UNIVERSITY OF NAIROBI

PATTERN OF UPPER LIMB AMPUTATIONS IN KENYATTA NATIONAL HOSPITAL: A FIVE-YEAR RETROSPECTIVE STUDY

A RESEARCH THESIS SUBMITTED AS PARTIAL FULFILLMENT FOR THE DEGREE OF MASTER OF MEDICINE IN ORTHOPEDIC SURGERY AT THE UNIVERSITY OF NAIROBI

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H58/34398/2019

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STUDENT DECLARATION

I declare that this proposal is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my work has been used, this has properly been acknowledged and referenced according to the University of Nairobi's requirements.

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LIST OF ABBREVIATIONS AND ACRONYMS

KNH -Kenyatta National Hospital

PWULA – People with upper limb absence

SPSS-Statistical Package for the Social Sciences

US – United States of America

OPERATIONAL DEFINITION

Patterns - the demographic characteristics such as age, sex, occupation and level of education

Incidence - the occurrence of a new event or disease in a specified population at risk

Prevalence - frequency of new and pre-existing events or disease at a point in time/over a period of time in a population at risk

Levels of amputation - the anatomical site and point at which an amputation is carried out

Indications for amputations - reasons for which a limb is surgically removed such as tumor

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ABSTRACT

Background: Upper limb amputations contributes about 8-20% of the total amputations done compared to lower limb amputations contributing about 75-90%. However, it causes more functional losses and psychological trauma on amputees, the bulk of whom are in the working and productive age group. Trauma causes the bulk of amputations followed by dysvascular conditions, infection, tumours and congenital malformations. There is a paucity of data on the subject in developing countries, a situation that hinders the development of workplace and occupational safety procedures, rehabilitation protocols, development and availability of suitable prostheses

Objectives: The study will establish the demographic characteristics, levels and indications of upper limb amputations at Kenyatta National Hospital

Study setting: Department of Records/Health Information at KNH

Study design: Descriptive retrospective study

Subjects: Two hundred and ninety-nine (299) patients who underwent upper limb amputations at KNH between 1st February 2018 to 31st January 2023

Results: The age range was from 2 months to 83 years with a mean age of 30 years. The highest number of amputees were in the 19-30 years age group, had primary education (44.5%) and were unemployed (44.2%). The leading indications were Trauma 83.9%, infections 6.0%, vascular abnormalities 3.0%, congenital abnormalities 2.7%, burns 2.3%, and tumors 2.0%.
Accidental lacerations caused the bulk of traumatic amputations. Trans phalangeal amputation was the most common level of amputation (76.2%)

Conclusion: Upper limb amputation is a common procedure in KNH. Trauma causes the bulk of the cases, majority of which are machine and workplace related, further studies are required into this area to guide in development of policy that enhance occupational safety

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Limb amputation is the removal of part of or the whole of a limb. In children, it can be congenital (occurring before birth) or acquired. It can be done urgently and electively. When done at a joint, it is referred to as a disarticulation

Amputations are done to control pain, provide independence and restore function. The major goals are to preserve function, preserve useful sensibility, prevent symptomatic neuromas, early prosthetic fitting and early return to work and recreation.

Upper limb amputations can be grouped as major or minor. Minor amputations are those done distal to the wrist while major ones are those done from the wrist and proximally. It is indicated in trauma, tumors, severe infections, vascular diseases and congenital malformations

Upper limb amputations are less common compared to lower limb amputations (1).

1.1.0 Demographics

1.1.0.1 Incidence and Prevalence

A total of 3% of the US amputee population have upper limb amputation(2), while in Finland generally, the upper limb amputation rate is 2.2 and the major amputation rate is 0.3 per 100,000 inhabitants per year (3). Upper limb amputations are less likened to lower limb amputations. In developing countries such as Rwanda and Nigeria, the prevalence of extremity amputations is in the range of about 1.6-3.2 in 100,000(4,5).

1.1.0.2 Age Incidence

The risk of losing a limb increases with age in the US, with the greatest risk being 65 years and older (6), while in Finland the incidence of upper limb amputations is commonest in the 20-59 years age group(3)

In developing countries such as Liberia, Nigeria, Taiwan and Kenya the mean age of amputees is much lower(6–8).

In Ghana, the bulk of trauma cases occurs in people younger than 40 years of age. They are 13 times more likely to undergo upper limb amputations than those of older age(9).

1.1.0.3 Sex Incidence

Incidences of partial hand amputations are a lot more in men as compared to women

Young males have a higher prevalence of upper limb loss with a much higher ratio of Men to Women (3,7,8,10). The male-to-female risk of upper limb amputation is high for workers in manufacturing, communications, storage and transport industries(11).

Males have much higher trauma-related amputations than females, while non-traumatic cases are of equal distribution among males and females. Moreover, females are more likely to experience non-trauma-related amputations than males(9).

1.1.0.4 Occupation

Commercial motorcyclists and commercial drivers undergo the highest rates of amputation(8). In other settings, equipment such as the table saw remains the main mechanism of injury leading to upper limb amputations(10). Occupation-related amputation cases are more prevalent among manufacturing, storage, transport and communication workers in Taiwan(11).

1.1.1 Levels of Upper limb Amputations

By the level at which upper limb amputations are performed, they are referred to as follows: Trans-phalangeal, trans-metacarpal, trans-carpal, wrist, trans-radial, elbow, trans-humeral shoulder, and forequarter amputation are among the distal to proximal procedures included. Trans-phalangeal is the commonest in the US(6).

Upper limb amputations can be categorized based on the section. The initial category is partial hand amputation, which may involve the fingers or part of the hand distal to the wrist. The occurrence of partial hand amputations is usually 3 to 6 times higher in men compared to women. Though the part of the upper limb seems minor, noteworthy is the fact that partial hand amputation may lead to significant functional or psychological loss.

Disarticulation at the wrist is commonly preferred to other shorter amputations. It involves separating the radius from the carpal bone, enabling substantial retention of pronation and supination and a long lever arm useful for lifting. It's commonly associated with cosmetic problems as the amputated side becomes longer than the intact side with the addition of a prosthesis and can be bothersome and intolerable. Trans-radial amputation is common, it involves sparing the elbow and the arm thereby making recovery easier. Trans-radial amputations are mostly traumatic and are further divided into short, medium, and long categories according to the length of the preserved limb(12).

Trans-humeral and elbow disarticulation procedures are mainly indicated due to high energy injury. It should be noted elbow disarticulation and trans-humeral amputation, both have their pros and cons. Trans-humeral amputation is a reconstructive procedure that preserves the maximal length of the arm and enhances optimal function. Elbow disarticulation involves the complete removal of the radius and ulnar from the humerus(12). It tends to enhance anatomic suspension

and allows for rotational control when the prosthesis is fitted. Trans-humeral amputation can be done at any length of the humerus(9). The humerus is completely removed from the glenoid during shoulder disarticulation(12). It is mostly performed for patients who have extensive malignant tumors not amenable to limb-preserving procedures. It can also be performed in severe post-traumatic upper limb trauma. Functionally depicts some similarity to forequarter amputation though with better cosmesis due to preservation of the shoulder point.

Forequarter amputation entails resection of the clavicle and all structures distally(13). It is performed in severe trauma and malignant tumors in the proximal arm, clavicle or scapula. Indicated where limb-sparing operations are not possible with the goal of removing soft tissue and bones of the upper extremity. Although the procedure leaves patients disfigured, it has proven effective in curing most tumors that affect the upper extremity.

