OCCURRENCE AND PATTERN OF MANDIBULAR FRACTURES SEEN AT TWO REFERRAL HEALTH FACILITIES IN NAIROBI, KENYA

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DECLARATION

I, Dr. Jonathan Kiprop, hereby declare that this is my original work and has not been presented to any other institution for academic or any other purpose. Where other people's work has been used, it has been acknowledged and duly referenced.

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DEDICATION

This work is dedicated to my wife Phylis Lalita, and our children, Llewellynn Lalang and Cherryllynn Cherono. Thank you for your encouragement and moral support throughout this research.

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LIST OF ABBREVIATIONS AND ACRONYMS

CI	Confidence Interval.
CT	Computed Tomography.
HBO	Hyperbaric Oxygen
IMF	Intermaxillary Fixation
IOPA	Intra-Oral Periapical.
IPV	Interpersonal Violence
KNH	Kenyatta National Hospital
MMF	Maxillomandibular Fixation
MVC	Motor Vehicle Crashes
NOE	Naso-Orbito-Ethmoid
OMV	Occipito-Mento-Vertex
OPG	Orthopantomogram
ORIF	Open Reduction and Internal Fixation
ORN	Osteoradionecrosis.
PA	Postero-anterior
RTC	Road Traffic Crashes
SMV	Submento-Vertex View
SPSS	Statistical Package for the Social Sciences
TBI	Traumatic Brain Injuries
TMJ	Temporomandibular Joint
UONDH	University of Nairobi Dental Hospital.
No.	Number

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ABSTRACT

BACKGROUND: Mandibular fractures are among the most common maxillofacial injuries in Kenya and all over the world. Aetiological factors vary with geographical, socio-economic and demographic variables. They are largely due to road traffic crashes and interpersonal violence. The vulnerable groups include motorcyclists, bicyclists, and pedestrians. This is mainly due to lack of compliance to road safety measures and poor enforcement of traffic laws. Alcohol abuse is one of the key risk factors in road traffic crashes. Few studies have focused on mandibular fractures and associated aetiological factors in Kenya most of which are studied as a subset of maxillofacial injuries in general. No previous local study has subjected mandibular fractures and the aetiological factors to statistical analysis.

STUDY OBJECTIVE: To investigate the socio-demographics, aetiology, pattern of occurrence and management of mandibular fractures at two referral health facilities in Nairobi, Kenya.

MATERIAL AND METHODS: This was a descriptive retrospective cross-sectional study done at Kenyatta National Teaching and Referral Hospital Department of Dentistry and University of Nairobi Dental Hospital. It comprised records of patients with radiographically confirmed fractures over a 5-year period from June 2014 to May 2019. Data was collected using a researcher administered data collection form. This data was retrieved from the patient’s files and review of the available radiographic investigations. Data collected included age, sex, place of residence, time of injury, alcohol use, aetiology, site and number of fractures, imaging modality, management modality and complications.

RESULTS: A total 534 patients’ records were examined with 469 (87.8%) being males and 65 (12.2%) were females giving a male to female ratio of 7.2:1. The overall mean age was 30±11.6 years with an age range of 1 to 74 years. Mandibular fractures were more common in patients in 3rd and 4th decades. Fractures were least common in extreme age groups.

Interpersonal violence (IPV) was the leading cause with 42.5%, followed closely by RTC (40.1%) and falls (14.4%). IPV was more common in males (92%) than females (8%). Of the RTCs, 120 (56.1%) patients sustained mandibular fractures from motor cycle accidents whereas 83 (39%) were from motor vehicle crashes. Notably, motor vehicle drivers, motorcycle riders and hand cart pushers combined comprised the largest proportion (n = 92, 43.2%,) of patients involved in RTCs.

The leading sites of fractures were body (28.2%), parasymphyseal (24.3%) and angle of the mandible (19.9%). There was a statistically significant site predilection of fractures caused by IPV with angle and body commonly affected ($p < 0.001$). Isolated mandibular fractures occurred in 269 (50.4%) cases whereas 265 (49.6%) fractures presented with other associated injuries. The commonest concomitant injuries were maxillary fractures (14.2%), zygomatic (8.8%) and traumatic brain injuries (8.1%). RTCs were commonly associated with concomitant injuries ($\chi^2 = 43.084$, $p < 0.001$).

Majority of mandibular fractures (n = 340, 63.7%) were treated by closed reduction (MMF) followed by ORIF (n = 122, 22.8%). Malocclusion was the leading complication (30.8%) followed by mal-union (22%).

There was a statistically significant association between sex and alcohol use with more males being affected ($\chi^2 = 22.139$, $p < 0.001$). Most of IPV-related mandibular fractures occurred at night ($\chi^2 = 38.528$, $p < 0.001$).

CONCLUSIONS: Interpersonal violence and road traffic crashes were the leading causes of mandibular fractures in patients seen at the two referral centres in Nairobi, Kenya. Falls were the commonest cause in children. Most fractures occurred in patients in their third and fourth decades. Mandibular fractures occurred seven times more in males than in females. Closed reduction by maxillomandibular fixation (MMF) was the main mode of management of mandibular fractures in two thirds of the patients followed by open reduction and internal fixation (ORIF) in a quarter of the patients.

RECOMMENDATIONS: Interventional preventive strategies of mandibular fractures should focus on reduction of interpersonal violence and improvement of road safety especially in regard to motorcycle-related crashes. Young males should be a priority in the public health awareness and prevention campaigns. Open reduction and internal fixation should be made readily available and affordable as an option of treatment for indicated cases. This is due to early return to function, personal convenience, and early return to work and professional engagement. There is need to conduct studies that objectively evaluate BAC in RTC patients reporting prior consumption of alcohol.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

The mandible is the only mobile bone in the facial skeleton. It articulates with the squamous temporal bone at the temporomandibular joint. The head of the condyle of the mandible articulates with the glenoid fossa with an intervening fibro-cartilaginous disc in between. This joint is capable of both rotational and translational movements.

Although the mandible is one of the strongest, densest and rigid bones of the face, it is the second most fractured facial bone after the nasal bone. Several studies showed that mandibular fractures are the commonest maxillofacial fractures[1-3].

This paradox is in part due to its minimal soft tissue buffer and its prominence in the lower face. Equally, its open arch architecture may be contributory. The presence of areas of weakness in the condylar neck, mental foramina, and canine regions add to its susceptibility to fractures[4]. Impacted teeth especially the 3rd molars further weaken the mandible due to increased stress concentration in these areas[5].

Aetiology of mandibular fractures and other maxillofacial injuries varies with geographical location, socio-economic and environmental factors. Several Kenyan studies have shown that interpersonal violence (IPV) and road traffic crashes (RTCs) to be the leading causes of mandibular fractures[6-8]. The proportion of RTC is on the rise against IPV as the leading cause[6-8].

Studies conducted in Kenya and other countries in the world have shown males to be affected more than females in almost all age groups. Male to female ratios vary from as low as 2.9:1 to as high as 8.4:1 in Kenya[6-8]. Mandibular fractures are more common in young adults in third and fourth decades. They are uncommon in the extremes of age[8]. This is possibly due less exposure to associated risk factors. Mandibular fractures in the paediatric age groups are mostly due to falls.

Mandibular fractures may present with pain, occlusal derangement, impaired mouth opening, neural damage, and deformities. A fraction of mandibular fractures may present with life-threatening injuries. These may include cervical vertebra injuries, spinal cord injuries, head injuries, traumatic brain injuries and potential compromise of the airway. Comminuted mandibular fractures are more likely to present with concomitant injuries[9]. Therefore, a thorough initial primary survey is critical to rule out and manage these injuries.

The mandible may be fractured in single or multiple areas. This is dependent on the velocity and force of injuries. High energy and high velocity injuries often result in comminuted fractures. Low-velocity injuries often lead to single fractures. Mwaniki and Guthua, (1990) reported 75.5% single fractures and 24.5% multiple fractures[6].

There is no site predilection on injuries sustained from road traffic accidents. However, the left side is affected more than the right side in cases of interpersonal violence[8]. This is attributed to the fact that most assailants are right handed and are more accessible to the left sides of their victims.

Several management modalities of mandibular fractures exist and are generally based on the principles of adequate reduction and immobilization. Closed reduction includes splinting for minimally displaced fractures or intermaxillary fixation. Open reduction and internal fixation (ORIF) is indicated for grossly displaced fractured segments and where intermaxillary fixation is contraindicated. It may be rigid or semi-rigid. Rigid fixation involves the use of stainless steel or titanium plate with screws. Semi-rigid fixation involves wire osteosynthesis. It is often done when plates are unavailable or unaffordable as is the case in regions of low socioeconomic status. Restoration of pre-injury occlusion is critical to ensure the accuracy of reduction. Conservative management is reserved for few cases which include isolated and non-displaced condylar fractures.

Optimal outcomes of management of mandibular fractures are based on prompt diagnosis and appropriate management. Thorough knowledge of both aetiology and the pattern of presentations is critical. Whereas simple fractures may be treated by a general practitioner, complicated cases may need the skills of a trained maxillofacial surgeon.

This study sought to determine the pattern of occurrence of mandibular fractures in two referral facilities in Nairobi, Kenya. It was aimed at determining the association between mandibular fractures and the various aetiological factors. Also, it was aimed at evaluating if the trends of injuries have changed with the changing dynamics in the transport industry with increasing motor cycle transport. The findings can be used to refine preventive strategies of mandibular fractures.

1.2 LITERATURE REVIEW

1.2.1 EPIDEMIOLOGY OF MANDIBULAR FRACTURES

The epidemiology of maxillofacial injuries varies with geographical locations, socio-demographic variables and socio-economic status.

The mandible is prominently and vulnerably exposed to trauma. Most maxillofacial injuries involve mandibular fractures. Road traffic crashes and interpersonal violence are the two leading aetiological factors[10-13].

The mandible is the most fractured bone in the maxillofacial region. An Indian study recorded a majority of maxillofacial skeletal fractures occurred in the mandible (n = 129, 71.3%) followed by zygomatico-maxillary complex fractures (n = 21,11.6%) and nasal fractures (n = 13, 7.18%)[10]

Al-Bokhamseen *et al*., (2018) studied maxillofacial injuries in a Saudi Arabian hospital. The mandible was the most frequently fractured bone (n = 260,54.6%) followed by midface fractures (n = 216,45.4%). Zygomatic fractures (n = 216,45.4%) were the most common midface fractures[12].

In Nigeria, Obimakinde *et al*., (2017) reported the mandible (n = 172,63.2%) to be the most predominant skeletal injury in the maxillofacial complex. Zygomatic fractures occurred (29%) predominantly in the midface[11].

In the year 2012, Tugaineyo *et al*., studied maxillofacial injuries occurring at a tertiary hospital in Uganda. Out of the 1069 maxillofacial fractures, 62% (663) were mandibular fractures. Most of the mandibular fractures were caused by IPV followed by RTCs[13].

A Kenyan study involving patients with maxillofacial injuries from motorcycle-related RTCs, showed that 16.5% involved mandibular fractures[14]. This was just a proportion of RTC-related injuries. Mandibular fractures should be suspected in RTC victims involving the maxillofacial region.

1.2.2 AGE AND SEX DISTRIBUTION

A typical patient with a mandibular fracture is a male in second to the third decades of life[9,15,16]. Paediatric mandibular fractures are less common and are often caused by falls and sports injuries. Children below 5 years have a proportionally larger skull compared to facial skeleton thus are more likely to get skull injuries than maxillofacial injuries. Other protective factors include more elastic bones with high cancellous to cortical ratio, diastatic sutures, and adipose tissue padding. Collectively, these make greenstick fractures common in the paediatric population[17]. Children are also protected and supervised by their families. They are less exposed to alcohol which is a known risk factor to mandibular fractures.

Mandibular fractures are more common in males than females. Zaleckas *et al.,* (2013) in a study involving 1508 patients found out a male to female ratio of 7.3:1[4]. Tuganeiyo *et al.,* (2012) studied and analyzed the records of 1203 patients with maxillofacial injuries who presented to Mulago Referral Facility in Uganda. Six hundred and sixty-three (663) had mandibular injuries with male to female ratio of 4.6:1[13]. A Kenyan study by Mwaniki and Guthua, (1990) had a slightly higher ratio of 8.4:1[6]. Multiple studies have established a male predilection with male to female ratios ranging from 4-9:1[15,16,18,19]. However, the disparity of male to female ratio is less in the paediatric population and the elderly[20-22]. Noteworthy, no studies have reported a higher incidence in females than in males.

Most injuries occurred over the weekends and in the late evening. They were also common around the warm months of the year which is possibly due to increased activity in the said period. This was observed in regions experiencing winter season[4].

1.2.2 AETIOLOGY OF MANDIBULAR FRACTURES

The aetiology of the mandibular fractures varies with geographical distributions, social economic and demographic characteristics as well as environmental factors. Generally, road traffic crashes and interpersonal violence (IPV) are the leading causes[3,4,6,9].

According to a Canadian study, IPV was the leading cause (41%) followed by motor vehicle crashes (MVCs) (26%) and falls (18%). Males were noted to be likely to suffer assaults than women[9].

A Swiss study reported falls (44%) to be the leading cause in all age groups. This was followed by IPV (25%) and sports (12%). RTCs caused only 6% of the fractures. There was a significant sex variation in the victims of falls with more females affected. Seventy-six percent of females sustained their fractures from falls whereas 35% of the males were victims. However, IPV and sports-related fractures dominated in younger patients. Winter sports especially ice hockey and skiing are popular sports in Switzerland and contribute to falls and sports associated mandibular injuries[22].

Falls are common in extremes of ages[21,22]. A Turkish study compared mandibular fractures in young patients and adults. Falls caused most mandibular fractures in children (n = 195,65%) followed by RTC (n = 65,22%). However, RTC was the most common cause in adults followed by falls accounting for 38% and 23% respectively[23]. Moore *et al.,* (2015) observed that falls were common in older females[3]. Similar finding was made by Yildirgan *et al.,* (2016) with about half of all mandibular fractures in elderly patients due to falls occurring in females. Limited mobility and osteoporosis may predispose elderly women to falls[21].

Interpersonal violence has consistently been the leading aetiology of mandibular fractures in Kenya. Mwaniki and Guthua (1990) analyzed 355 cases and found that 74.9% were caused by IPV followed by RTCs (13.8%)[6]. Similar findings were reported by Akama *et al.,* (1993) in a study done in Kisii District Hospital. The leading cause was IPV (69.2%) followed by RTC (23.1%) and accidental falls (7.2%)[7]. Owino *et al.,* (2003) in a later study noted the same pattern with IPV (61%) and RTC (23%)[8]. Notably, RTC appears to have gained proportionally over time against IPV as the leading aetiological factor (Table 1).

Table 1: Trends of Aetiological Factors of Mandibular Fractures in Kenya

Authors	Year	Sample Size	M:F Ratio	IPV(%)	RTC(%)
Mwaniki and Guthua[6]	1990	355	8.4:1	73.9	13.8
Akama *et al.*[7]	1993	39	2.9:1	69.2	23.1
Owino *et al.*[8]	2003	200	4.6:1	61	23

These trends compare with the finding of Zaleckas *et al.,* (2013) in Lithuania with interpersonal violence (70%), followed by falls and accidents (19%), and road traffic crashes (6%)[4]. Several studies have reported IPV as the most common aetiology of mandibular fractures[3,24]

Some studies have reported RTCs as the leading cause of mandibular fractures. Kansakar *et al.*, found the leading cause to be RTC with 50.77% followed by fall injuries (23.08%)[18]. RTCs are more common in developing compared to the developed countries. Barde *et al*., (2014%) recorded

RTCs as the leading aetiology, 68.8% in Central India, followed by falls (16.8%) and IPV (11%)[25]. Other studies have recorded RTCs causing majority of the mandibular fractures[10,12,26].

