDOMEN	23 (13.3)	12 (13.0)
PELVIS	5 (2.9)	5 (5.4)
SPINE	27 (15.6)	25 (27.2)
UPPER LIMB	50 (28.9)	45 (48.9)
LOWER LIMB	54 (31.2)	45 (48.9)
VASCULAR	1 (0.6)	1 (1.1)
REFERRALS		
TRAUMA	86 (49.4)	29 (31.1)
ICU	15 (8.8)	8 (8.9)
NEUROSURGERY	58 (33.5)	25 (26.7)
ORTHOPAEDICS	93 (53.2)	92 (100.0)
PLASTICS	5 (2.9)	4 (4.4)
MAXILLOFACIAL	32 (18.2)	16 (17.8)
SPINAL	2 (1.2)	2 (2.2)
HANDS	8 (4.7)	6 (6.7)
OPTHALMOLOGY	10 (5.9)	7 (7.8)
ENT	3 (1.8)	1 (1.1)
OTHER	6 (3.5)	4 (4.4)

Table 6: Imaging in orthopaedic patients. Presentation of data showing imaging modalities used for initial investigation of the patients' injuries in the trauma department.

	ORTHOPAEDIC PATIENTS N (%)
LODOX	58 (62.9)
CHEST X-RAY	25 (26.7)
C-SPINE X-RAY	12 (13.3)
PELVIC X-RAY	7 (7.8)
LIMB X-RAY	25 (26.7)
CT HEAD/ BRAIN/ C-SPINE	57 (62.2)
MRI	1 (1.1)
ANGIOGRAM	0 (0.0)
OTHER	1 (1.1)

Table 7: Operative versus non-operative management, length of stay and follow up in orthopaedic patients.

	ORTHOPAEDIC PATIENTS N (%)
OPERATIVE MANAGEMENT	61 (68.1)
NON- OPERATIVE MANAGEMENT	31 (31.9)
LENGTH OF STAY (MEAN DAYS)	14.9 (SD 18.2)
OUTPATIENT FOLLOW-UP	79 (86.4)

Orthopaedic injuries

Each orthopaedic patient had on average injuries to 1.74 body parts (range 1-6; SD 1.04). Thirty-five patients sustained open fractures (38%). The injuries incurred included fractures and nerve injuries. In order of frequency, injuries/ fractures were diagnosed in the tibia (N= 19), C-spine (N= 14), scapula (N= 13), ulna (N= 11), foot (N= 10), knee (including tibial plateau- N= 9), humerus (N= 9), clavicle (N= 9), radius (N= 8), hand (N= 8), femur (N= 8), thoracic spine (N= 6), lumbar spine (N= 6), ankle (N= 5), shoulder (N= 4), pelvis (N= 4),

acromioclavicular joint (ACJ- N= 4), sacrum (N= 3), brachial plexus (N= 3), acetabulum (N= 2), fibula (N= 2), peripheral nerve injury (N= 1), elbow (N= 1) and sacroiliac joint (SIJ- N= 1) (Table 8; Figure 7). Non-operative management was undertaken in 32% of patients. Operative management took place in 68% of patients. Nineteen patients who underwent surgery also had concomitant fractures managed conservatively. Conservative management was mostly for spinal fractures (Philadelphia collar, cones callipers, TLSO bracing), clavicle/ scapula/ shoulder injuries (collar and cuff). Undisplaced fractures of the ankle or forearm (including distal radius) were usually treated with plaster casting.

Table 8: Orthopaedic injuries. Presentation of data showing the frequency of injuries incurred by body part.