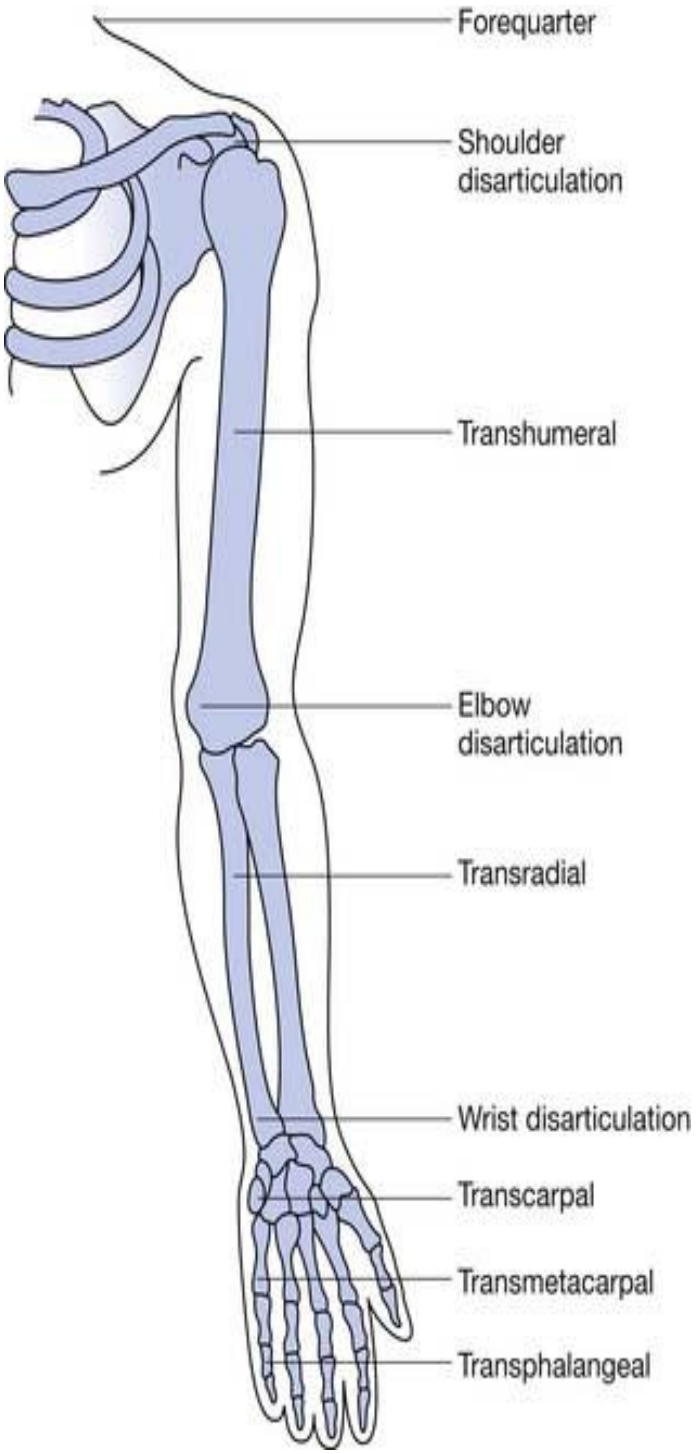


Figure 1: Levels of Upper Limb Amputations

1.1.2 Indications of Upper limb Amputations

There are varied causes/indications of amputations such as trauma, tumors, vascular complications, congenital malformations, infections and burns among others, with varying incidences across different geographical locations, populations and age profiles(14). Though majorly abandoned in western societies, amputation has also been used as a punitive or correctional method with roots in old civilization and is still used in some third-world societies(15).

In developing nations, trauma and diabetes limb disease are the major causes, while in developed nations, peripheral vascular disorders and diabetes limb disease are the top indicators(16). For instance, trauma, tumors and diabetes complications were the leading causes of main limb amputations in Kenya(1) while in the US, dysvascular amputations account for the majority of limb loss discharges with increasing incidence, the risk rising with age and black race. There are declining rates of trauma and cancer-related amputations(17). Trauma, mainly occupational accident, is the commonest cause of upper limb amputations(3,4,18) while in other settings, complications of diabetes cause the majority of upper limb amputations, followed closely by trauma and chronic ulcers(7). Congenital limb malformations and deficiencies(18) and soft tissue sarcomas(19) have also contributed to considerable cases of upper limb amputations.

Burns especially electrical burns contribute significantly to upper limb amputations(20).

1.2 Statement of the problem

The prevalence of upper limb amputations is quite sizeable. In the United States, it constitutes 3% of the amputee population(2).These figures are much higher in developing countries such as Rwanda and Nigeria(4). The incidence is much higher among males than females(3,7,8,10)with trauma and diabetic complications accounting for majority of cases in developing world

(1,16).Occupational accidents such as in commercial motorcyclists account for the majority of trauma cases(3,4,18).

Upper limb amputees face far reaching physical and psychological repercussions(21) and only a handful , 21.5%, have access to proper rehabilitation(1).With proper occupational safety measures, the incidence of upper limb amputations can significantly be reduced(22).

Studies done on amputations in Kenyan regional hospitals such as Nyeri(2) and Kikuyu(18) have differing findings , a scenario that may be settled by studies from a National referral hospital such as KNH

Despite the abundance of studies internationally, there is paucity of local data on upper limb amputations. As such a study is required to obtain local data that can inform policy on workplace and occupational safety and direct investment in rehabilitation

1.3 Study Justification

Epidemiology data are not as common as published data on functional outcomes following upper limb amputations. The available data points towards young people being the most affected and they suffer severe impairments of working status and independence. There is minimal data on the epidemiology, causes and mechanisms of injury and the anatomical levels of upper limb amputations in Kenya and the African continent at large. This is in contrast to the lower limb amputations that are relatively well researched. There is no such study that has been conducted in Kenyatta National Hospital.

This study will reveal the changes in trends in the indications of amputations, considering the increasing incidence of non-communicable diseases such as cancer and diabetes. This study is aimed at generating much-needed local evidence base data as a foundation on which future studies

can be done. This study will shed light on the above area and provide the much-needed data to inform workplace policy aimed at reducing occupation-related upper limb injuries culminating in amputations and enhancing continuous education and vigilance in occupational safety. The study is further aimed at providing evidence-based information needed to inform investments in prostheses for rehabilitating the various levels of amputation of upper limb amputees.

1.4 Study Questions

1. What are the demographic characteristics, the various causes and the types of upper limb amputations at KNH?

1.5 Broad Objectives

To describe the demographic characteristics, levels and indications of upper limb amputations in Kenyatta National Hospital.

1.5.1 Specific Objectives

1. To summarize the demographic characteristics of upper limb amputees in KNH.

2. To determine the anatomical levels of upper limb amputations in KNH

3. To investigate the indications of upper limb amputations in KNH

1.6 Conceptual framework

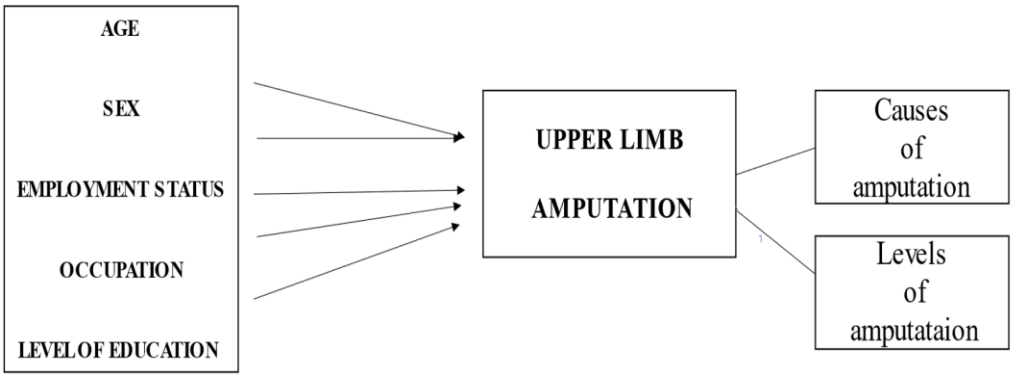


Figure 2*:* ***Conceptual framework showing association between demographics, levels and indications of amputations in upper limb amputations***

CHAPTER TWO

2.0 LITERATURE REVIEW

Amputations of the upper limb can be categorized as minor or major. Major amputations of the upper limb start from the trans-carpal to the forequarter while minor ones affect the fingers or parts of the hand. Compared to the lower limbs that are used for walking and weight bearing, the upper limbs help in diverse and intricate movements. After damage, the successful repair of the upper limb is usually determined by the extension of injury to the bones, blood vessels, nerves, and muscles. In instances where nerves and blood vessels have been severely damaged and the bones are in contact with the external environment, the only option is usually to amputate the section of the limb that has been affected(23).