Iatrogenic fractures of the mandible are rare complications following 3rd molar removal. Ethunandan *et al.*, (2012) analysed 130 cases of mandibular fractures following 3rd molar surgery. This study noted a male predilection and a general increasing risk with age. Most of the post-operative complications (57%) occurred in the second and third week. Majority of the fractures were associated with mesio-angular impaction (32.6%) and were least frequent in disto-angular impaction (12.8%). Mandibular fractures occurred frequently in fully impacted teeth (72%) [27].

1.2.4 ALCOHOL AND SUBSTANCE ABUSE

Alcohol intoxication is an important risk factor in trauma-related mandibular fractures. Blood alcohol concentrations (BAC) have been reported to be higher in drivers and riders of motorcycles involved in road accidents[3,4,15]. Kenya and most countries have set the BAC limit for driving at 0.08g/dL of blood or 0.35g/L of breath. BAC as low as 0.01–0.04 g/dL can impair driving performance with the risk of a crash increasing exponentially with increasing BAC[5]. Some countries have reduced their legal BAC limit for driving to 0.05 g/dL. Alcohol intoxicated drivers are at a higher risk of fatal crashes. This is also true for intoxicated pedestrians who are likely to be involved in RTCs. Alcohol and substance abuse is also a risk factor for falls and interpersonal violence. Intoxicated patients are more likely to be involved in altercations compared with their sober counterparts. It is noteworthy that most victims presenting with mandibular fractures may conceal their intoxication status[4]. Kansakar *et al.*, (2015) reported 68.97% of RTCs to have been due to alcohol intoxication[18].

1.2.5 SITE OF FRACTURE

The frequency of site variation of mandibular fractures is well documented. There is a direct correlation between the site of fracture and the aetiology. This is related to the direction and magnitude of force causing the injury. Furthermore, the nature of the object of impact and bone characteristics may affect the resultant pattern of injury. This is key to diagnosis of mandibular fractures[25].

Zaleckas *et al.*, (2013) noted mandibular angle fracture as the commonest (32%) followed by condylar process fractures (31%). The leading aetiology was interpersonal violence (70%)[4].

A prospective study by Kansakar *et al.*, (2015) involving 130 patients with 151 fracture sites of the mandible noted that parasymphyseal fractures were the most common (30.47%). This was followed by angle fractures (17.89%) and body (16.55%) with coronoid processes being the least fractured (0.66%). This was consistent with the leading aetiology being RTCs responsible for 50.77% cases followed by falls (23.08%)[18]. Mwaniki and Guthua, (1990) noted that isolated fractures of the body of the mandible were commonest (42.2%). However, the fractures of the angle were commoner in multiple fractures (50.5%)[6]. A Canadian study recorded symphyseal/parasymphyseal fractures being the commonest site comprising 29% of all fractures, followed by condylar (25%) and angle fractures (23%), respectively[9]. Similarly, A Chinese study with RTCs as the leading aetiology reported parasymphyseal/symphyseal fractures as the most common site, 26.4% followed by condylar fractures (24%)[26]. Same pattern has been observed by different authors[12,23].

The commonest site of Mandibular fractures reported in children is the condylar region[23,28]. Hiroto *et al.,* (2015) recorded condylar fractures as the most common fracture site (n = 126 ,41.3%), followed by the symphysis (114,37.4%) and angle (82, 26.9%), with ramus (6, 2.0%) as the least common site[21].

1.2.6 IMPACTED 3RD MOLARS AND MANDIBULAR ANGLE FRACTURES

A meta-analysis by Hanson *et al.*, (2004) involving six studies with 3,002 patients with mandibular fractures, sought to estimate the relative risk of mandibular angle fractures among people with a lower third molar compared with those without. The estimated relative risk was 2.4 (95% CI 1.9 to 3.0). This study concluded that impacted 3rd molar may double the risk of fracture of the angle of the mandible[29].

Kumar *et al.*, (2015) studied 64 patients with the aim of assessing the influence of the position of a 3rd molar on condylar and mandibular angle fractures. There was increased incidence of fractures associated with disto-angular and mesio-angular impaction[30].

Metin *et al.*, (2007) found statistically significant association between impacted 3rd molars and angle of mandibular fractures ($\chi^2 = 5.29$, $p < 0.05$). This study involved 41 fractures of the angle, 63.4% (26/41) of whom were associated with impacted 3rd molars[31].

Cortical integrity of the superior oblique ridge of the mandible is important in resisting the biomechanical forces and stresses. Any breach leads to susceptibility to angle fractures of the mandible. This supersedes the resistance offered by the medullary bone. The inferior border of the angle of the mandible is under compression while the superior border is under tension. Impacted third molars decrease the quality and quantity of the bone in the angle of the mandible[32].

Prophylactic extraction of impacted and partially erupted third molars may reduce mandibular fractures in contact sports in theory but there lacks fundamental evidence to back up the practice. It has been hypothesized that the presence of impacted third molars has a protective value to condylar fractures[32].

Tiwari *et al*., (2016) compared two groups of patients in this study. The group with partially or completely unerupted 3rd molar had 44.44% angle and 13.33% condylar fractures. The group with fully erupted or missing mandibular 3rd molar had 14.45% fractures of the angle and 31.77% condylar fractures. The author advised against prophylactic removal of mandibular third molar due to increased risk condylar fractures which are complex to treat and associated with more complications[33].

1.2.7 PATHOLOGICAL FRACTURES

Pathological fractures of the mandible occur in an already weakened mandible by an underlying pathological process. They may occur during third molar removal, osteomyelitis, osteoradionecrosis, neoplastic lesions, rim mandibulectomy, jaw cysts and bisphosphonate induced osteonecrosis of the mandible[34].They account for less than 2% of all mandibular fractures and occur commonly in the body of the mandible[35]. The leading cause is iatrogenic followed by osteoradionecrosis. Extensive bone removal and inadvertent use of excess force in the removal of 3rd molars may lead to a mandibular fracture. Colleti *et al.*, (2008) in a study involving 44 patients with pathological fractures reported ORN to be the leading cause (49%) followed by osteomyelitis and malignancy with 19% each[36]. Management modality varies with the cause. Some cases require mandibulectomy and reconstruction with a plate and a bone graft. Complex cases may require a flap reconstruction. Osteoradionecrosis can be treated with hyperbaric oxygen (HBO) dives[34,36]. Pathological fractures have very high complicate rates[37].

1.2.8 CONCOMITANT INJURIES

Czerwinski *et al.,* (2008) established that severe mechanism of injury presented with another facial fracture 59% of the time. Similarly, comminuted fractures of the mandible presented with another facial fracture 48% of the time[9].

In paediatric patients below 15 years, concomitant injuries occurring out of the face may be up to 11% with more limb and head and neck injuries. Upper limbs are predominantly affected than lower limbs. These injuries occur more frequently in falls from heights and motor vehicle accidents[38].

1.2.9 MANAGEMENT OF MANDIBULAR FRACTURES

There are several management modalities of mandibular fractures. They can be broadly classified into closed and open reduction. Closed reduction involves non-operative means whereas open reduction involves surgical exposure of the fracture site to visualize the segments for reduction. The reduced segments are then immobilized through either rigid fixation or semi-rigid fixation.

Closed reduction is simple, cost effective, less time consuming and poses less risk to damage of adjacent structures.

The presence of teeth in the mandible is an important factor that makes the approach of mandibular fractures a bit different from any other bone[21]. Establishment of a functional occlusion is the primary goal of treating mandibular fractures especially in dentate patients.

Indications of closed reduction include non- displaced favourable fractures, grossly comminuted fractures, condylar fractures, fractures in children, coronoid process fractures and atrophied edentulous mandible. Open reduction is often done in panfacial fractures involving the mandible, unfavourable fractures, displaced fracture, and in fractures with non-union or malunion. Alcoholics and epileptic patients are managed by open reduction and fixation.

Recent advances in biomaterial sciences with modern techniques and technologies used in open reduction and fixation have led to faster, safer and comfortable return to function.

Condylar fractures can either be managed conservatively of by open reduction. Indications of open reduction were outlined by Zide and Kent, (1983). Absolute indications include lateral displacement of the condyle, superior displacement into middle cranial fossa, presence of foreign object in the joint space and inability to get a functional occlusion by closed reduction. Relative indications include bilateral condylar fractures with other maxillofacial fractures, bilateral fractures in edentulous patients and whenever maxillomandibular fixation is medically contraindicated[39].

Lag screws can be used in treating true oblique fractures of the mandible especially symphyseal fractures. However, it can also be used in body and angle fractures. This involves use of a true lag screw or by over drilling the proximal segment to provide internal rigid fixation. A minimum of two screws are used to resist rotational and torquing movements. This technique is faster and obviates the need for plate adaptation intraoperatively without compromise of the resultant stability[40].

Infected fractures are best treated with open reduction and rigid fixation. Infections may delay bony union but as long as the fractures are rigidly fixated, they eventually unite[41].

Presence of developing tooth buds of permanent teeth complicates the management of fractures children with deciduous and mixed dentitions. The growing mandible further complicates the scenario. More conservative approaches are employed in managing fractures in paediatric patients. Observation with soft diet is often adequate for non-displaced and greenstick fractures. Displaced fractures are managed by maxillomandibular fixation or splinting by use of an arch bar. High osteogenic potential is a double-edged sword which facilitates faster healing and union but also increases the likelihood of TMJ ankylosis in condylar fractures.

Wu *et al*., (2012) used semi-rigid IMF method using self-drilling screws, elastics and an occlusal splint to manage 20 condylar fractures in 13 patients with good outcome. This lasted for 4 weeks and resulted in good maximum mouth opening and restoration of normal mandibular motion in all patients except one. There was no reported root or tooth germ damage[42].

Recent advances have led to development of resorbable plates with ideal use in non-load bearing areas and fractures in children[43,44]. These plates do not need to be removed as they undergo enzymatic biodegradation with time.

Edentulous mandibles with severe atrophy present a challenge in the management. Lack of teeth eliminates the option of maxillomandibular fixation. In the elderly, the blood supply is often compromised with reduced osteogenesis. However, treatment strategies with circumferential wiring and gunning splints and existing dentures can be used. Other modalities include external fixation, and ORIF with or without bone grafting[45].

Angle fractures are best managed by open approach with rigid fixation by plating or semi-rigid fixation by trans-osseous wiring. The use of mini-plates exploits the Champy's lines of osteosynthesis[46.]

1.2.10 COMPLICATIONS

Mandibular fractures may present with several complications. Even the best managed cases can still present with complications. This may include aesthetic problems and functional derangement.

Long-term complications may be due to delayed diagnosis, inappropriate management or non-compliance. They include infections, non-union, malunion, delayed union, hardware exposure or extrusion, occlusal derangement and TMJ disorders[10].

Complication rates are lower in young patients[23,44,47]. A systematic review by Bobrowski *et al*., (2017) analysed treatment outcomes of 178 paediatric patients. There were no complications in 6 patients treated with titanium plates. However, there was a complicate rate of 9.7% (3/31) and 8.5% (12/141) associated with non-surgical management and surgical management with use of biodegradable plates respectively[44]. Atilgan *et al*., (2010) recorded a complication rate of 1.3% in children and 3.4% in adults[23].

Infection is the most common complication of mandibular fractures. Furr *et al.,* (2006) reported an overall complication rate of 6.6% (18/273) with infections forming the majority of those complications. Smoking and alcohol abuse were observed to be key risk factors ($p = 0.021$). Use of plates resulted in more complications ($p = 0.04$)[48]. Abotelab *et al*., (2018) reported an overall complication rate of 18.4%. Majority of them were infections (8.8%) followed by malocclusion (5.8%)[26]. Antibiotic use has generally reduced infection rates although other authors have shown no benefit of antibiotic use in reducing infections[26]. Infections may manifest as chronic osteomyelitis, abscesses, cellulitis and/or persistent fistula.

Malunion may lead to malocclusion and are related complications. They often result from inadequate reduction and immobilization.

Delayed union is failure of fracture union by 2 months. Non-union occurs when there is arrested bone union. The latter needs further surgery to unite whereas the former may eventually unite without further intervention. These two complications are caused by infections, fracture mobility, and presence of systemic conditions. Non-union may necessitate debridement with bone grafting and rigid fixation.

Nerve injuries may occur from mandibular injuries or maybe iatrogenic during surgical management of the fracture. The commonly involved nerves include inferior alveolar nerve, and peripheral branches of the facial nerve especially the marginal mandibular nerve[47]. Patients present with paraesthesia, hypoaesthesia or anaesthesia depending on the degree of injury of sensory nerve. Paresthesia may be reversible in neuropraxia. Facial nerve injury leads to paralysis of the muscles of facial expressions supplied by the injured nerve.

In 2016, Schenkel *et al*., observed that hypoaesthesia occurred in as many as 79% of patients with mandibular fractures. However, complete recovery occurred in 70% and partial recovery in 20% patients. Permanent loss of nerve function occurred in 10% of patients. Recovery rates were worse in older patients[47].

Prolonged immobilization of condylar fractures may lead to TMJ ankylosis. This is a serious complication in children and may cause growth disturbances and other unfavourable sequelae including facial asymmetry, malnutrition, poor oral hygiene, periodontal breakdown, multiple caries and psychosocial disturbances[49].

Butt *et al*., (2015) studied 12 patients with TMJ ankylosis with an age range of 1-10 years. Majority of them were males with a M: F of 2:1. All of them had a positive history of trauma. Unilateral fractures were more common (67%). All of them underwent surgical correction with high success rates with only one patient having reduced inter-incisal opening[50].

1.3 PROBLEM STATEMENT

There have been changes in the mode of transport with the proliferation of motorcycles (Boda boda). According to the Kenya Economic Survey (2018), an average of 16,000 motorcycles out of 24,000 vehicles were registered every month in 2017 (Appendix 2). This translated to 67% of the total number of vehicles. Furthermore, there were 3 million registered vehicles in the Kenyan roads by the year 2017[51]. Kenya's population has steadily grown at the rate of 2.5% per annum with an estimated population of 48 million by 2018[52]. The WHO global status report on road safety (2018) estimated 27.8/100,000 fatalities from road crashes in 2016, with even more injuries to the survivors. This was attributed to poor compliance to road safety strategies and ineffective enforcement of road safety laws[52].

RTCs have been reported to cause most of the maxillofacial injuries. Majority of the fractures in the maxillofacial complex occur in the mandible. Studies have shown that mandibular fractures accounted for 16-71% of the maxillofacial fractures[11-14].

Simba *et al*., (2018) reported that 16.5% of maxillofacial fractures caused by motorcycle crashes occurred in the mandible[14]. However, previous Kenyan studies have shown that majority (60-74%) of mandibular fractures were from IPV[6-8].

It can be deduced from the above that mandibular fractures pose a major public health concern. They are a big burden to the victims, their families and to the healthcare system. Increased mandibular fractures places a big strain in terms of resources used in diagnosis and eventual management. High velocity injuries may result in complex injury patterns needing specialized services of a maxillofacial surgeons who are very few in Kenya, less than 30. Fractures needing surgical intervention are expensive and may not be affordable to many patients or may lead to overall delay of management. Furthermore, patients may resort to ineffective and inappropriate treatment options thus increasing poor outcomes and complications.