BODY PART	**ORTHOPAEDIC PATIENTS N (%)**
ACETABULUM	2 (2.2)
SIJ	1 (1.1)
ELBOW	1 (1.1)
NERVE INJURY	1 (1.1)
FIBULA	2 (2.2)
BRACHIAL PLEXUS	3 (3.3)
SACRUM	3 (3.3)
ACJ	4 (4.3)
PELVIS	4 (4.3)
SHOULDER	4 (4.3)
ANKLE	5 (5.4)
L-SPINE	6 (6.5)
T-SPINE	6 (6.5)
FEMUR	8 (8.7)
HAND	8 (8.7)
RADIUS	8 (8.7)
CLAVICLE	9 (9.8)
HUMERUS	9 (9.8)
KNEE	9 (9.8)
FOOT	10 (10.9)
ULNA	11 (12.0)
SCAPULA	13 (14.1)
C-SPINE	14 (15.2)
TIBIA	19 (20.7)
OPEN FRACTURES	35 (38.0)
AVERAGE INJURED PARTS PER PATIENT	1.74 (SD 1.04)

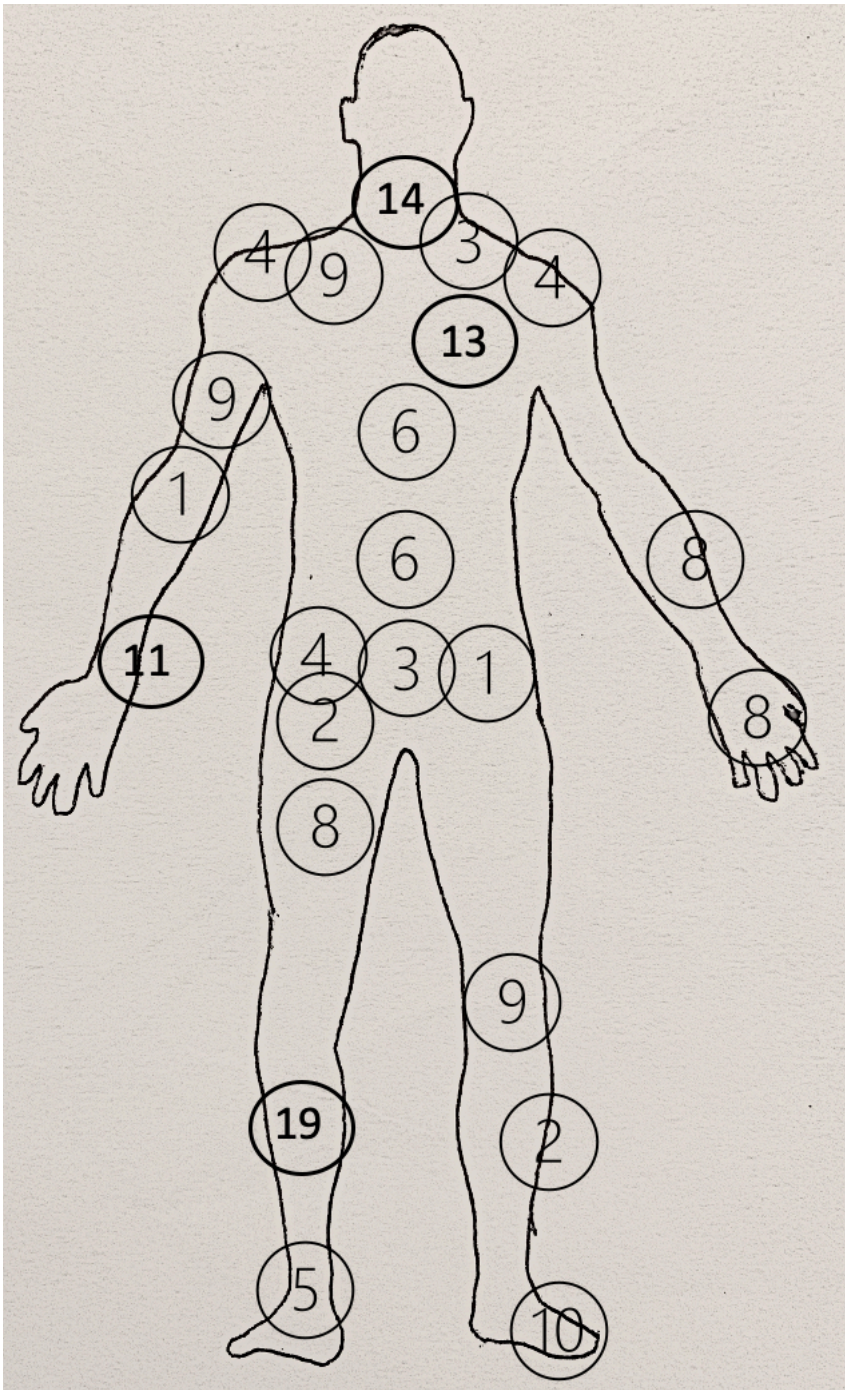

Figure 7: Body map showing frequency of orthopaedic injuries to each body part.

Operations

A total of 61 patients had surgery for orthopaedic injuries. Each patient underwent on average 2.38 operations. There were 145 theatre encounters for 172 procedures. Procedures included intramedullary nailing (N= 10), open reduction internal plate fixation (N= 35), uni/bi-planar external fixation (ex-fix N= 11), ring fixation (N= 1), skin graft (N= 8), skin flap (N= 2), Kirschner wiring (k-wires- N= 3), manipulation under anaesthesia (MUA- N= 3), wound debridement (N= 61), removal of ex-fix/ wires (N= 9), removal of metalwork (N= 8), ligament reconstruction (N= 1), and amputation (N= 19). Of the amputations, there was 1 upper limb (arm) and 19 lower limb amputations. Of the lower limb amputations, there were 2 