Amputations of the upper limb have far-reaching physical and psychological consequences for victims. People with upper limb absence (PWULA) need resources for psychological and occupational support, but in most cases, these services are not readily available, this is according to a qualitative cross-sectional study on the lived experiences of PWULA in Uganda. PWULA desire to work but encounters numerous employment-related obstacles. Limited resources, complicated parental and caring obligations, the local culture, and social structures all have both beneficial and negative effects on PWULA's day-to-day life(21).

2.1 Demographics

2.1.1 Incidence and Prevalence

Epidemiological data reveal that men face high risks for upper limb amputations following their increased exposure to traumatic events like work-related injuries, accidents, assault, and self-inflicted injuries(24).

There were 500,000 individuals in the US living with upper limb loss in 2005, accounting for one-third of all amputations of which 8% were major amputations(16), while in South Africa it constituted 9.52% of all amputations(25). In the operation Iraqi Freedom, however, upper limb amputations constituted 50% of all amputations, a figure that was reduced to less than 20% due to improvement in protective gear(22).

A study in Ghana on surgical amputations in a teaching hospital revealed that upper limb amputations constituted 20.5 % of all amputation cases(9). Trauma-related upper extremity amputations constituted 46/100000 trauma admissions in the US(26) and only 3% of hand trauma cases in France(10). A Canadian study of limb amputations from 2006 to 2009 showed lower extremity amputations (31+/-2 per 100,000) predominating upper extremity amputations (5.8+/-0.5 per 100000)(27).

In paediatric limb amputations in Ethiopia, amputations of the upper limbs were more recurrent than those of the lower limbs with the main cause being bonesetters gangrene(28).

2.1.2 Age Incidence

In the United States, the danger of limb loss escalates with age. The greatest risk is 65 years and above(6), while in Finland 62% of upper limb amputations happen in the 20-59 years age group with the mean age of all amputees being 42.7 years(3).

In Canada ages, 50-74 and 75+ are 5.9 and 10.6 times more likely to undergo limb amputation than those aged 0-49 years. Generally, amputation risk increases with increasing age (27). A study in France revealed that traumatic upper limb amputations, mostly involve middle-aged men with the mean age of surgical amputation being 59 years(10).

In developing countries, the mean age of amputees is 42.9 years in Liberia with an age range of 9-91n years(7), 33 years in Nigeria (8), 38+/-17 years in Pakistan, and 39.1 years in Taiwan and in Tanzania major limb amputee ages ranged between 2–78 years. The most affected age group is 30-49 years in Taiwan (19) and 41-60 years in Kenya(1). The average age of forequarter amputees in Kenya is 28.8 years(1). In Ghana, those <40 years constituted 75% of cases of trauma-related amputations and are 13 times more likely to undergo upper limb amputations than those> 40 years(9). A study on major upper extremity amputations in the US revealed that males constituted 76% of them with an average age of 42 years while females constituted 24% with an average age of 41 years of trauma-related upper extremity amputations(26).Young age of below 21 years is associated with 57.4 % of electrical burn associated upper limb amputations in Bangladesh

2.1.3 Sex Incidence

The prevalence of upper limb amputations is higher among young males in Finland with Men to Women ratio of 7.7:1 for all amputations and 10.5:1 for finger amputations(3). Male to female ratio is 2.4:1 in Liberia(7) and 1.7:1 in Nigeria(8). Females constitute 23% of upper limb amputees in Taiwan. The male-to-female risk of upper limb amputation ranges from 2.62 for manufacturing workers to 9.05 for transport, storage and communications workers(11).

In Pakistan, males constitute 83.58% of all amputees(29). In Ghana, trauma-related amputations constitute 87.5% of males and 12.2% of females, while non-traumatic cases were equally distributed among males and females. Moreover, females are 1.75 times more likely to undergo non-trauma-related amputations than males while males are 4 times more likely to undergo trauma-related amputations than females(9). The above pattern was also observed in France where most cases of upper limb amputations involved middle-aged men(10). Forequarter amputations in Kenya have a 2:1 male-to-female ratio(19).

Epidemiological data reveal that men face high risks for upper limb amputations following their increased exposure to traumatic events like work-related injuries, accidents, assaults, and self-inflicted injuries(24). This is in contrast to a study in South Africa where major limb amputations were more common in females than males with a ratio of 1.2:1(30).

In a prospective population-based study, 1.6 million people in a southern Swedish region were examined, and all upper extremity amputation and devascularization injuries were referred over nine years to the only replantation centre. The odds ratio (95% confidence interval) for upper extremity amputation or devascularization injuries presumably in need of replantation or revascularization was 1.9 (1.7-2.1), with a male-to-female difference of 3.3 (2.9-3.7) and 0.5 (0.4-0.7) per 100,000 person-years(6). The prevalence of incomplete hand amputations is usually 3 to 6 times higher in men compared to women(31).

An analysis of all people who underwent upper limb amputation procedures at the John F. Kennedy Memorial (JFK M), Hospital in Monrovia, Liberia, between January 2010 and December 2015, confirms the trend. The ratio of men (73) to women (27) among the 100 patients who underwent limb amputations between 2010 and 2015 was 2.4:1.

The prevalence and characterization of the main upper limit amputations in the National Trauma Data Bank in the US between 2009 – 2012 revealed that the Male sex constituted 76% while the Female sex contributed 24% of the trauma-related major upper extremity amputations. Trauma-related amputations constituted 46/100000 trauma admissions(26). The findings of a 10-year retrospective study of the epidemiology of upper limb amputations at a Hand emergency centre of Nancy university hospital in France showed that traumatic upper limb amputations mostly involve middle-aged men with the primary injury mechanism being the table saw(10). Males are twice as likely to undergo limb amputation as females in Canada(27). The ratio of male to female patients

was 2:1, and most patients (76.5%) had some informal education or none at all with 69.1% of patients being unemployed(32).

Age is a risk factor for limb loss (the greatest risk is age 65 and above). For men between the ages of 15 and 45, trauma is the most common reason for acquired upper limb amputations, accounting for 80% of cases. A study in Ghana on surgical amputations in a teaching hospital revealed that trauma-related amputations constituted 87.5% of males and 12.2% of females with age group <40 years constituting 75% of cases while nontraumatic causes had equal male-to-female distribution(9).Male sex 89% is associated with electrical burns and subsequent limb amputations(33). There was a male to female ratio of 13:5 motor vehicle fatalities associated with limb amputations ,commonest mechanism being head on impacts(25).

2.1.4 Occupation

The occupational group in Nigeria with the highest rates of amputations is commercial motorcyclists (33.9%), followed by commercial drivers(8). On the other hand, the table saw is the primary mechanism of injury in upper limb amputations in France(10) while in Taiwan, work-related upper limb amputation cases were more prevalent among male manufacturing workers followed by transport, storage and communication workers(11).