Literature shows very few Kenyan studies on mandibular fractures. There is inadequate recent local data. The last Kenyan study recorded in literature done by Owino *et al.*, (2003) did not evaluate alcohol as a major risk factor but recommended future studies to do so. No previous study has shown and tested statistical association between aetiological factors and fracture patterns.

1.4 STUDY JUSTIFICATION

This study sought to find out if the changing dynamics in transport sector especially with increased motorcycles and motor vehicles may have led to a change in the pattern of occurrence of mandibular fractures.

This is hoped to inform policy direction especially in resource allocation. This can be through equipping the facilities of care with appropriate tools and equipment and skills by training of maxillofacial surgeons. It may also help in development of robust and effective interventional towards reduction of mandibular fractures through a focused approach on the most common aetiological factors. This may be through a more stringent and tighter control of BAC limit for driving especially for young and inexperienced drivers. This study may provide an impetus to more collaborative and expanded studies in different maxillofacial centers to generate data that can be easily generalized to the Kenyan population at large.

Lastly, this study will add to the general understanding of the subject while adding to the ever-growing body of knowledge of mandibular fractures. It will also be a partial fulfillment of the investigator's requirement to be awarded a master's degree in oral and maxillofacial surgery.

1.5 OBJECTIVES OF THE STUDY

1.5.1 BROAD OBJECTIVE

To investigate the socio-demographics, aetiology, pattern of occurrence and management of mandibular fractures at the Kenyatta National Referral Hospital and University of Nairobi Dental Hospital.

1.5.2 SPECIFIC OBJECTIVES

1. To determine the socio-demographic characteristics of patients with mandibular fractures.
2. To determine the etiological factors associated with mandibular fractures.
3. To describe the pattern of the mandibular fractures.
4. To determine the association between mandibular fractures and various aetiological and demographic factors.
5. To determine the management modalities of the patients presenting with mandibular fractures.

1.6 VARIABLES

Table 2: Variables

Variables		Measurement
Socio-Demographic	Age	Number of years
	Sex	Male, female
	Occupation	Employed, self-employed, unemployed, student, pupil
	Place of Residence	Urban, rural.
Independent Variables	Aetiology	Road traffic crashes
		Interpersonal violence- domestic, assaults, gunshot
		Falls, sports, pathologic fractures
		Iatrogenic, others(specify)
	Associated Impacted Teeth	Present, absent
Dependent Variables	Mandibular Fractures	Anatomical site- symphyseal, parasymphyseal, body, angle, ramus, coronoid, condylar , dento-alveolar, others
	Number of Fracture Sites	1,2,3
	Concomitant Injuries	NOE, maxillary, zygomatic complex, orbital, frontal bone, head and traumatic brain injuries
		Thoracic, abdominal, limbs, vertebral, spinal cord, others (specify)
	Management Modality	Open reduction-rigid and semi-rigid fixation
		Closed reduction- Maxillo-mandibular fixation, splinting
	Complications	Immediate- infections, paresthesia
		Delayed- malocclusion, malunion, non-union, TMJ ankylosis, others

CHAPTER TWO

MATERIALS AND METHODS

2.1 STUDY AREA

This study was carried out at the Kenyatta National Referral and Teaching Hospital Department of Dentistry and University of Nairobi Dental Hospital. The former is the oldest and the largest National Referral Hospital in Kenya. They are both located about 4 km from the Central Business District of Nairobi County to the West of Upper Hill area. KNH has a total bed capacity of 1800. University of Nairobi Dental Hospital is also a teaching a referral facility. It offers both general and specialized dental health services to the public. The facility serves about fifteen new patients daily in its oral diagnosis clinic. It also attends to about the same number in each of its five specialized clinics. It has an operational theatre and an inpatient facility.

2.2 STUDY POPULATION

Records of patients with confirmed mandibular fractures presenting at the Kenyatta National Referral and Teaching Hospital and University of Nairobi Dental Hospital from June 2014 to May 2019.

2.3 STUDY DESIGN

This was a retrospective descriptive cross-sectional study.

2.4 DETERMINATION OF SAMPLE SIZE

The Fisher's formula was used to calculate the sample size as follows:

$$n_0 = \frac{Z^2 P(1-P)}{d^2}$$

Where

n_0 = sample size

Z value corresponding to 95% confidence level = 1.96

d is precision = 0.05

P was proportion of mandibular fractures from a previous study* = 55%

(* The proportion of mandibular fractures, the value of P was estimated at 55% based on the Tugaineyo *et al.*, (2013) study at Mulago Referral Facility in Uganda)[13]

Therefore,

$$n_0 = \frac{1.96^2 \times 0.55(1-0.55)}{0.05 \times 0.05} = 380$$

Sample size was adjusted for finite population using the formula below

$$n = \frac{n_0}{1+(n_0-1)/N}$$

Where

n = sample size with finite correction.

n_0 = sample size without finite correction.

N = study population

$$n = \frac{380}{1+\frac{(380-1)}{4000^*}}$$

n = 347.1

A minimum sample of 348 patients was required.

* The two institutions in which this study was carried out sees an average of 2 patients with mandibular fractures every day. This adds up to 3600 in the 5-year period. Therefore,4000 was chosen as the population of patients with mandibular fractures.

2.5 SAMPLING METHOD

All patients' records meeting the inclusion criteria were included in the study.

2.6 INCLUSION CRITERIA

- Patients' records with radiographically confirmed mandibular fractures
- Records of patients seen from June 2014 to May 2019.

2.7 EXCLUSION CRITERIA

- Incomplete records.

2.8 DATA COLLECTION METHODS

The daily registers of patients seen in the maxillofacial clinics in Kenyatta National Hospital department of Dentistry and Dental Hospital were reviewed from June 2014 and May 2019. Patients with mandibular fractures were identified and their hospital reference numbers obtained. Records of patients with radiographically confirmed mandibular fractures were retrieved with the help of the records officers.

Where radiographs were not available for review, a clearly documented radiographic report stating which radiographs were done and the anatomical site of the fractures was used.

Data was collected by the principal investigator using a data collection form (checklist) as shown in Appendix 1. Data collection tool was pretested to minimize errors and biases. Data collection was done in the months of June and July 2019. Data collected included the age of the patient, sex, occupation, place of residence, level of education, date of injury, alcohol use, mechanism of injury/aetiology, radiological investigations done, site of fracture, number of fractures and presence of associated impacted teeth for angle fractures. It also included concomitant injuries, management modality used and any associated complication.

2.9 DATA ANALYSIS AND PRESENTATION

All questionnaires were checked for completeness of responses. Data from all the fully completed questionnaires was entered into IBM Statistical Package for the Social Sciences (SPSS) Version 25. Data cleaning was done to eliminate any duplication and wrong entries. This was followed by data analysis. Descriptive statistics were computed. This included demographic variables. Overall mean age and standard deviation, median, modal ages and age range were computed. This was followed by the mean age and standard deviation of males and females. A cross tabulation of age-group and sex was made to show distribution of patients with mandibular fractures by age and sex. The highest level of education attained was represented by a table of frequency and percentages. Bar graphs were made from Microsoft excel to show distribution of patients by their occupational status, day of the week and month of the year when the injury occurred. A bar graph of frequencies and percentage of aetiological factors, anatomical site of mandibular fractures, classes of RTCs and category of road user in RTCs. Tables of frequencies and percentages represented imaging modality requested, distribution of mandibular fractures by site and side, management modality, concomitant injuries, and complications. Bivariate associations were tested for statistical significance using Chi square test. The p value was set at 0.05 and any value below this was considered significant. In cases where the assumptions of chi square were violated such as in cases with less than 5 counts per cell, Fisher's exact test was performed.

2.10 LIMITATIONS OF THE STUDY

1. Blood alcohol concentration (BAC) was not objectively evaluated in patients with mandibular fractures with prior history of alcohol and substance use. It was based on subjective reporting by the patients or accompanying persons.
2. The research was limited to two referral facilities in Nairobi with most patients drawn from urban areas. This may be biased against the pattern in a rural set-up. This may limit generalization of the findings to the general population.
3. The patient history forms were not standardized and both centres had different formats.

2.11 ETHICAL CONSIDERATIONS

Clearance and approval to conduct this research was obtained from KNH-UoN Ethics and Research Committee (P248/03/2019 dated 26th June 2019). Permission was sought and granted from the Kenyatta National Hospital and University of Nairobi Dental Hospital management to access the patients' records. Information obtained was treated with the utmost confidentiality. Records were handled within the confines of the hospital. Access to the identifiable data was restricted to the personnel conducting research only. Anonymization of patients was employed by allocation of unique serial numbers. An inventory of retrieved records was kept daily with the record's officer to avoid any loss. The findings of this study will be published in a peer journal for use by other medical professionals to help advance the standards of quality healthcare.

2.12 EXPECTED STUDY BENEFITS

This study is hoped to inform the policy makers in improving and implementing effective road safety programs towards reduction of road traffic crashes associated mandibular fractures. It may also help in rational allocation of resources to centres involved in management of mandibular fractures.

Thorough knowledge of the pattern of fractures in relation to the aetiology will help the clinicians request for appropriate imaging for diagnosis. This is important in a resource limited setting. Lastly, this dissertation will be submitted by the principal investigator in partial fulfilment of the requirements leading to the award of a master's degree in oral and maxillofacial surgery.

CHAPTER THREE

RESULTS

3.1 DEMOGRAPHIC CHARACTERISTICS

The records of patients with mandibular fractures that met the inclusion criteria were retrieved and studied. These comprised of 444 (83.1%) patients from Kenyatta National Hospital and 90 (16.9%) from University of Nairobi Dental Hospital.

3.1.1 AGE AND SEX

Out of the 534 patients' records examined, 469 (87.8%) were males whereas 65 (12.2%) were females giving a male to female ratio of 7.2:1. The age range was 1 to 74 years. The overall mean age was 30±11.6 years. The mean age for males was 30.4±11.7 whereas that of females was 26.8 ±13.9 years. The median and modal ages were 29.0 and 30.0 years, respectively. Whereas mandibular fractures were more common in patients in 3rd and 4th decades, they were least common in extreme age groups (Table 3).

Table 3: Distribution of Patients with Mandibular Fractures by Age and Sex (n = 534)

Age Group (Yrs)	Male		Female		Total		M:F
	No.	%	No.	%	No.	%	
≤ 9	16	3.0	11	2.1	27	5.1	1.5:1
10-19	35	6.5	8	1.5	43	8.1	4.4:1
20-29	187	35.0	17	3.2	204	38.2	11:1
30-39	133	25.1	17	3.2	150	28.1	7.8:1
40-49	73	13.7	8	1.5	81	15.2	9.1:1
50-59	17	3.2	3	0.6	20	3.7	5.7:1
≥60	8	1.5	1	0.2	9	1.7	8:1
TOTAL	469	87.8	65	12.2	534	100	7.2:1

3.1.2 RESIDENCE

Three hundred and seventy-nine (71%) patients resided in urban areas whereas 155 (29.0%) lived in rural areas.

3.1.3 LEVEL OF EDUCATION

Majority of the adult patients, 315 (59.0%) had attained secondary school education whereas a minority had informal education 5 (0.9%) (Table 4).

Table 4: Distribution of Patients by Highest Level of Education (n = 534)

Highest Level of Education Attained	Frequency (n)	%
Pre-School	9	1.7
Primary	52	9.7
Secondary	315	59.0
Tertiary	59	11.0
Informal	5	0.9
Not Specified	94	17.6
Total	534	100

3.1.4. OCCUPATIONAL STATUS

Self-employed patients had the highest percentage with mandibular fractures (42.7%) followed by those in formal employment (28.3%). Pre-school children had the least percentage (2.6%) with mandibular fractures (Fig. 1).

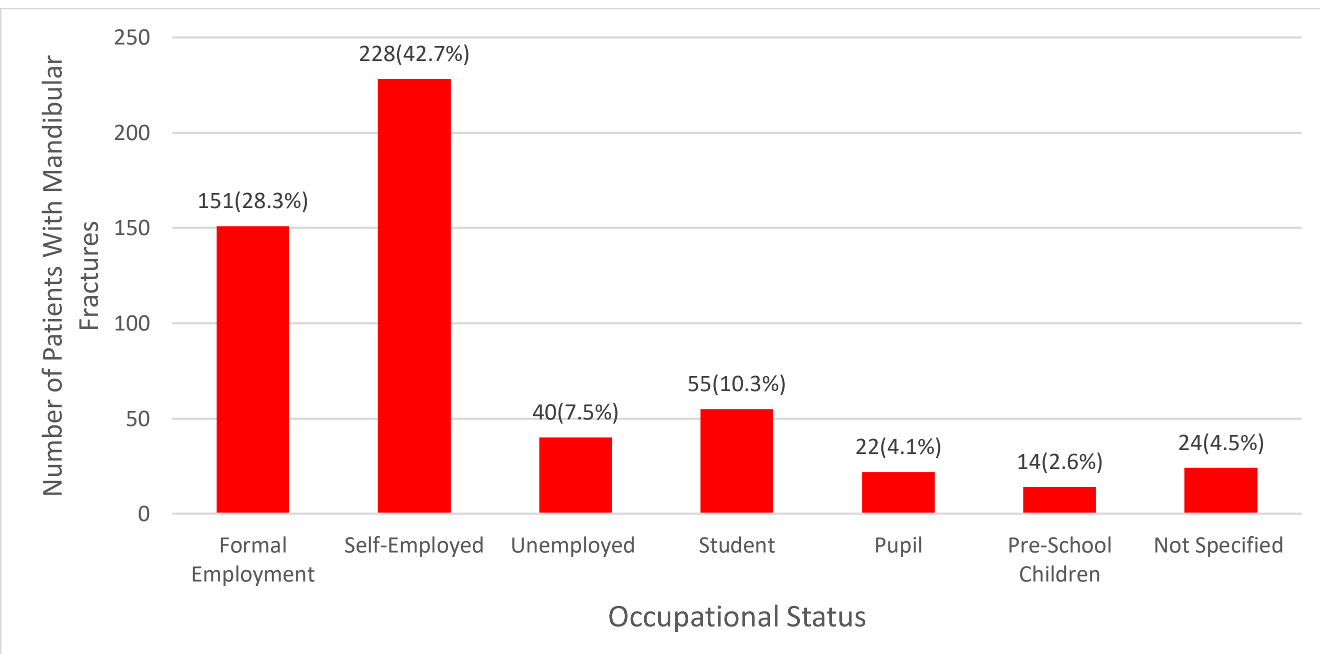

Figure 1: Occupational Status of Patients Presenting with Mandibular Fractures

3.2 MONTH, DAY AND TIME OF INJURY

3.2.1 Occurrence of Mandibular Fractures by Month of the year.

Majority of mandibular fractures occurred in August (10.1%), and the minority occurred in January (5.2%). Fig.2 illustrates the distribution of patients with mandibular fractures by the month of injury.