foot, 7 below knee (BKA), 5 through knee (TKA) and 5 above knee (AKA) procedures (including multiple returns to theatre on the same patients) (Table 9). There were 10 post-operative complications in total. There were 4 cases of wound sepsis, 1 non-union, 1 failure of fixation, 1 nerve injury, 1 infected metalwork, 1 stiffness and 1 case of heterotopic ossification (Table 10). Seven of these cases required a return to theatre for their complications.

Table 9: Orthopaedic operations. Presentation of data showing the frequency of each type of operation performed in the orthopaedic group.

OPERATION	**N (% OF OPERATIONS)**
INTRAMEDULLARY NAILING	10 (5.8)
OPEN REDUCTION PLATE FIXATION	35 (20.3)
EXTERNAL FIXATION	11 (6.4)
RING FIXATION	1 (0.6)
REMOVAL OF EX-FIX/ WIRES	9 (5.2)
REMOVAL OF METALWORK	8 (4.7)
SKIN GRAFT	8 (4.7)
SKIN FLAP	2 (1.2)
WOUND DEBRIDEMENT	61 (35.5)
K- WIRE FIXATION	3 (1.7)
MANIPULATION UNDER ANAESTHESIA	3 (1.7)
LIGAMENT RECONSTRUCTION	1 (0.6)
LIMB AMPUTATION	20 (11.6)
-UPPER LIMB	1 (0.6)
-LOWER LIMB	19 (11.0)
(FOOT)	2 (1.2)
(BELOW KNEE)	7 (4.1)
(THROUGH KNEE)	5 (2.9)
(ABOVE KNEE)	5 (2.9)
TOTAL OPERATIONS	172
TOTAL THEATRE ENCOUNTERS	145
AVERAGE OPERATIONS PER PATIENT	2.38

Table 10: Post-operative complications. Presentation of data showing the frequency of complications post operatively in the orthopaedic group.