2.2 Levels of Upper limb Amputations

In a study of epidemiology and pattern of limb amputation in Nigeria, of which upper limb amputations constituted 33% of all cases, digits and toes amputation was the most common procedure (35.1%) followed by below elbow amputations (27.2%)(8). A similar study in Ghana where upper limb amputations constituted 20.5% of cases revealed that above-elbow amputations constituted 65.2%, below elbow 26.1% and hand amputations 8.7%(9).

Atroshi et al. conducted a study in the US on amputations and severe injuries of the hand and established that trans-phalangeal amputations accounted for 78% of all upper extremity amputations(6). In Liberia, a study found that below-the-elbow and above-elbow amputations have the same rate of occurrence(7) while in Pakistan, trans-radial amputations were commonly followed by trans-humeral(29). This is in contrast to another study of trauma-related main upper extremity amputations in the US that reported trans-humeral (35%), trans-radial (30%) and hand (14%) constituting the most frequent amputation types(26). Digital amputations constituted 17.2% of all amputations in Ethiopia, accounting for the most frequent level of upper limb amputations in an Ethiopian referral hospital(34).

In a study of forequarter amputations in Kenya between 2012 and 2017, only 12 patients underwent the procedure at the facility, translating to about 2 to 3 patients per year(19). Among the paediatric population in Ethiopia, upper limb amputations predominate with above-elbow amputations (23.5%), below-the-elbow (24.5%), elbow disarticulation (1.9%), forequarter (1%) and finger amputations (2.9%)(28). In a study of major upper limb amputations for malignant tumours, of the 43 patients operated on,26 underwent forequarter,14 above elbow and 5 below elbow levels of amputations(25). Below elbow 48.5% and above elbow 32.54 % are the most common levels associated with electrical burns and subsequent limb amputation(33) In Saudi Arabia, partial hand amputations constitute 48% of all limb amputations with trauma being the commonest indication(35).

Partial hand amputation (75%) was the commonest level of amputation in British soldiers in Afghanistan war,60% had concurrent lower limb amputations(36).

Digital amputations are the commonest amputations associated with gangrene from snake bites(37).

2.3 Indications for Upper Limb Amputation

The commonest causes of limb amputation vary from one country to another; there is also variation from one city to another(4). Trauma, malignancies, infections, and uncontrolled diabetes mellitus are still the most common reasons for amputation in third-world nations, but dysvascular disease or complications from diabetes mellitus are a cause of amputation in developed nations(28).

African studies have revealed that trauma is the most frequent cause of upper limb amputation. A study by (8) revealed that trauma accounted for 75.8% of the upper limb amputations that were performed in Nigeria between the years 2006 and 2010. This study corroborates the observations in other parts of Africa such as Kenya where trauma is also the most prevalent sign of upper limb amputation(18).

In a study of major limb amputations in Adults, in Zaria, Nigeria at the Ahmadu Bello University Hospital, the major indication for upper limb amputations was trauma and post-fracture splintage accounting for 57% of all upper limb amputations(38). The most common reason for upper limb amputations in men between the ages of 15 and 45 is trauma, which accounts for 80% of cases. In most cases, tumours and vascular disease problems accompany these issues(6).

High incidents of upper limb amputations have been observed among drivers and commercial motorcyclists compared to other people in society because these persons are normally more exposed to trauma resulting from road traffic accidents (8). The commonest cause of amputations in Pakistan is road traffic accidents (38.38%) followed by complications of diabetes complications 15.42%, infections 14.26% and trauma 12.37%(29).

The majority of upper extremity amputations in the US are due to trauma, with work-related injuries accounting for most of the cases among civilians and improvised explosive devices accounting for most cases among military personnel (16).

The evaluation of upper limb ischemia is complex because of the many diseases that affect the small vessels of the upper limb. It can be acute or chronic. Acute ischemia occurs due to thromboembolic complications of underlying conditions while chronic ischemia occurs due to the progressive narrowing of the arteries. Studies on upper extremity ischemia amputations show that the procedure is less common and is rare in the paediatric population. Most cases of acute upper extremity ischemia are due to thromboembolism, common among older patients aged 74 to 78 years. A blunt or penetrating injury can also affect the arteries of the upper extremity causing ischemia. Many upper extremity amputations are normally a result of complex traumatic injuries that affect the nerves, arteries, and soft tissues or result in bone fractures(39).

Bone-setters' gangrene is the commonest cause of limb amputation among the paediatric population in Ethiopia accounting for 55% of all amputations. Malignancies, trauma and infections account for 29.2%, 11.1% and 2% respectively(28).

Minor and major upper limb amputations have been carried out due to gangrene from snake bites(30). Upper limb infections tend to be common among patients who suffer from diabetes mellitus because of immunodeficiency. Poor recovery among patients with the condition may result in superficial infections involving the deeper structures of the upper limb resulting in tissue destruction and/or sepsis.

Even though hand infections as a result of diabetes are not usually as common as foot ulcers, diabetic patients exhibit extensive infections that may lead to amputation of the upper limb or even

death because of sepsis. Immunopathy among diabetic patients as a result of neutrophil and monocyte dysfunction explains why eradicating infections among such patients may be difficult hence the need for amputation(40).

Malignant tumours affecting the upper limb may require surgical treatment. During such treatments, the goal is normally to eradicate the tumour through excision or to remove the entire bone or part that is affected by the tumour. Forequarter amputation has been performed among patients who have osteosarcomas and breast cancer. The most frequent indications for forequarter amputations are malignant tumours affecting the scapula, axilla, shoulder, and arm(41).

Large multifocal, recurrent tumours in which limb salvage surgery is no longer an option are indicated for amputation, sarcomas being the commonest (25).

In reducing prevalence, soft tissue sarcomas, carcinomas and bone sarcomas are the leading causes of major upper limb amputations, with most patients having stage IV disease(25). Congenital limb deformities may result from vascular disruption or soft tissue defects, exposure to teratogenic agents like thalidomide or primary intrauterine growth inhibition. The spectrum of abnormalities may result in different functional limitations.

There has been an association between congenital malformations of the upper limb and lethal syndromes with high mortality rates being documented among live-born patients who have upper limb deformities (42). Children with congenital limb deformities normally require thorough psychologic and functional evaluations before performing a therapeutic amputation on the upper extremity. One aspect that should be considered is the functioning capacity of the upper limb and the degree of malformation.

Different studies from different geographical locations at different points in time have a differing prevalence of the various indications of amputations. For instance, gangrene (6%), chronic ulcers (25%) and tumors (5%), as well as trauma (24%) and diabetes (29%), were reasons for limb amputations. in a retrospective investigation in Liberia(7). Nevertheless in Tanzania, trauma (38.4%), vascular disease (8.6%), and diabetic foot problems (41.9% each) were the most frequent causes of major limb amputations(32).

Burn injuries are associated with upper limb amputations, with the median age of amputations being 45 years and associated risks being renal injury, cardiac conditions, infections, sepsis, escharotomies and fasciotomies(43).

Upper limb gangrene due to digital snake bites are also associated with digital amputations(37).

CHAPTER THREE

3.0 METHODOLOGY

3.1.0 Study Design

A five-year descriptive retrospective study

3.1.1 Study Site

The study was done at Kenyatta National Hospital, department of health records. This facility is located in Upper Hill Nairobi and is used as a national referral and teaching hospital. The hospital is located 5km from the city center along Hospital Road with a 2000-bed capacity.

3.1.2 Study Duration

The study took place between 1st Feb 2023 to 30th April 2023.