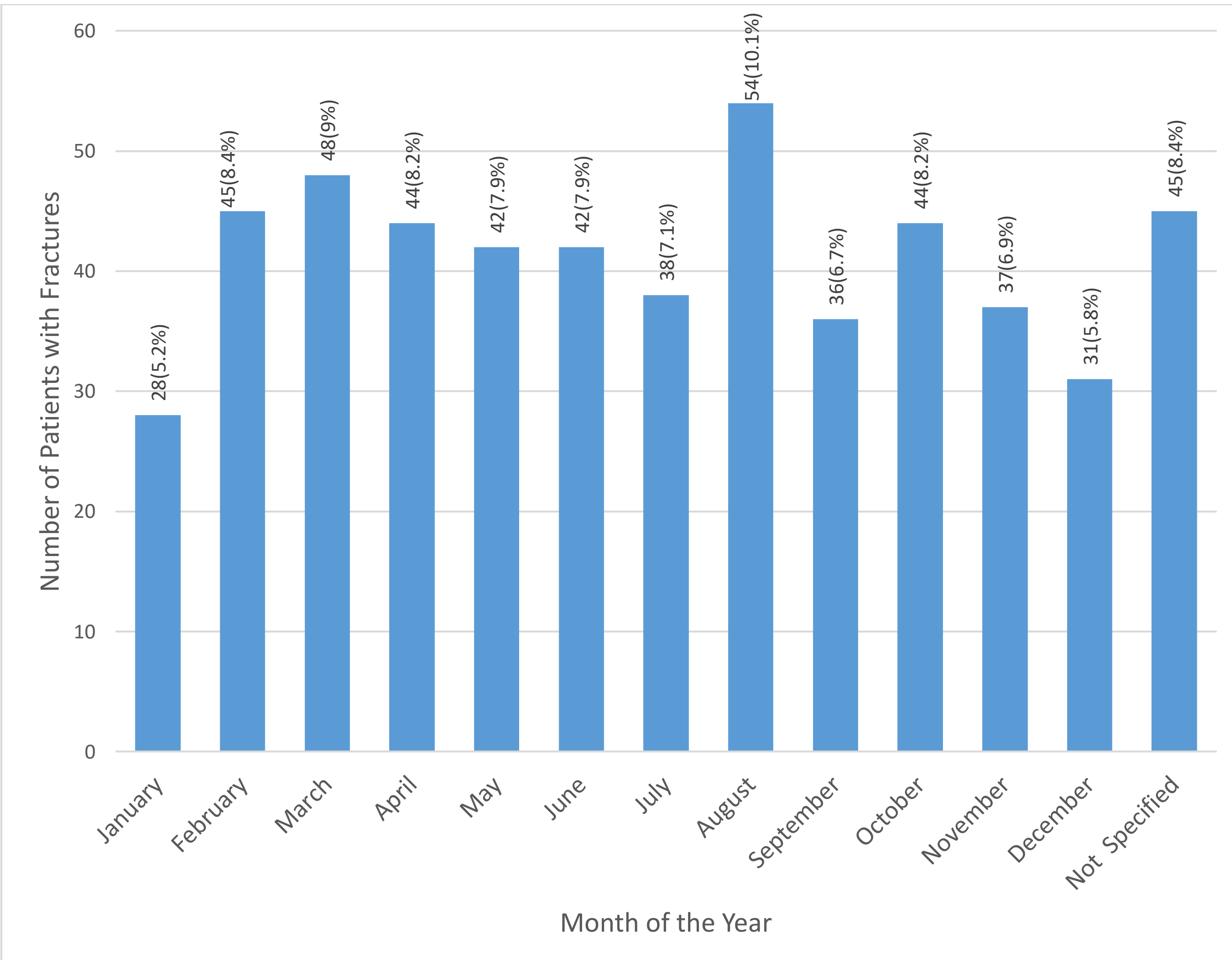

Figure 2: Occurrence of Mandibular Fractures by Month of the Year (n = 534)

3.2.2 Occurrence of Mandibular Fractures by Day of the Week.

More patients sustained mandibular fractures during the weekends than during other days of the week. Seventy-four (13.9%) patients sustained mandibular fractures on Fridays whereas 83 (15.5%) and 81 (15.2%) sustained them on Saturdays and Sundays, respectively (Fig.3). Patients were least likely to sustain fractures on Thursdays 42 (7.9%).

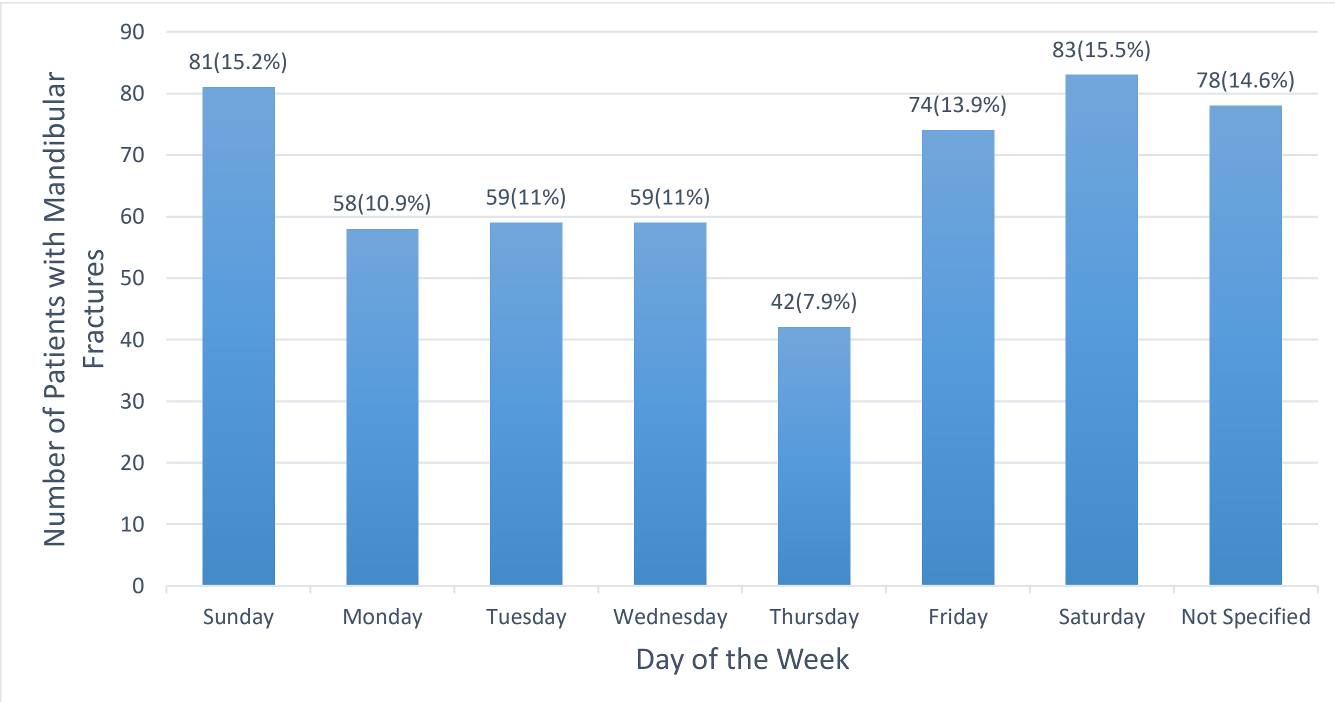

Figure 3: Occurrence of Mandibular Fractures by Day of the Week (n = 534)

3.2.3 Occurrence of Mandibular Fractures by Time of the Day.

Two hundred and eleven (39.5%) patients sustained mandibular fractures during the day whereas 197 (39.9%) occurred at night. The time of injury was not specified in 126 (23.6%) patients.

3.3 ALCOHOL AND SUBSTANCE USE

Three hundred and one (56.4%) of the patients were not on alcohol or substance use at the time of their injuries whereas 173 (32.4%) reported to have been under the influence of these substances. Those on alcohol and substance use included 167 (96.6%) males and 6 (3.4%) females. Sixty (11%) cases were not specified. Two patients reported to have used *Cannabis sativa* (Bhang).

3.4 AETIOLOGICAL FACTORS

Interpersonal violence (IPV) accounted for 42.5% of the patients with mandibular fractures (Fig.4). It was closely followed by RTC (40.1%) and falls (14.2%). Patients recorded in the category of others included two pathological fractures (due to osteoradionecrosis from neck irradiation of head and neck malignancies), three animal attacks (2 domestic and one wild animal) and an accidental hit by flying wooden object. All the sports injuries were sustained while playing football except one which was from a hockey stick.

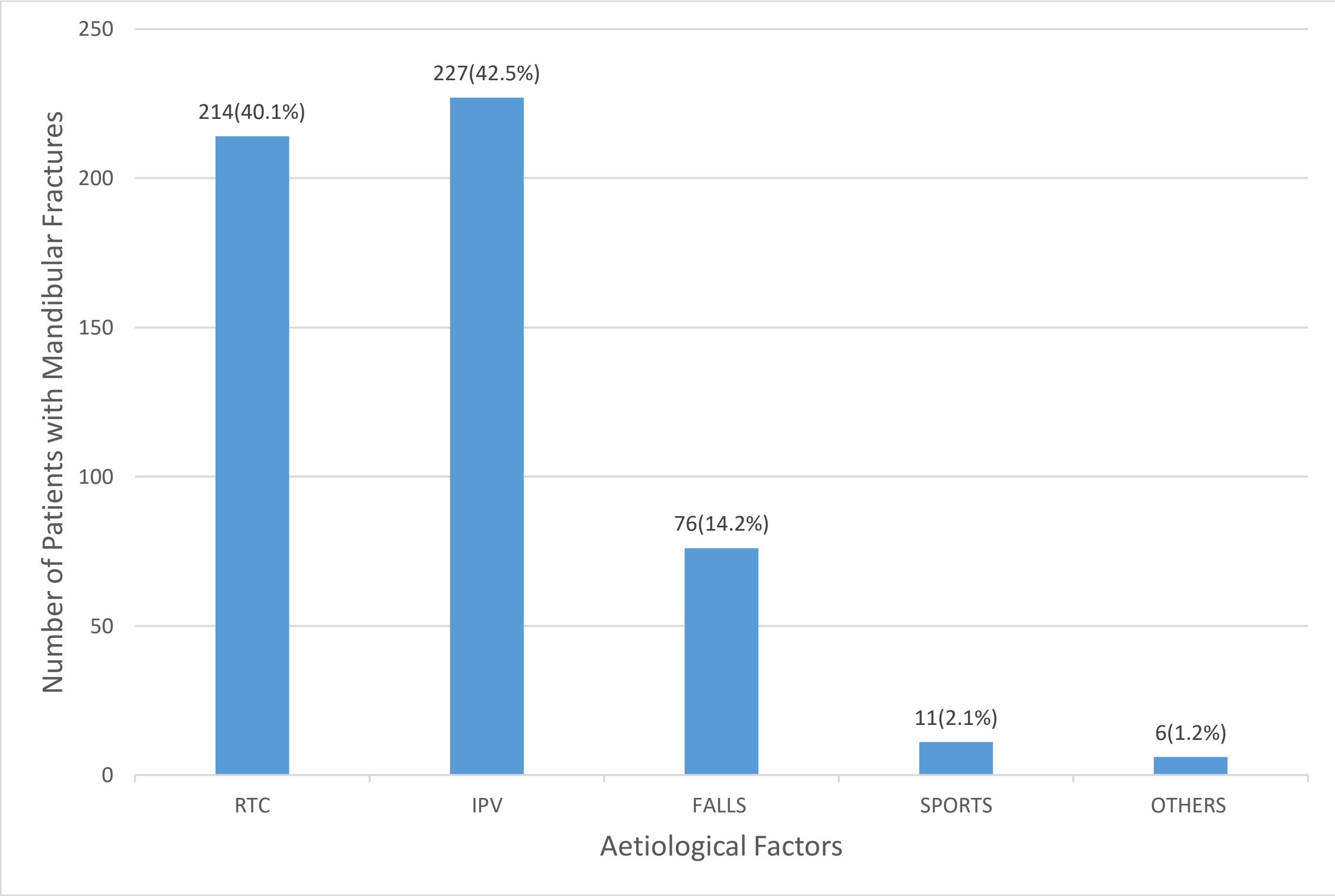

Figure 4: Distribution of Patients with Mandibular Fractures by Aetiological Factors

In children in their first decade, the leading aetiology was falls (n = 16, 55.2%). This was followed by RTC (n = 8, 27.6%), IPV (n = 4, 13.8%) and one animal attack (n = 1, 3.4%).

3.4.1 INTERPERSONAL VIOLENCE

Interpersonal violence was the leading aetiological factor accounting for 227 (42.5%)of patients. Males were affected more than females with 209 (92%) and 18 (8%) cases respectively. Three forms of IPV were reported. Domestic violence involved injuries caused by members of the same household mostly in a family set up while assaults comprised physical attacks caused by strangers or people not closely related to the victims. Non-war gunshot injuries were firearm injuries outside war set up.

Domestic violence accounted for 3.1% of all IPVs whereas assaults and non- war gunshots were responsible for 94.3% and 2.6% cases respectively. Domestic Violence was recorded in 4 (57.1%) males and 3 (42.9%) females. One hundred and ninety-nine (93%) males and 15 (7%) females sustained fractures during assaults. Most forms of IPVs were among patients between 3rd and 5th decades. Non- war gunshot injuries were reported only in six males (Table 5).

Table 5: Distribution of Patients with Mandibular Fractures Caused by Interpersonal Violence by Age Group (n = 227)

Age Group (yrs)	Domestic		Assault		Non- War Gunshot		**Total**	
	No.	%	No.	%	No.	%	No.	%
≥9	0	0.0	2	0.1	0	0.0	4	1.8
10-19	0	0.0	11	5.1	0	0.0	11	4.8
20-29	0	0.0	82	38.3	2	33.3	82	36.1
30-39	4	57.1	64	29.9	3	50.0	71	31.3
40-49	2	28.6	39	18.2	1	16.7	42	18.5
50-59	0	0.0	11	5.1	0	0.0	11	4.8
≥60	1	14.3	5	2.3	0	0.0	6	2.6
Total	7	100%	214	100%	6	100%	227	100

3.4.2 ROAD TRAFFIC CRASHES

Road traffic crashes was the second leading cause of mandibular fractures in 214 (40.1 %) patients. Of the RTCs, 120 (56.1%) patients sustained mandibular fractures from motor cycle accidents whereas 83 (38.8%) were from motor vehicle crashes (Fig.5). These included the drivers, riders, passengers and pedestrians.

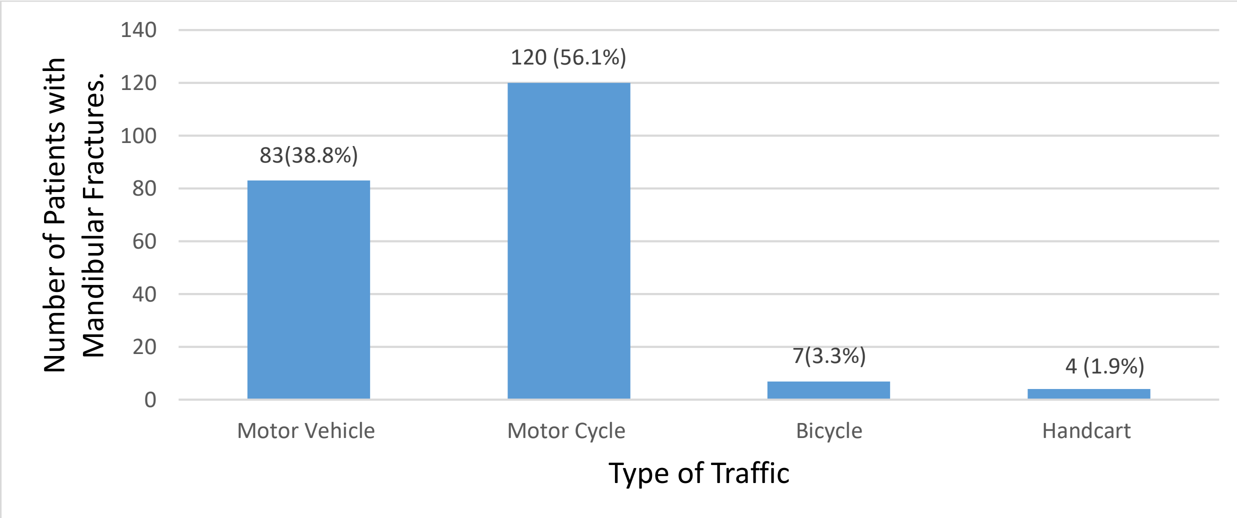

Figure 5: Distribution of Patients with Mandibular Fractures by the Type of Traffic Involved

Most of the fractures were from motorcycle and motor vehicle crashes. The patients with mandibular fractures were then categorized according to their role in road usage as motor vehicle drivers, motorcycle riders, passengers and pedestrians. Motor cycle riders accounted for 77 (14.4%) of all the cases and motor vehicle passengers 53 (9.9%) cases. This was followed by 30 (5.6%) motorcycle passengers and 25 (4.7%) pedestrians hit by motor vehicles. Handcart pushers accounted for 3 (0.6%) cases and 1 (0.2%) pedestrian. The category of road users is summarized in Fig. 6.