COMPLICATION	**N (% OF COMPLICATIONS)**
WOUND SEPSIS	4 (40.0)
NON -UNION	1 (10.0)
FAILURE OF FIXATION	1 (10.0)
NERVE INJURY	1 (10.0)
INFECTED METALWORK	1 (10.0)
POST-OPERATIVE STIFFNESS	1 (10.0)
HETEROTOPIC OSSIFICATION	1 (10.0)
TOTAL	10

Amputations

In total, 12 patients (6.9%) underwent amputations to 14 body parts. Ten of these patients had suffered traumatic amputations to 12 body parts. Two patients underwent amputation for unsalvageable limb injuries; one open comminuted patella fracture required an AKA and one mangled foot (MESS 7) required a BKA (Table 11).

Table 11: Orthopaedic injuries requiring amputation

ORTHOPAEDIC INJURIES SUSTAINED	**AMPUTATIONS PERFORMED**
TRAUMATIC AMPUTATION RIGHT 1ST TOE	Formalisation of right foot amputation
1. TRAUMATIC RIGHT BELOW KNEE AMPUTATION 2. TRAUMATIC LEFT MIDSHAFT TIBIA AMPUTATION	1. Right AKA 2. Left AKA
1. TRAUMATIC RIGHT LEG TRAUMATIC 2. TRAUMATIC LEFT BIG TOE AMPUTATION	1. Formalisation of traumatic amputation right tibia 2. Formalisation of left foot amputations
MANGLED LEFT LOWER LIMB (FOOT) MESS 7	Left BKA
TRAUMATIC AMPUTATION LEFT ARM	Formalisation of amputation left arm
OPEN FRACTURES RIGHT FOOT- BASE OF 1ST, 4TH AND 5TH METATARSALS	Right BKA
TRAUMATIC RIGHT LOWER LEG AMPUTATION- MANGLED LEG	Left BKA
TRAUMATIC LEFT FOOT AMPUTATION	Left BKA
TRAUMATIC RIGHT DISTAL FEMUR AMPUTATION	Right AKA
TRAUMATIC LEFT LEG THROUGH KNEE AMPUTATION	Left AKA
OPEN COMMINUTED RIGHT PATELLA FRACTURE	Right AKA
TRAUMATIC AMPUTATION RIGHT LEG- RIGHT SEGMENTAL TIBIA/ FIBULA FRACTURES COMMINUTED	Right TKA

Chapter 5 – DISCUSSION

A review of the findings has been prepared and presented in this chapter. A comparison was made using the available literature on the demographic findings for patients involved in train accidents. The types of injuries and surgical management have been reviewed as well as comparing rates of amputation with what is known already. Analysis of the findings has been performed and study limitations have been identified.

Statement of the problem

There is a high volume of train accident victims presenting every month to the trauma department at GSH. These patients often require admission and input from multiple disciplines in the hospital. The death rate is low for patients who make it to hospital in time following the train injury, however, many suffer life-changing events, including amputation of limbs. Pooling of the results of the previous chapter has been used to draw attention to the scale of orthopaedic injury and other clinical problems of patients with train injuries. The limitations of the methodology and the study in general are also included in the discussion.

Review of the methodology

The present study is a retrospective analysis on all patients presenting to the trauma unit at GSH over a 7-year period from January 2013 to July 2019. Full ethical approval was granted by UCT and GSH. All trauma registers available during this period were searched for 'train casualties'. The validity of data entered into these records depended on the accuracy of documentation by the ward clerks of the trauma unit as well as the history from the ambulance staff. Two-hundred and twenty-two patients were identified during this process.

The hospital numbers of these patients were noted onto a proforma which was used to search the medical records. During this process, there was a possibility of error in noting down the hospital number due to human error or not being able to read the handwriting on the trauma registers. The medical records team were unable to locate 48 of the folders/ their folders were incomplete with information, leaving 174 total

train injury patient records for analysis. The demographic and clinical data in these patients' folders was transferred onto a standardised proforma for ease of collection and to ensure validity of results. Not all patients had all information available as records are held on paper format and some papers had gone missing over the years. Again, the reliability of these records depends on the note keeping of the nursing and medical staff caring for the patient. The data from these forms was transferred onto a Microsoft Excel (Microsoft Corporation, 2018) spreadsheet for calculations and analysis to take place.