It involved the review of patients 'records dating back from 1st February 2018 to 31st January 2023.

3.1.3 Study Population

Hospital patients who underwent upper limb amputation procedures at Kenyatta National Hospital.

3.1.4 Eligibility Criteria

3.1.4.1 Inclusion Criteria

Patients with upper limb amputations conducted at KNH

Patients with re-amputation being conducted at KNH

3.1.4.2 Exclusion Criteria

Patient files with incomplete records

Inaccurate and inconsistent data in patients records

Patients with purely lower limb amputations

Patients with upper limb amputations which were conducted elsewhere other than Kenyatta National Hospital.

3.1.5 Sample Size Calculation

In a retrospective study of patterns of major limb amputation at a provincial hospital in Kenya, VM Muyembe and Muhinga reported that trauma, tumors and complications of diabetes Mellitus, each accounted for 26.5% of the amputations done. The value was used to calculate a sample size (n) using the Cochrane formula.

$$n = \frac{Z^2 p(1-p)}{e^2}$$

$$n = \frac{(1.96)^2\, 0.265(1-0.265)}{(0.05)^2}$$

$$n = \frac{3.8416 \times 0.265(0.735)}{0.0025}$$

$$n = \frac{0.7482}{0.0025}$$

$$n = 299.28$$

Parameter:

N: Required sample size

P: Proportion of amputations accounted for by trauma (26.5%)

Z 2: Normal Variate for alpha at 95% confidence interval (1.96)

e: Desired precision or absolute error (5%)

299 participants will be required

3.1.6 Sampling Procedure

All eligible patients/files will be enrolled via a consecutive sampling approach until the appropriate sample size is attained

3.1.7 Recruitment and Consenting Procedures

3.1.7.1 Informed Consent and Confidentiality

Application to the ethics committee for waiver of consent was done,and waiver obtained

3.1.8 Variables

Independent variables

1. Age

2. Gender

3. Occupation

4. Level of education

Outcome /dependent variables

1. Levels of amputation

2. Indications of amputation

a. Trauma

b. Tumors

c. Infection

d. Vascular compromise

e. Congenital malformations

3.1.9 Data Collection Procedures

Approval was obtained from UON/KNH ethics committee and KNH administration after which a visit was made to the KNH health records department

Research assistants were healthcare workers with diploma in Orthopedic oriented course (Diploma in Orthopedic and Trauma medicine or Orthopedic technician with experience in research data collection

Four such assistants were employed and worked under the direction of the principal investigator. They were trained by the principal investigator

The principal investigator and the research assistants had access the patients' files, the files were reviewed and checked for completeness and upon satisfaction of inclusion criteria they were immediately recruited into the study

Relevant data from the files were abstracted to the data collection tool. This tool had been developed with various elements adopted from the Kenya Demographic and Health Survey 2022

Majority of similar studies done in Africa (7,8,14,18,28,30,34) had employed similar and related tools in their data collection with minimal challenges

The tool had simple, clear instructions, quick and easy to administer with minimal challenges and the contents and results thereof are generalizable to different populations

The principal investigator collected and reviewed all the filled-in abstraction forms for completeness and accuracy and thereafter keep them under lockable cabinet

The recruitment of files and data abstraction continued until the sample size is achieved

3.1.10 Training Procedures for Recruited Research Assistants

Research assistants underwent a three-day training on study procedures and research ethics. Information on handling of abstraction tools, extraction of accurate data, data handling, entry and confidentiality formed the core of the training

Their knowledge on Orthopedics and Orthopedic surgical procedures, particularly amputations were assessed and further training done on the same

3.2.0 **Quality Assurance and Quality Control Procedures**

Quality was maintained by timely recruitment of trained and qualified assistants

Data collection tool was submitted to the supervisors and the ethics committee to ascertain whether the data collected addressed the research objectives, and the recommended changes were made before the study commenced, this accorded it face validity

The principal investigator checked and ensured all the data entered was complete and accurate before filing for submission and analysis

A statistician was hired to analyze data to maintain the quality of results.

3.2.1 Ethical Considerations

Approval was sought from the orthopedic thematic unit, the Department of Surgery, the UON/KNH ethics and KNH administration before the study commenced.

Personal identifying information of participants was NOT extracted from the files. Only the variables of concern were collected and unique study numbers were used for identification instead.

Physical data collection tools were stored in a locked cabinet and the data collected was only accessible to the study team. Any interested third party was required to produce written approval from the ethics.

Moreover, electronic data was password protected.

3.2.2 Data Management, Analysis and Presentation Plan

3.2.2.1 Data Cleaning and Entry

Data was moved from the questionnaires to the excel sheet

Checking for missing data to ensure no case has missing data

Any case with missing data was deleted and excluded from the study

3.2.2.2 Data Storage and Archival

Physical data collection tools were filed and stored in a locker.

Digital data was stored in password-protected computers.

Digital data was backed up in the cloud.

Data analysis was done, and the data will stored for 5 years after which it will be destroyed.

3.2.2.3 Data Analysis

Data was moved from Excel to SPSS spreadsheets, SPSS version 25 was utilized

In demographics, numerical data such as age was summarized into mean, and median and presented in tables or figures. Categorical data such as sex and level of education on the other hand was summarized into frequency distribution charts and percentages

Amputation levels were summarized using frequency distribution charts and percentages. A comparison was done to test association between levels of amputation and demographics using the Chi-Square test at a 95% confidence interval. A probability value of 0.05 indicated statistical significance.

Indications for amputations was summarized using frequency distribution counts and percentages and a comparison was done between indications of amputation and demographics using a Chi-Square test at a 95% confidence interval, and a probability value of 0.05 indicated statistical significance.

A Poisson regression was used to determine the strength of the above associations

3.2.3 Study Results in Dissemination Plan

Results was packaged in a dissertation which was shared with the thematic Unit of Orthopedic surgery, department of Surgery

It will also be packaged into a manuscript publishable in a medical journal and the results presented at a conference locally or internationally

3.2.4 Study Limitations

Inaccurate and inconsistent data entered in the patients' record was mitigated by excluding the particular file from the study

The study was carried out in one center, Kenyatta National Hospital, this was mitigated by the fact that KNH is a national referral hospital and receives cases from within and outside the country

CHAPTER FOUR: RESULTS

4.1.0 Demographic characteristics

299 patients with a median (IQR) age of 31 (21-46) years, age range of 0-83 years were evaluated.

Table 1. Demographic characteristics of upper limb amputees in KNH

Variable	Category	Frequency (%)
Age, years	MED (IQR)	31 [21-46]
Age group	<18 years	59 (19.7)
	19-30 years	103 (34.4)
	31-40 years	65 (21.7)
	41-50 years	35 (11.7)
	51+ years	37 (12.4)
Sex	Female	54 (18.1)
	Male	245 (81.9)
Level of education	None	36 (12.0)
	Primary	133 (44.5)
	Secondary	100 (33.4)
	Tertiary	30 (10.0)
Employment status	Employed	67 (22.6)
	Machine operator	21 (31.3)
	Casual worker	8 (11.9)
	Security guard	7 (10.4)
	Mechanic	6 (9.0)
	Carpenter	4 (6.0)
	Other*	21 (31.5)
	Self employed	98 (33.1)
	Business	23 (23.5)
	Farmer	20 (20.4)
	Carpenter	9 (9.2)
	Machine operator	9 (9.2)
	Motorbike rider	8 (8.2)
	Welder	6 (6.1)
	Other**	23 (23.4)
	Unemployed	131 (44.3)
	Not reported	3

*Teacher, Driver, Waiter, Caretaker, Clerk, Accountant, Foreman, Herdsman, Loader, Public health officer, Technician, and Transformer technician