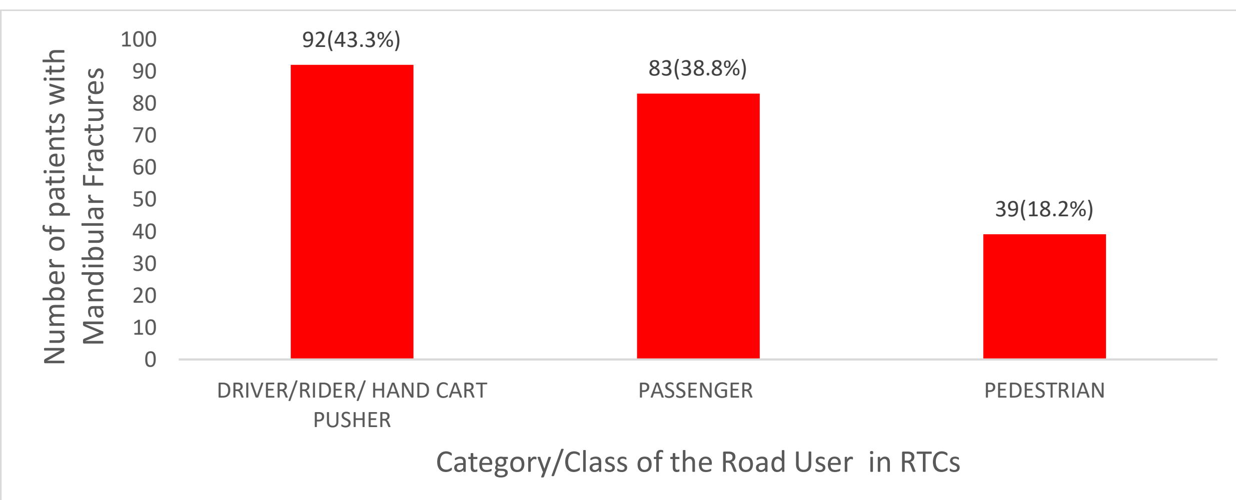

Figure 6: Category of patient with Mandibular fractures in Road Traffic Crashes (n = 214)

3.5 IMAGING MODALITIES IN THE DIAGNOSIS OF MANDIBULAR FRACTURES

Several imaging modalities were done to make a definitive diagnosis and characterize mandibular fractures (Table 6).

Table 6: Type of Imaging Done

Imaging modality	**Specific Type**	**Number**	**% n =691***	**% n =534****
Plain Radiographs	OPG	479	69.3	89.7
	PA	21	3.0	3.9
	Reverse Towne's view	1	0.1	0.2
	Lateral view of mandible	15	2.2	2.8
	IOPA	1	0.1	0.2
	OMV	2	0.3	0.4
	SMV	1	0.1	0. 2
Computed Tomography Scan		171	24.7	32.0
TOTAL		691	100	100

* Total number of radiographic investigations done.

** Total number of patients with mandibular fractures.

Orthopantomogram (OPG) was the most frequent investigation done in 479 (69.3%) followed by CT scan in 171 (24.7%) of X-rays. Mandibular plain X-ray views included PA and lateral mandible views with 3.0% and 2.2% respectively (Table 6).

3.6 SITE OF FRACTURE

A total of 845 fractures were diagnosed in 534 patients. The leading sites of fractures were body (28.2%), parasymphyseal (24.3%) and angle of the mandible (19.9%). Ramus and coronoid process fractures were the least with 1.5% and 1.4% respectively (Fig.7).

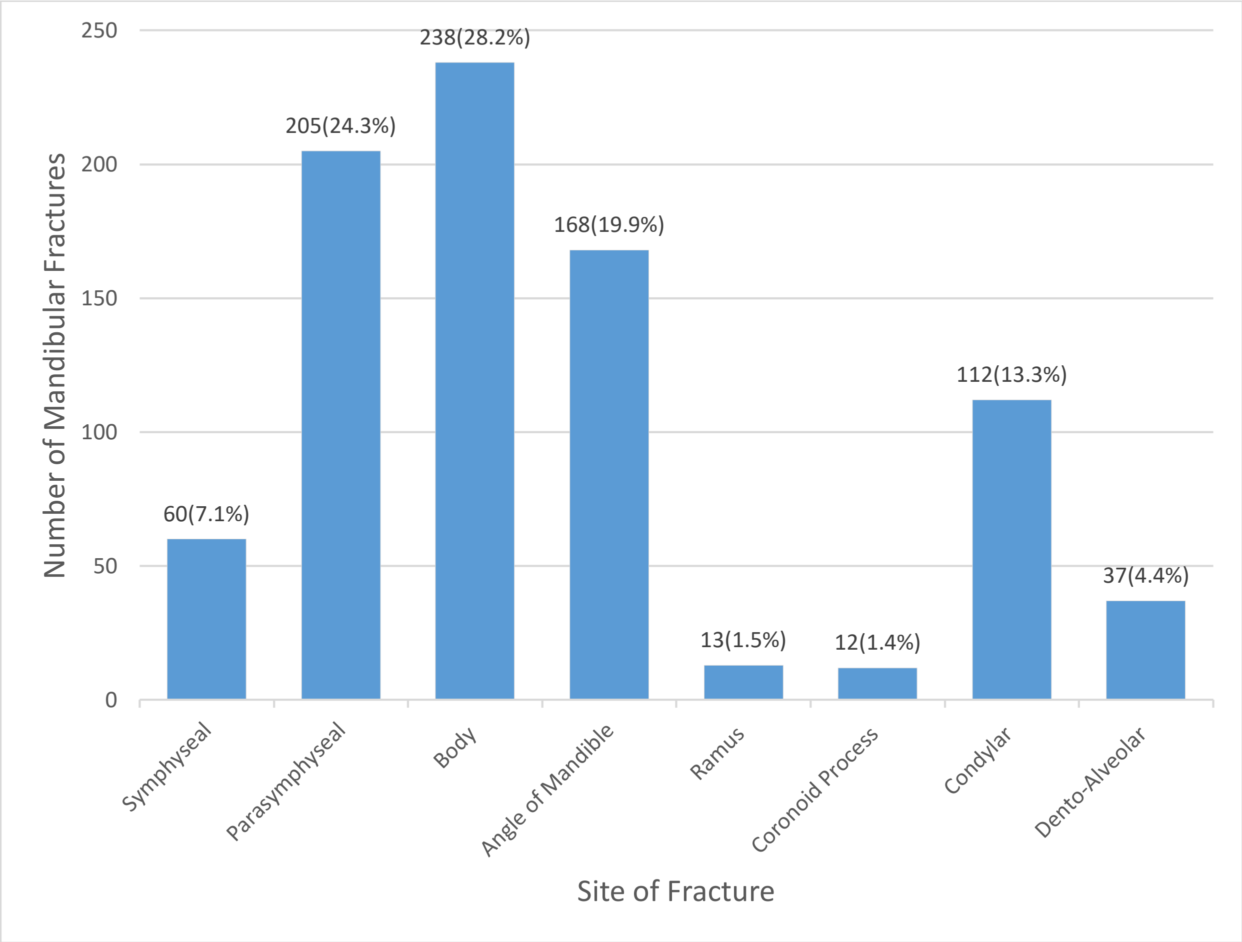

Figure 7: Distribution of Mandibular Fractures by Anatomical Site (Total Number of Fractures = 845)

Bilateral fractures (fractures occurring in the corresponding anatomical site in right and left sides) were more common in the body (n = 34, 4.0%) and condylar regions (n = 22, 2.6%)

Forty-three (25.3%) of angle of mandible fractures were associated with the presence of impacted third molars.

Table 7: Distribution of Mandibular Fractures by Anatomical Site and Side of Mandible Affected (n = 845)

	Fracture Site	**Right**		**Left**		**Bilateral**		**Total**	
		No.	%	No.	%	No.	%	No.	%
1	Symphyseal *	-		-		-		60	7.1
2	Parasymphyseal	112	13.3	93	11.0	12	1.4	205	24.3
3	Body	103	12.2	135	16.0	34	4.0	238	28.2
4	Angle of Mandible	66	7.8	102	12.1	5	0.6	168	19.9
5	Ramus	6	0.7	7	0.8	0	0	13	1.5
6	Coronoid Process	8	0.9	4	0.5	1	0.1	12	1.4
7	Condylar	60	7.1	52	6.2	22	2.6	112	13.3
8	Dento-Alveolar	20	2.4	17	2.0	2	0.2	37	4.4
	Totals	375	44.4	410	48.5	76	9.0	845	100

Symphyseal fractures were not classified as right or left as they lie in the midline

3.7 SIDE OF FRACTURES

There were generally more left side fractures (n = 410, 48.5%) compared to the right side (n = 375, 44.4%). The distribution by side is shown according to anatomical area involved (Fig 8).

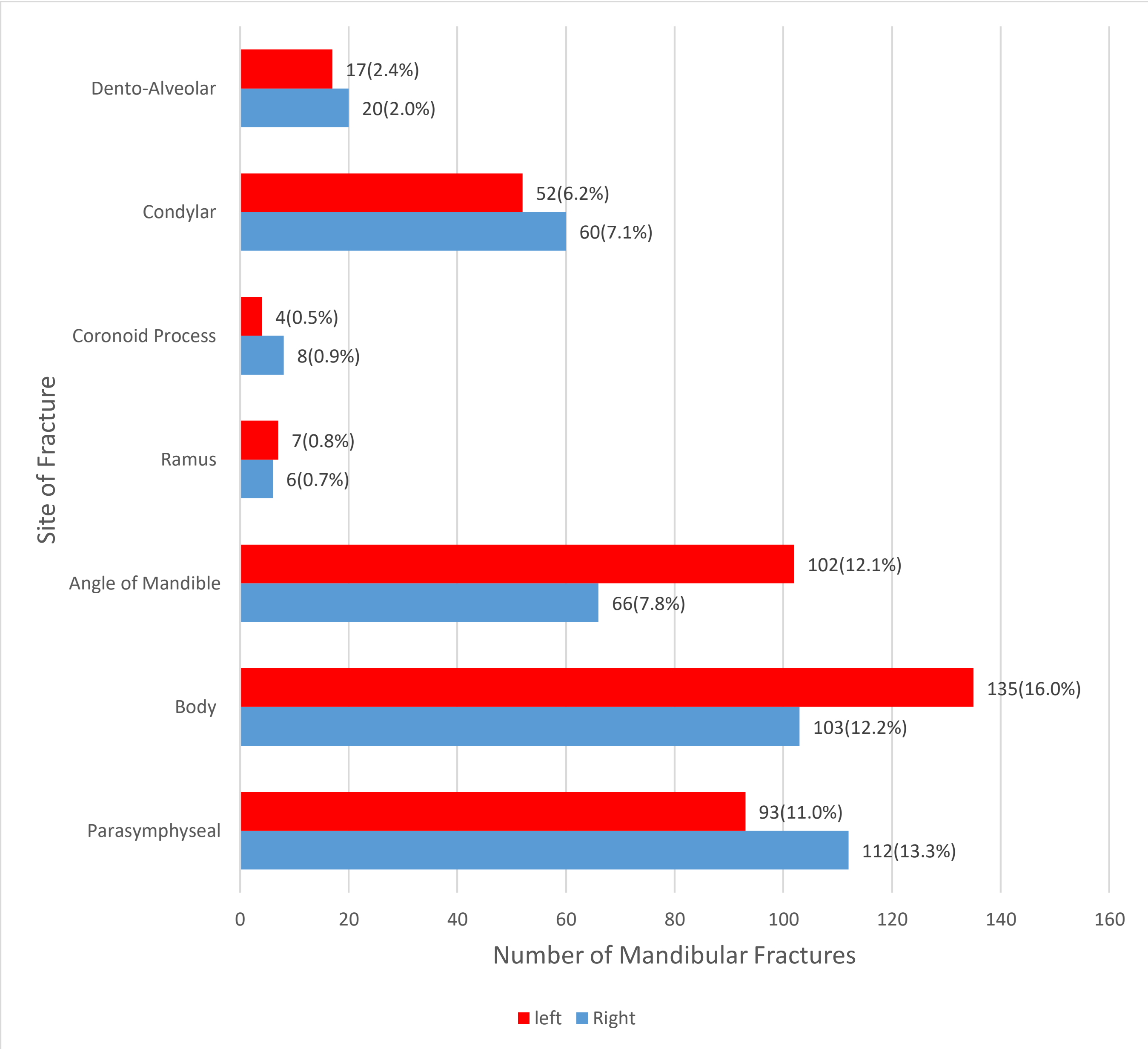

Figure 8: Distribution of Mandibular Fractures by Side of Mandible Affected

There were more left-sided fractures of the ramus, angle and body of the mandible. Fractures of the parasymphyseal, coronoid process, condylar and dento-alveolar processes were more common in the right side.

3.8 NUMBER OF FRACTURES

Most multiple fractures (more than one) of the mandible were associated with IPV (n = 128, 44.8%) and RTC (n = 118, 41.3%) (Figure 9).

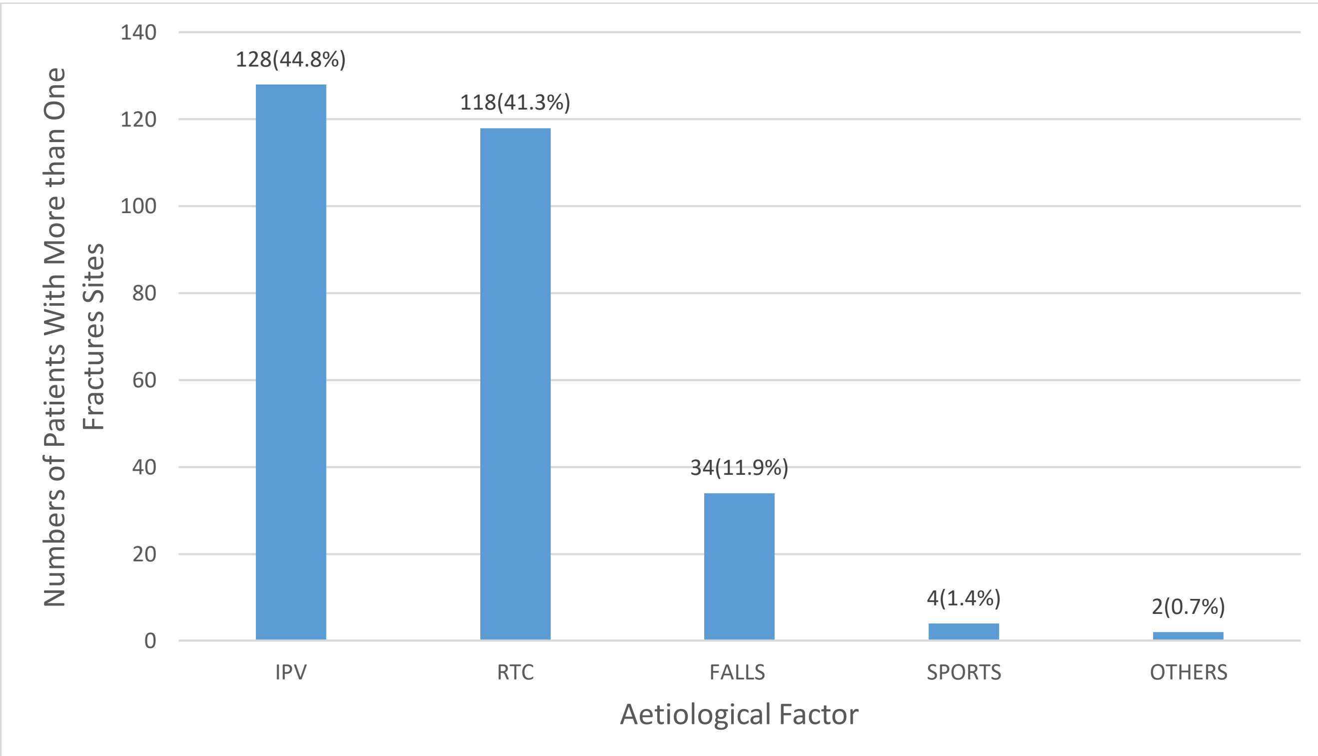

Figure 9: Distribution of Patients with More Than One Mandibular Fractures by Aetiological Factors (n = 286)

The category others included a pathological fracture and an animal slaughter man who was hit by a cow.