Statistical analysis

Statistical analysis was descriptive for the majority of data using frequencies and percentages for categorical data. Normally distributed data was described using mean and standard deviation. A power calculation was not performed as this was fundamentally an observational study. There were no two distinct groups for comparison as all patients being studied were train accident victims having presented to one trauma centre. Where comparisons were made for example orthopaedic patients versus non-orthopaedic patients or deaths versus survivors, the number of patients per group was deemed too small for meaningful statistical analysis.

Summary of the results

Of 174 train accident victims, the average age was 32 years and 87% were male. This was similarly the case for the orthopaedic patients whose average age was 33 years and 89% were male. A large number were not formally employed. The overall unemployment rate in Cape Town in 2020 is 24.8%; the percentage of patients unemployed in our study, 40.8%, is higher than this average (Democratic Alliance, 2020). Nearly all patients came from poor socioeconomic areas. The spread of stations where the accidents occurred was varied, although large numbers seemed to occur in the township areas (rather than the city centre). There were 92 patients referred with orthopaedic injuries and over two thirds of these required surgery. Overall 12 patients underwent 20 amputations, only one of these was upper extremity. The most commonly performed operations were debridement and ORIF. The debridements occurred mostly for open fractures and amputation stumps before

definitive closure. The rate of post-operative complications was low. Average length of stay for orthopaedic patients was 14.9 days and 87% had outpatient follow up.

Discussion of the findings/results

Over half of the patients in this study presenting following a train accident were referred to the orthopaedic team. Two thirds of these patients required surgical intervention and those undergoing surgery underwent on average 2.38 procedures. The length of stay was on average just over two weeks and the majority of patients required follow up. This information shows that there is a high burden of trauma as a result of train accidents. The patients require high levels of intervention and lengthy inpatient stays. This increases the pressure on the department in terms of theatre time and inpatient beds. Nevertheless, the low death rate and low complication rate for patients admitted under the orthopaedic team is encouraging and suggests that the management of these patients and their injuries is appropriate and effective. Just under 7% of patients underwent amputations and this figure is far lower than the rate of fixation for fractures.

Interpretation of the results

It can be deduced that young male workers commuting from their homes in the township areas to their places of work are often targets for violence or sustain accidents on the railways, often embarking/ disembarking the train. The fatality rate once in hospital is relatively low, although our study encompasses all train accident incidences, it is possible that patients who are struck by trains or other high energy mechanisms are pronounced dead at the scene and do not make it to the hospital.

Patients sustaining orthopaedic injuries have similar characteristics to the entire cohort. They also suffer high rates of concurrent head, thoracic and abdominal trauma. Their lengthy inpatient stay and high follow up rate implies the complexity of their injuries. Often patients required multiple returns to theatre, usually for soft tissue debridement in the case of amputations or open fractures. This supports the notion that limb salvage does have a place over amputation in this patient cohort particularly when considering the psychological and economic consequences further down the line.

Comparison of the current study results to previous findings

The study findings are in keeping with what we know from previous reports that victims of train accidents are mostly male and in their thirties. The rates of suicide attempts in this study and generally in the developing world are much lower than the models demonstrated in developed countries. In comparison to studies on railway accidents undertaken in Cape Town over thirty years ago (Singer and Anderson, 1988), there is a higher proportion of accidents as a result of violence in this study. The percentage of accidents occurring during the morning and evening commutes are comparable, but interestingly the highest rate of accidents occur during the evening-night-time hours; this is also in keeping with a high proportion of violent accidents which may favour hours of darkness. There already exists a spread of fatality rates as a result of these accidents in the literature, however, number of deaths in our study are on the lower side, as is the rate of amputation. Although we have not investigated the correlation of alcohol with our patients involved in train accidents, a number of studies have found a high prevalence of intoxication amongst train accident victims. The low rate of amputation found in this study (6.9%) is comparable with the results from a previous study performed at the same hospital in 1988 where 6.2% of patients required amputation (Singer and Anderson, 1988). This number remains low and may indicate that amputation was and still is being carried out as a last resort for unsalvageable limbs. As per the findings in the study by Sousa et al. where fatality rates dropped following a television campaign, this small intervention could potentially have a great impact on train accident numbers and should be considered as a preventative strategy (Sousa *et al*., 2015).