**Butcher, Casual worker, Mason, Mechanic, Plumber, Porter, Artisan, Electrician, Painter, Pastor, Salesman, Tailor, and System

Most participants were in the age group of 19-30 years (34.4%), were male (81.9%), had a primary level of education (44.5%) and were unemployed (44.3%)

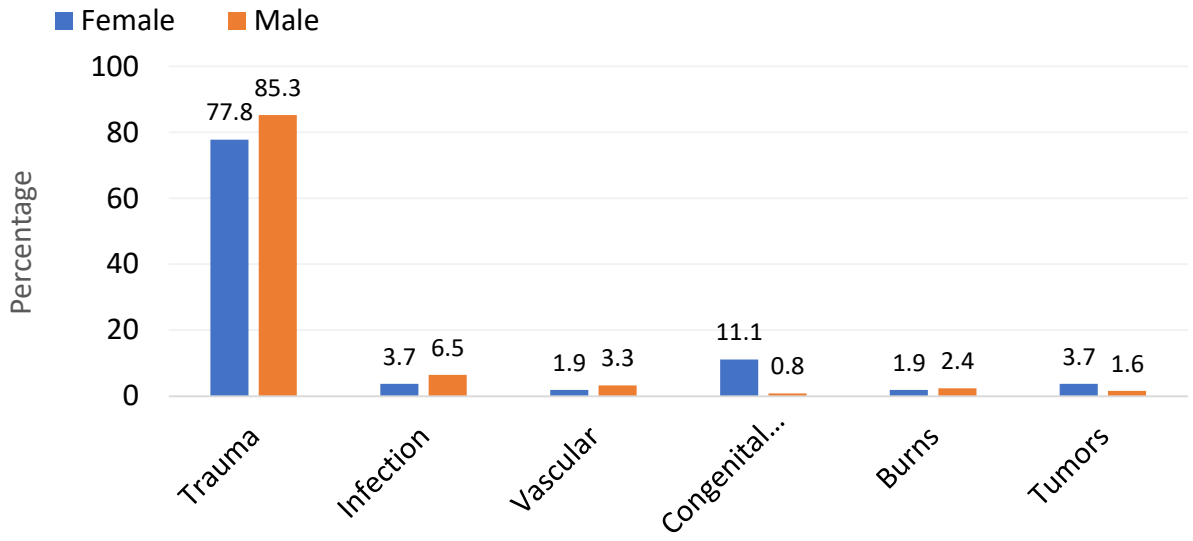
33.1% were self-employed, mainly as business persons (23.5%) and farmers (20.4%), while 22.6% were employed, mainly as machine operators (31.3%), casual workers (11.9%), and security guards.

4.2.0 Indications of upper limb amputations by gender and age

Table 2. Indications of upper limb amputations by gender and age

Indications	Total (%)	Female, n= 54	Male, n= 245	Age, years Mean±SD
Trauma	251 (83.9)	42 (77.8)	209 (85.3)	29.8±15.3
Infection	18 (6.0)	2 (3.7)	16 (6.5)	31.1±16.5
Vascular	9 (3.0)	1 (1.9)	8 (3.3)	58.7±21.9
Con. Malformations	8 (2.7)	6 (11.1)	2 (0.8)	1.2±1.2
Burns	7 (2.3)	1 (1.9)	6 (2.4)	22±11.5
Tumors	6 (2.0)	2 (3.7)	4 (1.6)	43.8±10.5

Figure 3: Indication of amputation by gender/sex



83.9% of amputations were due to trauma, 6.0% infections, 3.0% vascular abnormalities, 2.7% congenital abnormalities, 2.3% burns, and 2.0% tumors.

Females compared to males were likely to have an amputation due to congenital malformations (11.1% versus 0.8%) and tumors (3.7% versus 1.6%).

Males compared to females were likely to have amputations due to trauma (85.3% versus 77.8%), infections (6.5% versus 3.7%), vascular abnormalities (3.3% versus 1.9%) and burns (2.4% versus 1.9%).

The mean age of participants who had a trauma was 29.8±15.3 years, infections 31.1±16.5 years, vascular abnormalities 58.7±21.9 years, congenital malformations 1.2±1.2 years, burns 22±11.5 years, and tumors 43.8±10.5 years.

4.2.1 Mechanisms of injury

Table 3. Traumatic indications by gender

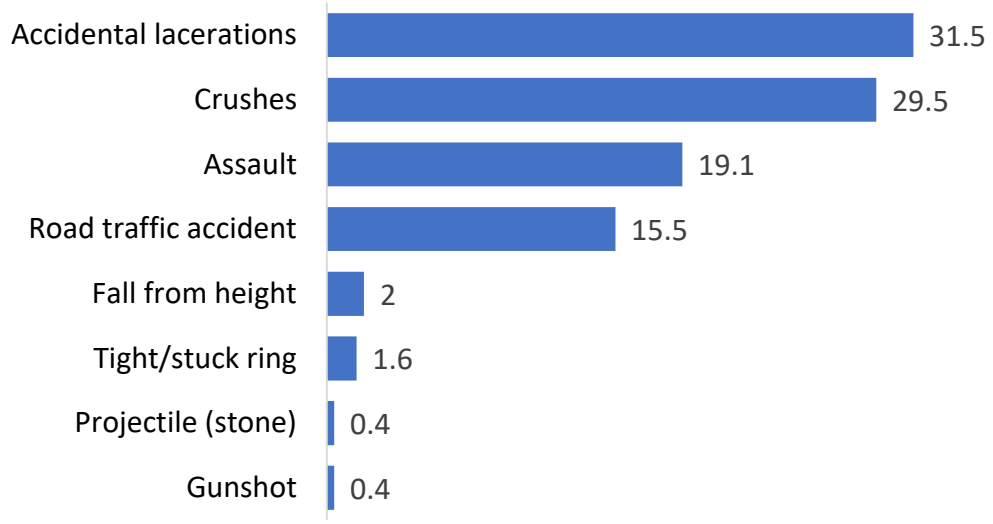
Indications	Total (%)	Female, n = 42	Male, n = 209
Accidental lacerations	79 (31.5)	10 (23.8)	69 (33.0)
Chuff cutter	31 (39.2)		
Wood saw	12 (15.2)		
Grinder	6 (7.6)		
Meat cutter	5 (6.3)		
Iron sheet	4 (5.1)		
Others*	21 (26.7)		
Crushes	74 (29.5)	9 (21.4)	65 (31.1)
Machine	51 (68.9)		
Door	7 (9.5)		
Gate	3 (4.1)		
Metal object	3 (4.1)		
Other**			
Assault	48 (19.1)	11 (26.2)	37 (17.7)
Pangas/machetes	36 (75.0)		
Human bite	5 (10.4)		
Stabbing	5 (10.4)		
Blunt object	2 (4.2)		
Road traffic accident	39 (15.5)	10 (23.8)	29 (13.9)
Vehicle	20 (51.3)		
Motorbike	15 (38.5)		
Bicycle	2 (5.1)		
Cart	1 (2.6)		
Train	1 (2.6)		
Fall from height	5 (2.0)	0 (0.0)	5 (2.4)
Tight/stuck ring	4 (1.6)	1 (2.4)	3 (1.4)
Projectile (stone)	1 (0.4)	1 (2.4)	0 (0.0)

Gunshot	1 (0.4)	0 (0.0)	1 (0.5)

**Motorcycle spokes, Pangas, Milling machine, Car fan belt, Car radiator fan, Paper cutter, Barbed wire, Electric slasher, Juice extractor, Lawn mower, Metal cutter*

*** Falling object, Table, Cart, Gas cylinder, Grill, Transformer, Wheelbarrow, Window frame*

Figure 4: Mechanism of traumatic amputation



31.5% of patients who had traumatic amputations were likely to have accidental lacerations from chuff cutters (39.2%), wood saws (15.2%) and grinders (15.2%).