Most comminuted (more than two fractures in the same site) fractures of the mandible were associated with RTCs (n = 38, 50.7%). This was followed by IPV (n = 29, 38.7%) (Fig.10). There was no statistically significant association between comminuted fractures and RTCs ($\chi^2 = 1.248$, df = 1, p = 0.264).

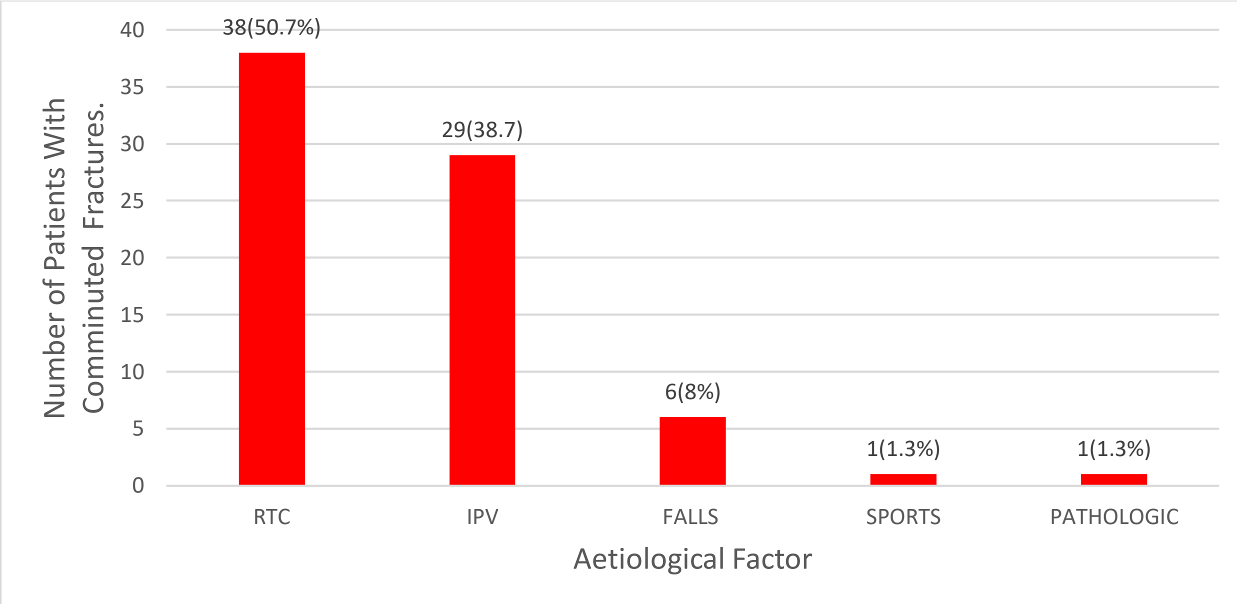

Figure 10: Distribution of Patients with Comminuted Mandibular Fractures by Aetiological Factors (n = 75)

3.9 TREATMENT MODALITIES AND COMPLICATION RATES OF MANDIBULAR FRACTURES

3.9.1 Treatment Modalities

Majority of mandibular fractures (n = 347; 62.9%) were treated by closed reduction followed by ORIF (n = 129; 23.4%). One fracture was not treated (Table 8).

Table 8: Treatment Modality for Mandibular Fractures (n = 552)

Management Modality	Number	%
ORIF (Open Reduction and Rigid Fixation)	129	23.4
Wire Osteosynthesis (Semi-Rigid Fixation)	10	1.8
Closed Reduction (MMF)	347	62.9
Splinting	20	3.6
Circumandibular Wiring	5	0.9
No Treatment*	1	0.2
Conservative Management	40	7.2
TOTAL	552	100

**Patient left without treatment against medical advice*

3.9.2 Complication Rate in patients with Mandibular Fractures.

Eighty-eight complications occurred in 78 patients. Ten patients had two complications each. This translates to an overall complication rate of 14.6%. There were more post-treatment complications (73.8%) than pre-treatment complications (26.2%). Immediate complications comprised pre-treatment infections (14.8%) and paresthesia (11.4%) as shown in Table 9.

The long-term complications recorded during follow ups included malocclusion, malunion, non-union, TMJ ankyloses, chronic infection, and implant failure. There was a single case of plate fracture.

Malocclusion was the leading delayed (post-treatment) complication with 30.7% of the total complications followed by mal-union with 21.6% (Table 9).

Table 9: Distribution of Patients with Mandibular Fractures by Type of Complications (n = 88)

Complications	**Category**	**Number**	**%**
Immediate (Pre-treatment)	Infections	13	14.8
	Paresthesia	10	11.4
Delayed (Post-treatment)	Malocclusion	27	30.7
	Non-union	5	5.7
	Mal-union	19	21.6
	CMJ ankylosis*	3	3.4
	Chronic infection	10	11.4
	Implant failure**	1	1.1
Total		88	100

**The three patients with CMJ ankylosis were children of 7 and 11 years after falls and a 32-year-old male who did not have treatment. His injury was from assault.*

*** Implant failure reported was due to plate fracture*

3.10 CONCOMITANT INJURIES

Isolated mandibular fractures occurred in 269 (50.4%) patients whereas 265 (49.6%) fractures presented with associated injuries. The commonest concomitant injuries were maxillary fractures (14.2%), zygomatic bone (8.8%) and head injuries (8.1%). There were no spinal cord injuries reported. The concomitant injuries are summarized in table 10

Table 10: Distribution of Patients with Concomitant Injuries Associated with Mandibular Fractures (n = 534)

Type of Injury	Number	%
Head and Traumatic Brain Injuries	43	8.1
Naso-Ethmoidal Fractures (NOE)	17	3.2
Zygomatic	47	8.8
Maxillary	76	14.2
Orbital	32	6.0
Frontal Bone	12	2.2
Chest	4	0.7
Abdominal	2	0.4
Pelvic	1	0.2
Upper Limbs Fractures	12	2.2
Lower Limbs Fractures	18	3.4
Vertebral*	1	0.2

**The vertebral injury reported was a C2 Spine Fracture.*

3.11 ASSOCIATIONS BETWEEN VARIOUS DEMOGRAPHIC, AETIOLOGICAL AND MANDIBULAR FRACTURE VARIABLES

3.11.1 Aetiological and Demographic Factors.

3.11.1.1 Aetiological Factors and Time of Injury

There was a statistically significant association between time of injury and IPV ($p < 0.001$) and falls ($p < 0.001$). RTCs and falls were more common during the day whereas IPV were more common at night (Table 11). All Sports injuries and pathologic fractures occurred during the day. There was statistically significant association between the time of injury and sports injuries, pathological fractures and animal attacks combined ($p = 0.0002$).

Table 11: Association Between Various Aetiological Factors and Time of Injury

Aetiology		**Time of Injury**		χ^2 (df)	p Value
		Daytime Number	Night Number		
RTC	Yes	83	68	1.015 (1)	0.314
	No	128	129		
IPV	Yes	59	115	38.528 (1)	0.000
	No	152	82		
Falls	Yes	53	13	25.769 (1)	0.000
	No	158	184		
Others*	Yes	16	1	-	0.0002
	No	195	196		

* Others include sports, pathologic, and animal attacks - Fischer’s Exact Test was used to calculate the statistical significance because the assumptions of Chi Square test were violated with one of the figures less than 5.

3.11.1.2 Sex, Alcohol Use and Time of Injury

Alcohol use and sex had a statistically significant association with night injuries with p values of 0.006 and < 0.001 respectively (Table 12).

Table 12: Association Between Sex, Alcohol and Substance Use and Time of Injury

		Time of injury		χ^2 (df)	p value
		Daytime Number	Night Number		
Sex	Male	176	182	7.629 (1)	0.006
	Female	35	15		
Alcohol Use*	Yes	48	86	26.701 (1)	0.000
	No	155	89		

**Alcohol use was based on subjective reporting i.e by word of mouth by the patient or accompanying person*

3.11.1.3 Association Between Alcohol Use and Age, Sex and Aetiological Factors.

There was a statistically significant association between alcohol use and age group (χ^2 = 44.474, p < 0.001) with patients in 3rd and 4th decades commonly affected. There was also statistically significant association between alcohol use and RTCs (χ^2 = 10.886, p = 0.001). Males used alcohol more than females (χ^2 = 22.139, p < 0.001). There was no reported case of alcohol use in patients whose mandibular fractures were associated with sports and pathological fractures (Table 13). There was a statistically significant association between alcohol usage and falls (χ^2 = 8.373, p = 0.004).

Table 13: Association Between Alcohol Use and Age, Sex and Aetiological Factors

		Alcohol and Substance Use			
		Yes Number	No Number	χ^2 (df)	p value
Age Group(yrs)	≥19	6	64	44.474 (4)	0.000
	20-29	62	114		
	30-39	55	80		
	40-49	42	25		
	≥50	9	17		
Sex	Male	167	245	22.139 (1)	0.000
	Female	6	56		
IPV	Yes	105	92	41.059 (1)	0.000
	No	68	209		
RTC	Yes	51	135	10.886 (1)	0.001
	No	122	166		
Falls	Yes	16	58	8.3730 (1)	0.004
	No	157	243		

3.11.1.4 Association Between Age, Sex and Interpersonal Violence

IPV occurred more in 3rd and 4th decades, a finding which was statistically significant (χ^2 = 23.963, $p < 0.001$). There was a statistically significant association between sex and IPV with more males affected (χ^2 = 6.649, $p = 0.010$) as shown in Table 14.

Table 14: Association Between Age, Sex and IPV.

		Interpersonal Violence			
		Yes Number	No Number	$\mathcal{X}^2$ (df)	p value
Age Group(yrs)	≤ 19	13	57	23.963 (4)	0.000
	20-29	84	120		
	30-39	71	79		
	40-49	42	39		
	≥50	17	12		
Sex	Male	209	260	6.649 (1)	0.010
	Female	18	47		

Domestic violence was significantly associated with the sex of the patient with mandibular fractures ($\mathcal{X}^2 = 6.247$, $p = 0.012$).

3.11.1.5 Association Between Age, Sex and RTC

A statistically significant association existed between sex and RTC ($p = 0.016$). There was no statistically significant association between age and RTC (Table 15).

Table 15: Association Between Age, Sex and RTC

		RTC			
		Yes Number	No Number	$\mathcal{X}^2$ (df)	p value
Age Group(yrs)	≥9	8	19	7.689 (5)	0.174
	10-19	20	23		
	20-29	89	115		
	30-39	60	90		
	40-49	31	50		
	≥50	6	23		
Sex	Male	179	290	5.844 (1)	0.016
	Female	35	30		

3.11.1.6 Association Between Age, Sex and Falls

There was an association between age and falls. Falls were more frequent in 1st,4th and 5th decades ($p < 0.001$). There was no statistically significant association between sex and falls (Table 16).

Table 16: Association Between Age, Sex and Falls

		FALLS		χ^2 (df)	p value
		Yes Number	No Number		
Age Group(yrs)	≥9	16	11	49.530 (4)	0.000
	10-19	8	35		
	20-29	24	180		
	30-39	18	132		
	≥40	10	100		
Sex	Male	65	404	0.439 (1)	0.508
	Female	11	54		

There was a statistically significant association between age and pathological fractures with pathological fractures occurring more common in older age groups ($\chi^2 = 41.171$, $p < 0.001$).

3.11.2 ASSOCIATION BETWEEN AETIOLOGICAL FACTORS AND SITE OF FRACTURE

Statistical tests were done to evaluate the association between various aetiological factors and site of fracture.

3.11.2.1 Association Between RTC and Site of Fracture

There was statistically significant association between RTC and condylar, dento-alveolar process, and angle of mandible fractures ($p < 0.001$). Similarly, there was a statistically significant association between RTC and parasymphyseal fractures ($p = 0.016$), body ($p = 0.020$) as shown in Table 17.1.

Table 17.1: Association Between Road Traffic Crashes and Site of Fracture

Site of Fracture		**RTC** Yes Number	No Number	χ^2 (df)	p value
Symphyseal	Yes	29	185	1.920 (1)	0.160
	No	31	289		
Parasymphyseal	Yes	90	124	5.773 (1)	0.016
	No	102	218		
Body	Yes	69	145	5.372 (1)	0.020
	No	135	185		
Angle of Mandible	Yes	42	172	20.623 (1)	0.000
	No	122	198		
Ramus/ Coronoid	Yes	7	17	1.2050 (1)	0.272
	No	206	304		
Condylar Process	Yes	61	153	17.673 (1)	0.000
	No	44	276		
Dento-Alveolar	Yes	26	188	18.254 (1)	0.000
	No	9	311		

3.11.2.2 Association Between IPV and Site of Fracture

Angle of the mandible, condylar, dento-alveolar fractures were significantly associated with IPV ($p < 0.001$). IPV was associated with body and symphyseal fractures with ($p = 0.002$ and 0.037) respectively (Table 17.2).

Table 17.2 Association Between Interpersonal Violence and Site of Fracture

Site of Fracture		**IPV** Yes Number	No Number	χ^2 (df)	p value
Symphyseal	Yes	18	209	4.328 (1)	0.037
	No	42	265		
Parasymphyseal	Yes	77	150	0.710 (1)	0.400
	No	115	192		
Body	Yes	104	123	9.693 (1)	0.002
	No	100	207		
Angle of Mandible	Yes	93	134	19.523 (1)	0.000
	No	71	236		
Ramus/ coronoid	Yes	10	14	0.0040 (1)	0.947
	No	216	294		
Condylar Process	Yes	25	202	18.701 (1)	0.000
	No	80	227		
Dento-Alveolar	Yes	5	222	11.345 (1)	0.000
	No	30	277		

3.11.2.3 Association Between Falls and Site of Fracture

There was a significant association between falls and fractures of the ramus and coronoid of the mandible (p = 0.001) (Table 17.3). There was no statistically significant association between falls and other fracture sites.