Limitations of the study

There are many limitations to this study. The presented data is as accurate as it can be from the records that were kept, bearing in mind the opportunity for human error when entering and transferring notes. This data is based on analysis of available registers and folders which can skew the outcomes when taking averages into account. Patients with missing notes who had some data available were still included in the analysis. There was a reliance on accurate emergency service and nursing notes when analysing the data. Employment status may not be accurate if

patients were informally employed. The retrospective nature of the study makes it a lower level of evidence. The study was carried out at a single trauma centre in one city in South Africa and may not be representative of the wider region or country. Only victims who survived the initial trauma and brought to hospital are featured in the study, therefore the number of fatalities from train accidents is likely to be much higher than the number who died after presentation to the trauma unit. Children are mostly not included in the study as they are not usually admitted to GSH. No analysis of intoxication was performed as this information was not available.

Chapter 6 - CONCLUSION AND RECOMMENDATIONS

Conclusions

The findings of this study provide an insight into train accident victims and their orthopaedic injuries and management with a large sample size. As could be predicted from previous studies, most of the victims of these accidents are young males from poor socioeconomic areas. The victims who make it to hospital have a good chance of survival and even limb salvage. However, in this day and age, more needs to be done in terms of controlling railway violence and increased health and safety measures need to be implemented in order to minimise accidental injuries on the railways in Cape Town. Campaigns targeting high risk groups (male workers in their thirties from townships) could potentially raise awareness about railway safety and reduce the burden of train accidents.

Further research into the long-term outcomes of these patients and their surgeries would provide further evidence into the role for limb salvage procedures and whether amputation rates have decreased given current trends in polytrauma management. In practice, it should be known that these patients require an MDT approach to their management as they often present with multiple body system injuries. However, fixation of fractures and debridement of wounds as necessary should play a role alongside limb amputation where this is indicated in non-salvageable cases.

The limitations of this study are that it is based on one trauma unit in one area of Cape Town. The data collected was reliant on accurate notes available during the patients' admission in hospital. Future studies where possible should be designed in a prospective manner incorporating train accident victims from throughout the region or country. Coding the injuries and operations performed to ensure validity and reliability would create a database of accurate data which can be used to study all victims of these accidents, including children. It would be of economic importance to calculate the financial burden of these injuries and how they affect return to employment. Future studies could evaluate the proportion of victims who are also intoxicated and this could focus preventative approaches even further.