29.5% were likely to have crushes from machines (68.9%), doors (9.5%) and gates (4.1%), while 19.1% were assaulted mainly with pangas (75.0%), human bites (10.4%), and knives (10.4%).

15.5% had accidents on vehicles (51.3%) and motorcycles (38.5%), while (2.0%), (1.6%), and (0.4%) fell from height, had tight rings, and had gunshot wounds respectively.

More females compared to males were likely to be assaulted (26.2% versus 17.7%) and be involved in road traffic accidents (23.8% versus 13.9%). More males compared to females were likely to have accidental laceration (33.0% versus 23.8%) and crushes from machines, doors and gates, et cetera (21.4% versus 31.1%).

Figure 5: Accidental lacerations

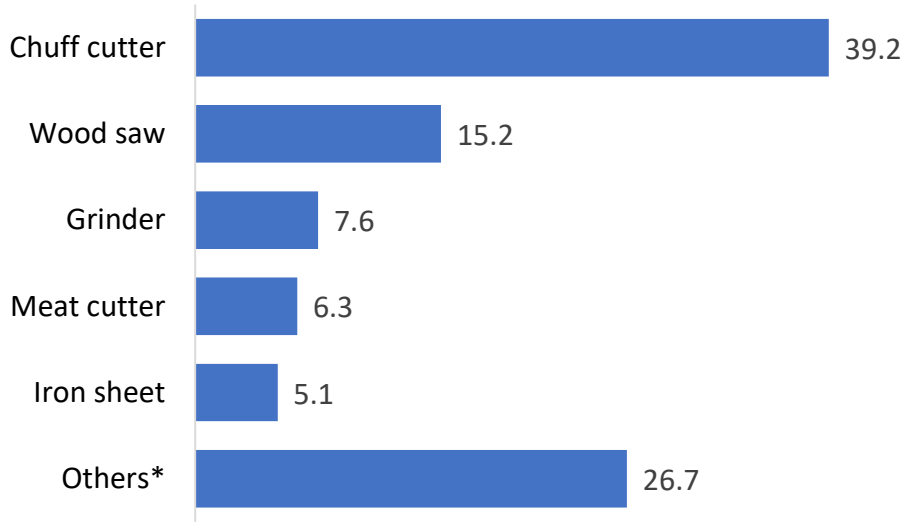


Table 4. Infectious, congenital, and vascular indications for amputations by gender

Mechanism	Indications	Total (%)	Female	Male
Infections (N=18)	Cellulitis	15 (83.3)	1 (50.0)	14 (87.5)
	Osteomyelitis	3 (16.7)	1 (50.0)	2 (12.5)
Vascular (N=9)	Diabetes gangrene	6 (66.7)	1 (100)	5 (62.5)
	Tight/stuck ring	1 (11.1)	0 (0.0)	1 (12.5)
	Snake bite	1 (11.1)	0 (0.0)	1 (12.5)
	Peripheral arterial disease	1 (11.1)	0 (0.0)	1 (12.5)
Con. Malform. (n=9)	Polydactyly	7 (87.5)	6 (100)	1 (50.0)
	Amniotic band syndrome	1 (12.5)	0 (0.0)	1 (50.0)
Tumors (n=4)	Malignant melanoma	2 (33.3)	1 (50.0)	0 (0.0)
	Squamous cell carcinoma	2 (33.3)	1 (50.0)	1 (25.0)
	Enchondroma	1 (16.7)	0 (0.0)	1 (25.0)
	Pleomorphic sarcoma	1 (16.7)	0 (0.0)	2 (50.0)

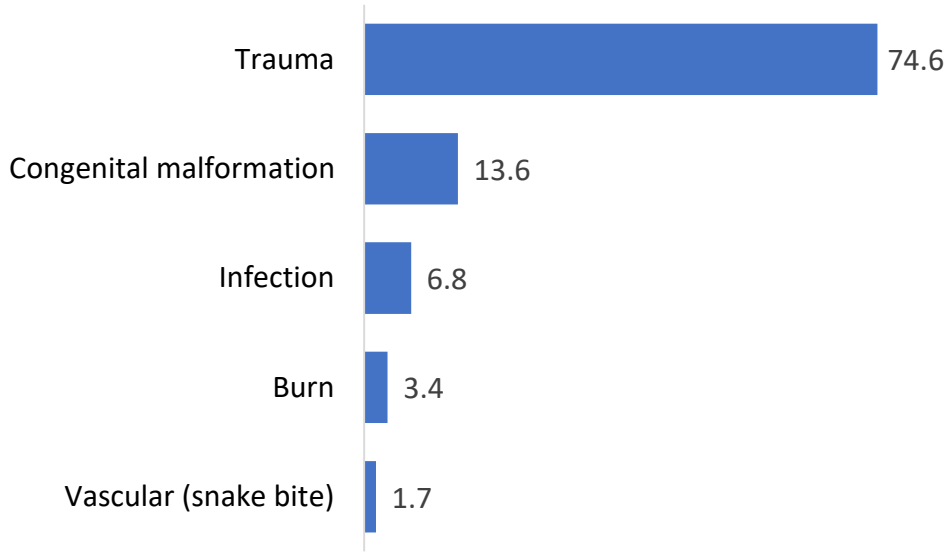
Majority (83.3%) of respondents with infections had cellulitis. 66.7% of those with vascular complications had diabetes gangrene, while 87.5% of those with congenital malformations had Polydactyly and 33.3% of those with tumors had malignant melanoma/squamous cell carcinoma. More males compared to females who had infections were likely to have cellulitis (87.5% versus 50.0%). More females compared to males who had vascular complications and congenital anomalies had diabetes gangrene (100% versus 62.5%) and polydactyly (100% versus 50.0%)

4.2.2: Indications of amputations within the age group 0-18 years

Table 5. Indications of amputations within the age group 0-18 years

Indications for amputation	Frequency (%), N = 59
Trauma	44 (74.6)
Deep lacerations	20 (45.5)
Crushes	11 (25.0)
Road traffic accident	9 (20.5)
Assault	1 (2.3)
Tight/stuck ring	1 (2.3)
Projectile	1 (2.3)
Fall	1 (2.3)
Congenital malformation	8 (13.6)
Polydactyly	7 (87.5)
Amniotic band syndrome	1 (12.5)
Infection	4 (6.8)
Cellulitis	3 (75.0)
Osteomyelitis	1 (25.0)
Vascular (snake bite)	1 (1.7)
Burn	2 (3.4)

Figure 6: Indications in pediatric population (0-18) years



Trauma was the leading indication for the amputation (74.6%). Of these, 45.5% had deep lacerations, 25.0% crushes, and 20.5% had road traffic accidents. Congenital malformations (13.6%) were the second leading indication mainly polydactyly (87.5%), while 6.8% had infections, mainly cellulitis (75.0%). Two (3.4%) had burns while one (1.7%) had a snake bite.

4.3.0 Anatomical levels of upper limb amputations

Table 6. Anatomical levels of upper limb amputations in KNH

Amputation	Total (%) N=298	Female n=53	Male n=245
Trans phalangeal	227 (76.2)	31 (58.5)	196 (80.0)
Trans radial	22 (7.4)	5 (9.5)	17 (6.9)
Trans metacarpal	19 (6.4)	7 (13.2)	12 (4.9)
Wrist disarticulation	15 (5.0)	5 (9.4)	10 (4.1)
Trans humeral	6 (2.0)	2 (3.8)	4 (1.6)
Trans carpal	6 (2.0)	2 (3.8)	4 (1.6)
Shoulder disarticulation	2 (0.7)	1 (1.9)	1 (0.4)
Forequarter	1 (0.3)	0 (0.0)	1 (0.3)

76.2% of amputations were trans phalangeal while 7.4%, 6.4%, and 5.0% were trans radial, trans metacarpal, and wrist disarticulation respectively.