Table 17.3: Association Between Falls and Site of Fracture

Site of Fracture		FALLS		χ^2 (df)	p value
		Yes Number	No Number		
Symphyseal	Yes	13	63	3.061 (1)	0.080
	No	47	411		
Parasymphyseal	Yes	20	56	3.575 (1)	0.059
	No	172	286		
Body	Yes	22	54	3.215 (1)	0.073
	No	182	276		
Angle of Mandible	Yes	22	54	0.130 (1)	0.719
	No	142	316		
Ramus/coronoid	Yes	7	17	4.271 (1)	0.039
	No	71	439		
Condylar Process	Yes	19	57	1.598 (1)	0.206
	No	86	372		

3.11.2.3 Association Between Sports, Pathologic Fractures, Animal Attacks and Site of Fracture

There was a statistically significant association between animal attacks and body of the mandible fractures (χ^2 = 4.880, p = 0.027). However, there was no statistically significant association between sports, pathological fractures and site of fracture.

3.11.3 Association Between Sex and Site of Fracture

There was a statistically significant association between Fractures of the condylar process and dento-alveolar segments with sex with p values of 0.006 and 0.046 respectively (Table 18).

Table 18: Association Between Sex and Site of Fracture

Site of Fracture		SEX Male Number	SEX Female Number	χ^2 (df)	p value
Symphyseal	Yes	54	6	0.298 (1)	0.585
	No	415	59		
Parasymphyseal	Yes	169	23	0.010 (1)	0.919
	No	300	42		
Body	Yes	186	18	3.463 (1)	0.063
	No	283	47		
Angle of Mandible	Yes	149	15	2.027 (1)	0.155
	No	320	50		
Ramus/coronoid*	Yes	21	3	-	1.000
	No	448	62		
Condylar Process	Yes	84	21	7.491 (1)	0.006
	No	385	44		
Dento-Alveolar	Yes	27	8	4.000 (1)	0.046
	No	442	57		

***** Fischer's Exact Test was used to calculate the statistical significance because the assumptions of Chi Square test were violated with one of the figures less than 5.

3.11.4 Association Between Age and Site of Fracture

There was no statistically significant association between age group and sites of fractures (Table 19).

Table 19: Association between Age and Site of Fracture

Site of Fracture		AGE				χ^2	p value
		≤19	20-29	30-39	≥40		
Symphyseal	Yes	11	14	20	14	5.830	0.120
	No	62	188	131	94		
Parasymphyseal	Yes	28	81	51	32	3.877	0.275
	No	45	121	100	76		
Body	Yes	24	77	61	41	1.183	0.757
	No	49	125	90	67		
Angle of Mandible	Yes	16	65	50	34	3.276	0.351
	No	57	137	101	74		
Ramus/coronoid	Yes	5	6	7	6	2.327	0.507
	No	68	196	144	102		
Condylar Process	Yes	21	30	30	24	7.243	0.065
	No	52	172	121	84		
Dento-Alveolar	Yes	9	10	8	8	5.34	0.149
	No	64	192	143	100		

*The table above had three degrees of freedom.

3.11.5 Association Between RTC, IPV and Side of Fracture Affected

There was a statistically significant association between Interpersonal violence and fractures occurring on the left side of the mandible (p = 0.038) (Table 20). There was also a statistically significant association between mandibular fractures occurring in the right side and RTC (p = 0.005).

Table 20: Association Between RTC, IPV and Side of Mandibular Fracture

		RTC				IPV			
		Yes Number	No Number	χ^2 (df)	p value	Yes Number	No Number	χ^2 (df)	p value
Right	Yes	151	188	7.717 (1)	0.005	140	199	0.557(1)	0.455
	No	63	132			87	108		
Left	Yes	140	227	1.816 (1)	0.178	167	200	4.306(1)	0.038
	No	74	93			60	107		

3.11.6 Association Between Multiple Fractures and Concomitant Injuries and CT Scans Done

3.11.6.1 Association Between Multiple Fractures and Concomitant Injuries

There was no statistically significant association between multiple fractures of the mandible and concomitant injuries (χ^2 = 1.855, p = 0.173) (Table 21).

Table 21: Association Between Multiple Fractures and Concomitant Injuries

		Concomitant Injuries			**χ^2 (df)**	**p value**
		Yes	No	Total		
Multiple Fractures	Yes	77	211	288	1.855 (1)	0.173
	No	79	167	246		
Total		156	378	534		

3.11.6.2 Association Between CT Scans Done and Multiple Fractures and Concomitant Injuries

CT scans were frequently done in patients with concomitant injuries. This was statistically significant ($p < 0.001$) (Table 22).

Table 22: Association Between CT Scan Imaging and Multiple Fractures and Concomitant Injuries

		Multiple Fractures				Concomitant Injuries			
		Yes n	No n	χ^2	p value	Yes n	No n	χ^2	p value
CT Scans	Yes	85	86	1.807	0.179	90	81	66.711	0.000
	No	203	160			66	297		
	Total	288	246			156	378		

Note: Each of the calculations of p-value in the table above has one degree of freedom.

CHAPTER 4

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

4.1 DISCUSSION

This study sought to determine the occurrence and pattern of mandibular fractures in patients seen at two referral health facilities in Nairobi, Kenya. These were Kenyatta National Hospital and University of Nairobi Dental Hospital. It included 534 patients' records with radiographically confirmed mandibular fractures between June 2014 and May 2019.

4.1.1 DEMOGRAPHIC FACTORS

Mandibular fractures were common in patients in 3rd and 4th decades. This is line with previous studies[9,15,16]. Patients in these age groups are very active and tend to be active in sports, career-related activities and are also likely to use alcohol. There was a statistically significant association between age and alcohol use with more patients in 3rd and 4th decades reporting alcohol use ($\mathcal{X}^2 = 44.474$, $p < 0.001$). Notably, fractures were less common in older patients. Their reduced activities and also reduced indulgence in alcohol is a possible explanation[19]. This study observed that children in their first decade were also less affected. This is consistent with what has been found in previous studies[23,53.] This is possibly because children are often supervised by their parents, care givers and teachers while at school. They are also least exposed to occupation related injuries.

Males predominantly suffered mandibular fractures than their female counterparts in all age groups. This study recorded a male to female ratio of 7.2:1. This is in agreement with previous studies[4,6,7,15,20]. Some studies have revealed a slightly lower male to female ratio[13,22]. The male preponderance is likely to be due to their indulgence in alcohol ($\mathcal{X}^2 = 22.139$, $p < 0.001$). Male are predominantly engaged in transport industry as motor vehicle drivers, motorcycle riders and even in businesses. Various authors have speculated that males display aggressive behaviours than their female counterparts.

Majority of the patients seen were from urban areas. Nairobi County is largely urban and most patients seeking treatment came from within. Patients from rural areas were probably referred to Kenyatta National Hospital and University of Nairobi Dental School for advanced specialized services. This may have been due to the complexity of injuries sustained, lack of a qualified maxillofacial surgeon or due to previous unsuccessful treatment attempts.

Employed people were most affected. This included both formally employed and those who were self-employed. This is contrary to previous studies which reported mandibular fractures being common in the unemployed[20]. It is possible that these two groups were highly mobile increasing their risk of RTCs. There was no statistically significant association between occupation and alcohol use.

Majority of the patients had dual imaging; OPG and Computed Tomography (CT) scans. The OPG was frequently done partly due to its readily availability, affordability and clinicians' mastery of interpretation. Plain radiographs being two dimensional have limited diagnostic value and treatment planning. The superior diagnostic imaging modalities of the CT scans may have contributed remarkably to its frequency of use (32%). CT Scans are important in ruling out head and brain injuries and characterizing other head and neck injuries. A Swiss study reported an even higher use (83%) of CT scans in patients presenting with mandibular fractures[22]. Ansari *et al.*, (2015) analyzed the diagnostic value of conventional radiographs and 3D CT. The results indicated that 3D CT was statistically more significant ($Z = 8.8$, $p < 0.001$) in terms of detecting fractured sites as compared to conventional radiographs. Furthermore, 3D CT was superior in displaying the extent of fractures and the degree of comminution. It provided additional conceptual information as compared to conventional radiographs in majority of patients having maxillofacial trauma[54].

There was a statistically significant association between computed tomography scans and concomitant injury ($\mathcal{X}^2 = 66.711$, $p < 0.001$). Therefore, it is justified to request for a CT scan when concomitant injuries are present or suspected.

4.1.2 TIME OF OCCURRENCE OF MANDIBULAR FRACTURES

There was no significant difference between the time of the day and occurrence of mandibular fractures. However, there was a statistically significant association between the time of the day and mandibular fractures caused by IPV ($\mathcal{X}^2 = 38.528$, $p < 0.001$). Criminal elements may take advantage of the darkness and may contribute to this observation. Most alcoholics drink late into the night and may add to this occurrence. This study demonstrated a significant association between alcohol use and the time of occurrence of mandibular fractures ($\mathcal{X}^2 = 26.701$, $p < 0.001$).

This study demonstrated that most falls occurred during the day (χ^2 = 25.769, p = 0.021). Similarly, most road traffic crashes occur during the day (χ^2 = 1.015, p < 0.001). Children who were commonly afflicted by falls are often active during the day and are less likely to be under close supervision. The increased traffic and movement during the day may increase conflict between road users and thus more RTCs.

Most mandibular fractures seem to occur in the month of August. In the current study, majority of fractures (10.1%) occurred in August. However, there was no clear reason for such an occurrence. An Indian study made the same observation citing monsoon rains as a cause of poor road conditions with increased slipperiness[25]. A Turkish study explained majority of mandibular injuries to be associated with school holidays and summer season with increased falls. This was from a reported habit of sleeping on the roofs, a behavior that is common in summer[23].

4.1.3 AETIOLOGICAL FACTORS

Over the years, interpersonal violence has been the leading aetiology of mandibular fractures in Kenya[6-8]. However, the proportion of RTCs has risen steadily against IPVs. This study found a slightly different pattern with 42.5% (IPV) and 40.1% (RTC) from a previous local study with 74.9% (IPV) and 13.8% (RTC)[6]. This could be due to a true increase in RTCs especially with increased number of bodabodas in the country[14]. On the contrary, it is possible that IPV cases are decreasing (Table 1). A similar pattern was observed in a New Zealand study with IPV as the leading aetiology (n = 641; 61.7%) followed by RTA (n = 110; 11 %)[3].

A Ugandan study reported the most common aetiology as RTC (58%) followed by assaults (38%)[15]. Several studies have reported RTC as the leading aetiology of mandibular fractures [11,18,55]. In the present study, 55.9% of mandibular fractures from RTCs were caused by motorcycles which is a slight increase from a local study which reported 50.6%[13]. A Taiwanese study reported a very high proportion of motorcycle accidents of 76.3%[56]. In Switzerland, Yildirgan *et al.,* (2016) recorded falls (44%) to be the leading aetiology in all age groups. This was followed by IPV (25%) and sport activities (12%). This study classified bicycle accidents as falls. The proportion of the Road Traffic Injuries would have risen to 19% if bicycle accidents were included making it a third leading factor (19%)[22]. This pattern differed from the current study where IPV and RTC were the two leading causes of mandibular fractures with 42.5% and 40.1% respectively. The two leading aetiologic factors are almost in equal proportions.

Majority of the victims of all forms of interpersonal violence were males ($\chi^2 = 6.649$, $p = 0.010$). This means that effort towards violence prevention should focus on males. Gunshot injuries occurred exclusively in males. However, Domestic violence showed a female predilection ($\chi^2 = 6.247$, $p = 0.012$).

Falls were the commonest cause of mandibular fractures in paediatric patients under ten years. These ranged from simple falls from high seats, raised platforms, stairs to falls from storey buildings**.** One child, a four-year-old child was kicked by a donkey. This was a child from a rural area where there is a close interaction with farm animals. Young children are often naïve to environmental dangers. Their curiosity adds to their susceptibility to maxillofacial injuries. Similar findings have been reported in a Turkish study[23].

An Egyptian study noted RTC (36.3%) as the leading cause of mandibular fractures in children followed by falls (28.9%). However, this study reported animal attack of 2.9% which compared to 3.4% from the current study[28]. The two cases reported in the two studies were from kick attacks by a donkey.

Although it was not statistically significant, ($\chi^2 = 1.557$, $p = 0.212$) all sports related mandibular fractures occurred in males. A similar finding was reported by a Japanese study[21.]

The two pathological fractures in this study were from osteoradionecrosis (ORN) secondary to irradiation for head and neck malignancies. Both cases were in patients over fifty years of age. This comprised 0.04% of the total mandibular fractures. Most studies have reported ORN to be the commonest cause of pathological fractures responsible for less than 2% of total mandibular fractures which agrees with the present study[57]. Three cases of animals attacks were recorded. One was attacked by unknown wild animal near Maasai Mara Reserve. The other were kick attacks from a cow and a donkey. Whereas other studies report few iatrogenic fractures[22], this current study did not record any.

4.1.4 ALCOHOL AND SUBSTANCE USE

Thirty-three percent of patients reported having consumed alcohol prior to injury. A Ugandan study reported a lower level of intoxication of 16% with a South African study reported a higher level of intoxication of 65%[15,20]. A Nepalese study on Mandibular fractures recorded 44.6% alcohol intoxication[18]. In the present study, an objective evaluation of blood alcohol concentration

(BAC) was not possible. It was based on subjective reporting by the patient or an accompanying person.

Only two patients reported active use of *Cannabis sativa.* History of drug and substance use is rarely volunteered and has to be elicited actively. Such substances are illegal in Kenya and may attract prosecution if known to the authorities. Patients may have concealed such critical information out of such fear.

There was a statistically significant association between alcohol use and age group ($\chi^2 = 44.474$, $p < 0.001$) with patients in 3rd and 4th decades most commonly affected. A previous Kenyan study showed the same association ($p = 0.016$) though the commonly affected age group was 41-50[14].

There was also statistically significant association between RTCs and alcohol use. ($\chi^2 = 10.886$, $p = 0.001$). On the contrary a Taiwanese study showed no association between alcohol and motorcycle-related accidents ($p = 0.164$)[57]. Males used alcohol more than females ($\chi^2 = 22.139$, $p < 0.001$). Simba *et al*., (2018) found a similar association ($p = 0.022$)[14].

4.1.5 SITE OF MANDIBULAR FRACTURES

A total of 845 fractures were diagnosed in 534 patients with 53.6% having multiple fractures. This translated to an average of 1.6 fractures per patient. A Swiss and Indian studies reported the same averages[22,25]. The mandible is often fractured in more than one area. This is due to its almost ring-like structure. This explains a higher number of fractures than the number of patients. This consigns with previous studies[16,18,53,56].

The mandible was fractured more in the left side (n = 410, 48.5%) compared to the right side (n = 375, 44.4%). Fractures of the body and angle of the mandible were common in the left side with 56.8% and 59.5% respectively. There was statistically significant association between IPV and left-sided fractures ($\chi^2 = 4.306$, $p = 0.038$). Out of mandibular fractures due to IPV, 73.6% (n = 167) occurred on the left side. Most assailants are presumed right-handed, and on confrontational stance are likely to injure the left of their victim. This pattern compares with a South African study reporting left side predilection (n = 59, 45%) over right-sided fractures (n = 46, 34%)[20].

Isolated mandibular fractures occurred in 50.4% patients whereas 49.6% fractures presented with associated injuries. The commonest concomitant injuries were maxillary fractures (14.2%), zygomatic bone (8.8%) and head injuries (8.1%). A Japanese study had a higher proportion of isolated mandibular fractures (n = 274, 89.8%). However, the commonest associated facial fractures were maxillary (n = 25, 8.2%) and zygomatic fractures (n = 3, 10%). This pattern of the associated facial fractures compares with the current study[21]. On the contrary, a Saudi Arabian study reported a lower proportion of isolated mandibular fractures (25.8%) with the majority (74.2%) occurring with other facial fractures[12].