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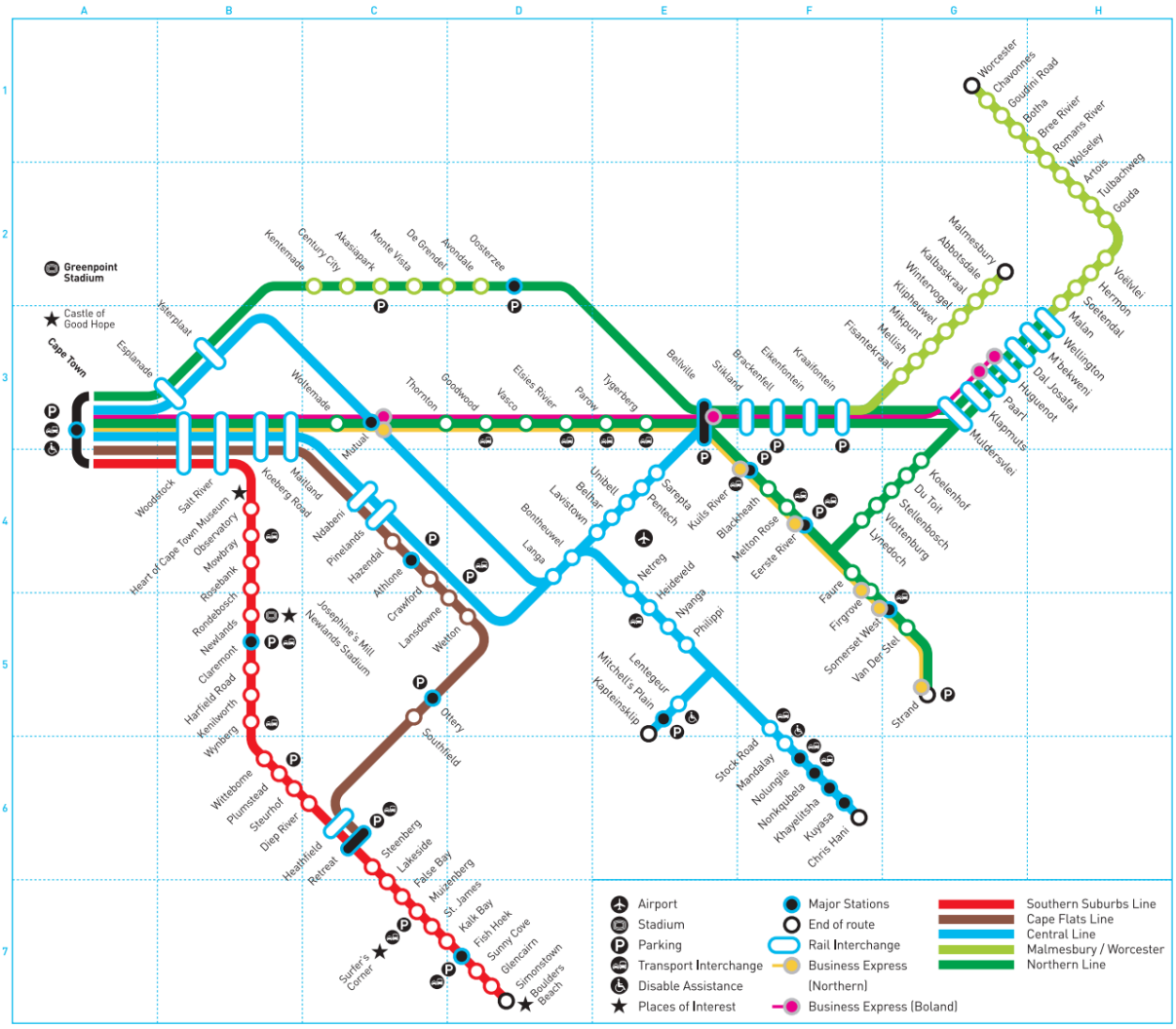
Appendix



Cape Town Rail Map. Taken from:

http://www.metrorail.co.za/maps/CT_RailMap.pdf

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6626
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

01 July 2019

HREC REF: 419/2019

A/Prof S Maqungo
Orthopaedic Surgery
H49, OMB

Dear A/Prof Maqungo

PROJECT TITLE: ORTHOPAEDIC INJURIES AS A RESULT OF TRAIN ACCIDENTS IN CAPE TOWN (MSc Candidate - Dr C Kontoghiorghe)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until 30 July 2020.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

The HREC acknowledge that the student, Dr Christina Kontoghiorghe will also be involved in this study.

Yours sincerely

Signature removed

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.