More females compared to males had trans metacarpal (13.2% versus 4.9%), trans radial (9.5% versus 6.9%), trans humeral (3.8% versus 1.6%), trans carpal (3.8% versus 1.6%), and shoulder disarticulation (1.9% versus 0.4%).

More males compared to females had trans phalangeal (80.0% versus 58.5%) and forequarter (0.3% vs 0.0%) amputations

4.3.1 Levels of amputations within the age group 0-18 years

Table 7. Levels of amputations within the age group 0-18 years

Levels of amputations	Frequency (%) N = 59
Trans phalangeal	43 (72.9)
Trans radial	6 (10.2)
Trans metacarpal	3 (5.1)
Wrist disarticulation	3 (5.1)
Trans carpal	3 (5.1)
Shoulder disarticulation	1 (1.7)

72.9% of participants ages <18 years had trans phalangeal amputations. 10.2% were trans radial, 5.1%, 5.1%, and 5.1% were trans metacarpal, wrist disarticulation, and trans carpal respectively, while one (1.7%) had shoulder disarticulation.

DISCUSSION

This study clearly shows that the age range for upper limb amputation in KNH is 0-83 years with the average and median ages being 30.1 and 31 years respectively. The age group most commonly affected is 19-30 years

This finding is echoed in similar studies in developing countries such as Nigeria (8), Pakistan (29) and Taiwan (11) with average ages of amputees being 33 years, 38+/-17 years and 39.1 years respectively. The age range is however lower than those observed in developing countries such as Taiwan with 30-49 years and strikingly different from that observed in a similar study in a Kenyan provincial hospital of 41-60 years (1)

This observation is however, in contrast to age ranges in Canada observed to be between (50-70) years (26) which could be largely due to ageing population, a pattern commonly seen in developed countries

The male to female ratio is 4.5:1, a picture that is replicated in similar studies in other developing countries Liberia (7), **Nigeria (8) and Taiwan (11).** This could be due to the fact that the male gender is commonly involved in high-risk occupations such as construction and in the commercial motorcycle industry, exposing them to occupational accidents

The majority of the amputees have attained primary level of education or no education at all and are unemployed, a finding echoed in a similar study in Tanzania, that pointed out that males with primary level of education and are unemployed were more likely to sustain upper limb amputation compared to other groups (32). The majority of the employed work as machine operators and the self-employed are mainly business people and farmers

Trauma was the most common indication for amputation accounting for 83.9 % of all the cases. The ratio of traumatic male to female amputations is 5:1. This is in keeping with findings of a similar study in Ghana where males were way more likely to sustain trauma related amputations than females (7.5:1) (9).

Trauma, by far, remains the commonest cause of upper limb amputation in various developing countries and is followed distantly by other varied indications such as infections (4,7,8,14). Whereas trauma is common in a younger population with mean age of 29.8+/-15.3 years, vascular indications are more common in older population with mean age of 58.7+/- 21.9 years Accidental lacerations constitute the bulk (31.5 %) of the traumatic amputations and the chaff cutter is responsible for the majority (39.2 %) of the accidental lacerations. A similar study in France found that the table saw was the most common mechanism of hand injuries that eventually ended up in amputations (3)

Other forms of trauma included crush injuries, assaults, road traffic accidents tight stuck rings on fingers and fall from heights. Accidents involving vehicles constituted the bulk of the cases of road traffic accident, this contrasts to road traffic accidents involving motorcycles being mentioned to contribute to the bulk of upper limb amputations in a similar study in Nigeria (8) Assaults were more common among females than males (26.2 vs 17.7 %), with the most common mechanism being deep lacerations inflicted by machetes/pangas on the victims. This is followed closely by human bites and stabbings

Other common indications for amputations included infections 6.0%, vascular abnormalities 3.0%, congenital abnormalities 2.7%, burns 2.3%, and tumors 2.0%. Majority of the vascular indications were due to diabetic gangrene, while polydactyly accounted for the bulk of congenital malformations.

A study in Kikuyu, Kenya (18) also found diabetic gangrene (26.5%) to account for the majority of vascular complication leading to amputations.

Most patients who had burns were males and sustained electrical type of burns, this echoes a study in Bangladesh that found male predominance in burns (33).

Tumors were mainly malignant melanomas and squamous cell carcinomas.

In the pediatric population, trauma (74.6%) continues to be the dominant indication for amputation with congenital malformations constituting a paltry 13.6%. This finding is in contrast to findings in Ethiopia where bone setters' gangrene (a complication of conservative management of pediatric closed fractures) accounted for 55% of pediatric limb amputations followed by malignancy (29%), and trauma coming third with a paltry 11% (28)

Trans phalangeal amputation (76.2%) is the commonest level of amputation among the pediatric age group in this study. Other levels were trans radial (7.4%), trans metacarpal (6.4%), and wrist disarticulation (5.0%). These findings were different from those in Ethiopia where below elbow (24.5%) and above elbow (23%) were predominant with only 2.9% of amputations being trans phalangeal in nature (28).

The above findings are however in line with a similar study in USA (6) and a separate study Ethiopia (34) that mentioned trans phalangeal as the commonest level of amputation

A study in Liberia reported above elbow (65.2%) and below elbow (25%) respectively to be the commonest levels of amputations (7).

Only one forequarter amputation was done in KNH during the study period, this number is much less than the 12 cases done in MTRH, Kenya, in the same duration between 2012 to 2017(19). The main indication for forequarter amputation was however the same in both studies, soft tissue sarcomas (41).

CONCLUSION

Upper limb amputation at KNH is commonest among the age group of 19-30 with a mean age of 30.1 years. It predominantly affects the male sex, those with low level of education (primary) and the unemployed.

Trauma is the commonest indication for amputation, both in adult and pediatric age groups, with accidental lacerations with a chaff cutter machine accounting for the majority of cases. Assaults are more common among the female sex

The commonest level of amputation is at the trans phalangeal area

RECOMMENDATIONS

Trauma causes the bulk of upper limb amputations, majority of which are machine and workplace related, further studies into this area to guide in development of policies that enhance occupational safety

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APPENDICES

Appendix 1

Pattern of upper limb amputations in Kenyatta National Hospital: A five year retrospective study

Data Checklist

Done	Question	Answer
☐	**1. Study number**	**…….**
☐	**2. Age (in years)**	
☐	**3. Sex** **(tick appropriately)**	**a) Male** b) **Female**
☐	**4. Level of education** **(tick appropriately)**	**a) None** **b) Primary** **c) Secondary** **d) Tertiary**
☐	**5. Employment status** **(tick appropriately)**	**a) Employed** **b) Self-employed** **c) Unemployed**
☐	**6.Occupation**	**Specify …….**

☐	**7. Indication for amputation** **(tick appropriately)**	a) **Trauma; specific mechanism……** **b) Tumor; specify……...** **c) Infection; specify……** **d) Vascular disorder; specif..……** **e) Congenital malformation; specify..** **f) Other indication…….**
☐	8. **Level of amputation** **(tick appropriately)**	**a) Trans-phalangeal** **b) Wrist disarticulation** **c) Trans-humeral** **d) Trans-metacarpal** **e) Trans-radial** **f) Shoulder disarticulation** **g) Trans-carpal** **h) Elbow disarticulation** i) **Forequarter**