Majority of mandibular fractures in the present study were treated by closed reduction (n = 347, 64.9%) followed by ORIF (n = 129; 24.2%). This is different from New Zealand where the major treatment modality was ORIF (n = 736, 74%) whereas 24.6% (n = 245) were treated conservatively[3].

Open reduction permits early return to function (mastication and speech), better airway control, improved oral hygiene, and general patient comfort. Additionally, early return to work, adds to the preference of open reduction. However, overall cost of treatment may have favoured maxillomandibular fixation in patients in this study. Maxillomandibular fixation is a simple and cost effective mode of management and can be done by a general dental practitioner.

The overall complication rate was 14.6% with malocclusion as the commonest complication. A Nigerian study reported a higher complication with malocclusion being the commonest complication[58]. A Chinese Study recorded a higher complication rate of 18.4% majority of which were infections (8.8%) and malocclusions (5.8%). On the contrary, an American study reported a low complication rate of 6.6%[48].

4.1.6 ASSOCIATION BETWEEN DEMOGRAPHIC, AETIOLOGICAL FACTORS AND MANDIBULAR FRACTURES

There was no statistically significant association between age group and symphyseal fractures ($\chi^2 = 5.830$, $p = 0.120$). Hiroto *et al.,* (2015) reported statistically significant association between age group and condyle ($p < 0.001$, Cochran-Armitage Test) and angle fractures ($p < 0.001$, Cochran-Armitage Test), age group and symphyseal fractures ($p = 0.001$, Cochran-Armitage Test) which the current study did not[21].

A statistically significant association existed between sex and RTC ($\chi^2 = 5.844$, $p = 0.016$). Mandibular fractures in females were commonly related to RTC. An American study observed that RTC-related fractures were more common in women (53.7%) with a statistically significant association ($p < 0.001$)[57]. Condylar fractures were common in RTCs with statistically significant finding ($p < 0.001$). This was in agreement with previous studies with $p < 0.001$[25,57].

There was a statistically significant association between IPV and angle of mandible fractures ($\chi^2 = 19.523$, $p < 0.001$) condylar $\chi^2 = 18.701$, $p < 0.001$) and dento-alveolar ($\chi^2 = 11.345$, $p < 0.001$) fractures. A similar association occurred with body of mandible fractures ($\chi^2 = 9.693$, $p = 0.002$). These results consign with an American study with angle fractures likely to occur after an assault ($p < 0.001$), followed by MVAs ($p < 0.001$)[57]. The same observation has been made by other authors[25]. In clinical practice, angle and body fractures must be actively ruled out in IPV-related fractures.

RTCs were significantly associated with concomitant injuries ($\chi^2 = 43.084$, $p < 0.001$). A Finnish study made similar observation with concomitant injuries occurring more frequently after motor vehicle accidents and falls from height compared with other etiologies ($p < 0.001$)[38]. In the initial survey of trauma patients, associated injuries should be ruled out.

RTC-related mandibular fractures were common in parasymphyseal region ($\chi^2 = 5.773$, $p < 0.016$). This compares with an Indian study with majority of RTA-related fractures occurring in the parasymphyseal regions (n = 203,39.8%)[25].

All fractures of the mandible caused by animal attacks occurred in the body of the mandible. There was a statistically significant association between the mandibular body fractures and animal attacks ($\chi^2 = 4.880$, $p = 0.027$).

Thorough knowledge of the pattern of mandibular fractures from these associations between aetiological factors and site of fractures, equips the clinician to make prompt diagnosis and request for appropriate imaging. This will facilitate prompt management with improved outcomes.

4.2 CONCLUSIONS

1. Interpersonal violence and road traffic crashes were the leading causes of mandibular fractures in patients seen at the two referral centres in Nairobi, Kenya.
2. Most fractures occurred in patients in their third and fourth decades. Mandibular fractures were more common in males than in females.

3. Closed reduction by maxillomandibular fixation (MMF) was the main mode of management of mandibular fractures in the two centres and was used in two thirds of the patients followed by open reduction and internal fixation (ORIF) which was used in a quarter of the patients.
4. The most common long-term complications of mandibular fractures were malocclusions and malunion.

4.3 RECOMMENDATIONS

1. Interventional preventive strategies of mandibular fractures should focus on reduction of interpersonal violence and improvement of road safety especially in regard to motorcycle-related crashes. Young males should be a priority in the public health awareness and prevention campaigns.
2. Open reduction and internal fixation(ORIF) should be made readily available and affordable as an option of treatment for indicated cases. This is due to early return to function, personal convenience, and early return to work and professional engagement.
3. There is need to conduct studies that objectively evaluate blood alcohol concentration(BAC) in Road traffic crashes(RTC) patients with mandibular fractures reporting with prior consumption of alcohol.

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APPENDICES

APPENDIX I: DATA COLLECTION FORM.

OCCURRENCE AND PATTERN OF MANDIBULAR FRACTURES SEEN AT TWO TERTIARY REFERRAL HOSPITALS IN NAIROBI, KENYA.

(Tick against the right response or write the answer in the spaces provided)

PATIENT'S BIODATA

SERIAL NUMBER____

AGE ____

AGE GROUP

1. ≤9
2. 10-19
3. 20-29
4. 30-39
5. 40-49
6. 50-59
7. ≥60

SEX

1. Male
2. Female

PLACE OF RESIDENCE

1. Urban
2. Rural

OCCUPATION/EMPLOYMENT STATUS

1. Employed
2. Self-employed
3. Unemployed
4. Student
5. Pupil
6. Others(specify)____

LEVEL OF EDUCATION

1. Primary
2. Secondary
3. Tertiary
4. Informal
5. Others(Specify)____

DATE OF INJURY____

DAY OF THE WEEK ____

MONTH OF THE YEAR _____________________________________

TIME OF INJURY

1. Daytime
2. Night
3. Information missing

HISTORY OF ALCOHOL/ SUBSTANCE USE

1. Yes
2. No
3. Information missing

AETIOLOGY

1. Road Traffic Crashes *(tick appropriately)*

Motor Vehicle	Driver		Passenger		Pedestrian	
Motor Cycle	Rider		Passenger		Pedestrian	
Bicycle	Rider		Passenger		Pedestrian	
Handcart	Pusher		Passenger		Pedestrian	

2. Interpersonal Violence
    a. Domestic
    b. Assault
    c. Gun Shot
3. Falls
4. Sports
5. Pathologic e.g. from osteoradionecrosis, neoplasms, cysts and others
6. Iatrogenic
7. Animal attacks
8. Others(Specify)____

INVESTIGATIONS /IMAGING DONE

1. Plain Radiographs
    a. OPG
    b. PA Mandible
    c. Reverse Towne's view
    d. Lateral view of mandible
    e. TMJ Tomograms
    f. Others e.g. occlusal views, periapical(specify)_________________________
2. CT scans

SITE OF FRACTURE

		Symphyseal	Right	Left	Bilateral
1	Symphyseal				
2	Parasymphyseal				
3	Body				
4	Angle of Mandible				
5	Ramus				
6	Coronoid Process				
7	Condylar				
8.	Dento-alveolar				

NUMBER OF FRACTURE SITES

1. One
2. Two
3. ≥ Three

ASSOCIATED IMPACTED TEETH IN MANDIBULAR ANGLE FRACTURES

1. Present
2. Absent
3. Information missing
4. N/A (Not Applicable)

OTHER ASSOCIATED INJURIES

1. Head/ Traumatic brain injuries(TBI)
2. Maxillofacial (apart from mandibular injuries)-
    a. Naso-ethmoidal fractures
    b. Zygomatic fractures
    c. Maxillary fractures
    d. Orbital fractures
    e. Frontal Bone fractures.
3. Thoracic
4. Abdominal
5. Pelvic injuries

6. Upper limbs
7. Lower limbs
8. Vertebral
9. Spinal cord injuries
10. Others(specify)____

TREATMENT MODALITY

1. Conservative Management
2. Closed Reduction
   a) Maxillo-Mandibular Fixation
   b) Splinting
3. Open Reduction
   a) Rigid Fixation
   b) Semi-Rigid Fixation
      i. Wire Osteosynthesis/Trans-Osseous Wiring
      ii. Circumandibular wiring/ circumferential wiring
4. No treatment

COMPLICATIONS

1. Immediate
   a) Infections
   b) Neural injury- Paresthesia, anaesthesia.
2. Delayed/long-term
   a) Malocclusion
   b) Delayed healing
   c) Mal-union
   d) Non-union
   e) TMJ ankylosis
   f) Chronic infection e.g. osteomyelitis
   g) Implant failure e.g. extrusion, fracture.
   h) Others(specify)____
3. No complication

APPENDIX II: NEW MOTOR VEHICLES AND MOTOR CYCLE REGISTRATION IN KENYA, 2014-2018

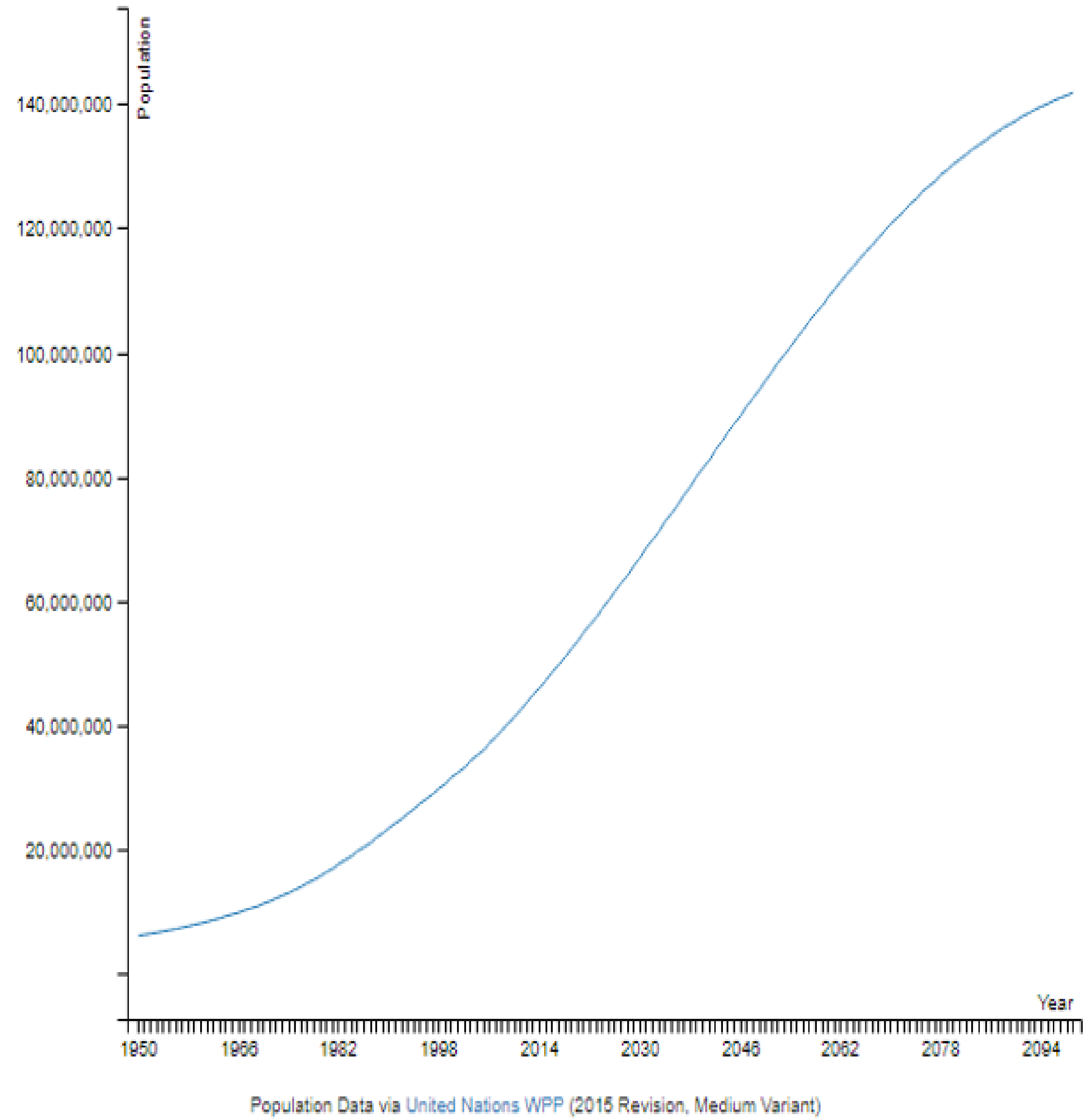
Number

Type of Vehicle/Motor Cycle	2014	2015	2016	2017	2018*
Saloon Cars................................	15,902	14,369	12,490	11,376	10,504
Station Wagons...........................	53,542	54,120	46,123	55,322	64,179
Panel Vans,Pick-ups,etc...............	12,568	13,878	12,722	9,866	11,220
Lorries/Trucks..............................	10,681	13,785	9,632	7,460	6,514
Buses and Coaches.......................	2,210	2,342	1,765	1,072	1,065
Mini Buses/Matatu.......................	213	581	519	459	812
Trailers...	2,925	3,905	2,829	1,953	2,083
Wheeled Tractors.........................	2,032	2,259	2,478	2,703	4,040
Other Vehicles..............................	2,533	2,522	1,618	860	1,619
Total Motor Vehicles	**102,606**	**107,761**	**90,176**	**91,071**	**102,036**
Motor and Auto Cycles...............	111,124	134,645	119,724	186,434	188,994
Three Wheelers............................	4,327	4,775	3,815	5,167	6,259
Total Motor Cycles	**115,451**	**139,420**	**123,539**	**191,601**	**195,253**
Total Units Registered	**218,057**	**247,181**	**213,715**	**282,672**	**297,289**

Source: National Transport and Safety Authority

* Provisional.

APPENDIX III: KENYA'S POPULATION TRENDS



APPENDIX IV: KNH/UoN ETHICS REVIEW COMMITTEE LETTER OF APPROVAL

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
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KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/244

26th June, 2019

KENYATTA NATIONAL HOSPITAL
APPROVED
26 JUN 2019
KNH/UoN-ERC
P.O. BOX 20723 - 00202 NAIROBI

Dr. Jonathan Kiprop
Reg. No.V60/81092/2015
Dept.of Oral and Maxillofacial Surgery
School of Dental Sciences
College of Health Sciences
University of Nairobi

Dear Dr. Kiprop

RESEARCH PROPOSAL: AETIOLOGY, DEMOGRAPHIC CHARACTERISTICS AND PATTERN OF MANDIBULAR FRACTURES SEEN AT TWO REFERRAL FACILITIES IN NAIROBI, KENYA (P248/03/2019)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above research proposal. The approval period is 26th June 2019 – 25th June 2020.

This approval is subject to compliance with the following requirements:

a. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
c. Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
g. Submission of an *executive summary* report within 90 days upon completion of the study.
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

Protect to discover

For more details consult the KNH- UoN ERC website **http://www.erc.uonbi.ac.ke**

Yours sincerely,

PROF. M. L. CHINDIA
<u>SECRETARY, KNH-UoN ERC</u>

c.c. The Principal, College of Health Sciences, UoN
The Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information, KNH
The Dean, School of Dental Sciences, UoN
The Chair, Dept. of Maxillofacial and Oral Surgery, UoN
Supervisors: Dr. Walter Odhiambo, Prof. Symon Guthua, Prof. Francis Macigo

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