Institutional Review Board (IRB) number: IRB00001938

NHREC-registration number: REC-210208-007
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

UNIVERSITY OF CAPE TOWN

Department of Surgery
Departmental Research Committee
Dr Timothy Pennel
D24 Office, Groote Schuur Hospital
Observatory 7925
South Africa
Tel (021) 404 3430
Email: **tim.pennel@uct.ac.za**

20 Jun 2019

Dr C Kontoghiorghe

Department of Surgery
University of Cape Town

Dear Dr Kontoghiorghe

RE: Project 2019/068

PROJECT TITLE: Orthopaedic Injuries As A Result Of Train Accidents In Cape Town

The above protocol has been reviewed by the Department of Surgery Research Committee. I am pleased to inform you that the committee approved the scientific merit of the study, and endorse the protocol for submission to the relevant ethics committee.

Although this letter serves as confirmation that the above protocol has successfully passed through the surgical DRC, respective ethics committees still require DRC chair signature before submission.

Please use the above project number in all future correspondence,

Yours sincerely

Signature removed

DR TIMOTHY PENNEL
CHAIRMAN: RESEARCH COMMITTEE

A) PATIENT DEMOGRAPHICS

1. **Folder Number:** _____
2. **Age/ DOB:** ☐
3. **Gender:** (1) Male (2) Female ☐
4. **Occupation** _____
5. **Pt Address** _____

4. Referring hospital (1) None (2) NSH (3) MPH (4) Vic (5) Day hospital (6) HEC ☐

B) CASUALTY DETAILS

1. **Location:** (1) train station (2) railway line ☐
2. **Mechanism of injury:** (1) Jumping on/off train (2) Crossing railway line (3) Suicide (4)Violence (pushed) (5) Bystander ☐
3. **Date and Time of arrival**_____ 4. Month (1-12) ☐
4. **Train station** _____
5. ***Mechanism of arrival:* (1) Self (2) Ambulance (3) Other** ☐

C) *TRAUMA WARD PRESENTATION*

1. ***Presentation:*** (1) Stable (2) Unstable ☐

2. **Injuries:**

(1) Head ☐
(2) Face ☐
(3) Neck ☐
(4) Thorax ☐
(5) Abdomen ☐
(6) Pelvis ☐
(7) Spinal ☐
(8) Upper limbs ☐
(9) Lower limbs ☐
(10) Vascular ☐

3.Vitals

(1) BP _____
(2) HR _____
(3) RR _____
(4) Temp _____
(5) GCS _____
(6) Hb _____
(7) Urine dipstix_____
(8) ABG (pO_2)_____

4. Bloods

FBC_____

U& E_____

INR_____

5. **Investigations**

Lodox ☐ _____

Chest XRay ☐ _____

C- spine Xray ☐ _____

Pelvic Xray ☐ _____

CT brain/ head/ Cspine ☐ _____

MRI ☐ _____

Angio ☐ _____

6. **Does resus need blood:** (1) Yes (2) No ☐ If yes, number of units____

7. **Post resus- outcome:** (1) Survive (2) Death ☐

8. **Injury severity score** (ISS) ☐ 9. **Revised Trauma Score** (RTS) ☐

D) ICU STAY

(1) Yes (2) No ☐ 2. **Number of days in ICU** ____ 3. **Number of days ventilated**_____

E) IN-GSH HOSPITAL STAY

1. Date of admission_____ 2. Date of Departure_____ 3. Length of stay_____

F) IN- HOSPITAL MANAGEMENT (types of surgeries and findings)

Trauma surgery ☐ _____

ICU ☐ _____

Neurosurgery ☐ _____

Ortho ☐ _____

Plastics ☐ _____

Maxfac ☐ _____

Spinal unit ☐ _____

Hand surgery ☐ _____

Ophthalmo ☐ _____

Complications: General _____

Procedure- related _____

G) Orthopaedic injuries:

_____

_____

_____

_____

H) Orthopaedic management (+ time in theatre):

_____

_____

_____

_____

I) Bone involved + time to union:

_____

_____

_____

_____

J) **LONG- TERM OUTCOME**

1. Any further surgery and if yes, which one: _____

_____

2. Clinic follow- up: (1) Yes (2) No ☐