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Original Research Article

Management of Patients with Upper Limb Chaff Cutter Injuries at Moi Teaching and Referral Hospital, Eldoret, Kenya

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Abstract: ***Background*:** Chaff cutter is a device used in farms to cut maize stalks into small pieces and feed to livestock. There has been increase in number of cases of upper limb injuries due to use of the device in Kenya. However, there is little published or documented research in this area, hence the need for the study. **Objective:** To discuss the management of patients with upper limb chaff cutter injuries at Moi Teaching and Referral Hospital (MTRH), Eldoret, Kenya. ***Methods*:** A prospective study conducted at MTRH, involving census of 44 patients being managed for upper limb injuries caused by chaff cutters, after satisfying inclusion criteria (all ages and gender, specifically injured by the device, and consented to participate). Structured questionnaires were used for data collection on sociodemographic factors, clinical characteristics and treatment modalities, while validated Quick Disabilities of the Arm, Shoulder and Hand (QDASH) questionnaires were used for data collection on the assessed patient reported short-term outcome measures during the follow up at 2, 6 and 12 weeks. Data was analyzed for variables listed in both the Structured and the QDASH questionnaires using SPSS version 21. Kruskal Wallis test was used to assess QDASH scores. ***Results*:** Chaff cutter injuries patients were 44 out of 214 who had upper limbs injured due to other causes, giving a burden of 20.56% of all in-patient upper limb injuries. Mean age was 29.42 (SD: 9.27) years. Males were 42 while females were 2. Full- time farmers were 45.5%. Right upper limb injuries were 59.1% and no formal training had been done for 97.7%. There were a total of 102 different types of injuries with about two-thirds being traumatic amputation/disarticulation with 50% of the participants having injury up to the fingers level. Tetanus toxoid injection, analgesics and antibiotics were administered before surgery to all and 90.9% had formal amputation/disarticulation. QDASH score increased with increased severity of the injury but decreased over the time of follow up (p<0.05). ***Conclusion*:** Most of the injured were young adult males without formal training. The most common injury was traumatic amputation of the fingers. All patients underwent operative treatment (majority- amputation). Though burden of injury was high, short- term outcomes of the treatment was good. ***Recommendations*:** Included are the installation of safety devices and development of manufacturing guidelines. Sensitization of the chaff cutter operator on caution while at work. Training on the safe use of chaff cutter and study on risk factors for increased injury. Avoid wearing long sleeved shirts or other loose fitting clothes. Education of farmers on first aid. Operative treatment should aim at salvage procedures. QDASH score of patients should be encouraged for rehabilitation purposes. A study on rehabilitation of such injuries is also recommended.

Keywords: Amputation, Burden, Chaff Cutter, Debridement, Disability, Disarticulation, Management, Outcome, Upper Limb Injury.

INTRODUCTION

As a part of the upper limb, the hand is an extreme part of the human body enabling a variety of functions. These functions include gripping of objects (power grip enabled by a strong pad of tendons called the aponeurosis and precision grip). The hand, though a

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small structural part of the body, harbors an intricate, complex, and fascinating anatomy. The basic skeleton of the hand and wrist comprises a total of twenty-seven bones. These are grouped into phalanges, carpals, and metacarpals (Fragaszy & Crast, 2016).

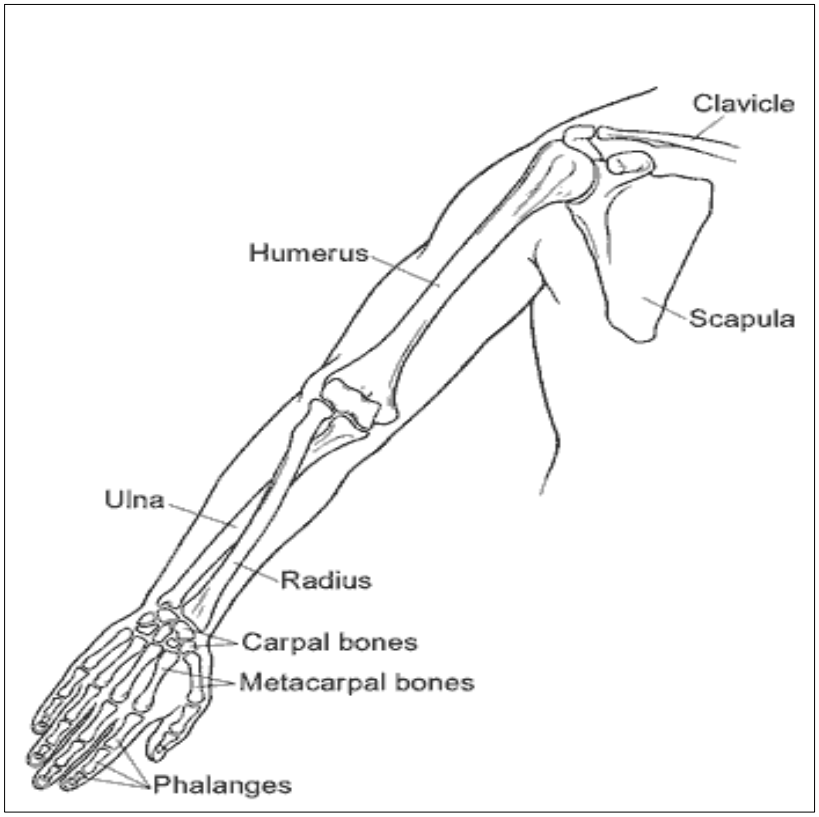

Figure 1: Bony anatomy of the upper limb (Source: Med syndicate website)

Research depicts the wrist to be the most complex body joint. It is made up of eight carpal bones that are grouped into two rows that are characterized by a motion restriction between them. The proximal row composition from ulnar to radial comprises of pisiform, triquetrum, lunate, and the scaphoid bones (Maw *et al*., 2016). On the other hand, the distal row is made up by the hamate, capitate, trapezoid, and trapezium bones, in the same order as above. All carpal bones have a fundamental role in the function of the wrist, except for the pisiform, regarded as a sesamoid bone that harbors the passage of the flexor carpi ulnaris tendon (Standring, 2020). The link between the rows is potentiated by the scaphoid, hence the bone's vulnerability to fractures. The distal carpal bone row strongly attaches to the base of the third and second metacarpals to form a fixed unit, which is the reference point determining the movement of all other mobile units (Solomon, 2015). The flexor retinaculum forms the carpal tunnel roof and is attached radially to the trapezium and scaphoid radially, and the hook of harmate and pisiform ulnarly (Standring, 2020).

The hand is made up of five metacarpals, with each being characterized as having a head, neck, shaft, and a base. The thumb's metacarpal bone is the most mobile and shortest, and articulates with trapezium proximally (Shier *et al*., 2015). The rest of the metacarpals articulate with hamate, trapezoid, and capitate at the base, and distally with the digits' proximal phalanges. There are fourteen phalanges in total, with each digit comprised of three phalanges (distal, middle, and proximal), except for the thumb, comprised of two phalanges (Solomon, 2015). The hand's innervation is through three nerves, namely the radial, median, and ulnar nerves. Each of the three comprises of motor and sensory components. The median nerve is responsible for the innervation of muscles that carry out pinch and fine precision hand functions. Its origin is in the medial and lateral brachial plexus cords (Silverthorn *et al*., 2015). Its anterior interosseous branch supplies the flexor digitorum profundus, flexor pollicis longus, and the pronator quadratus muscles. The palmar cutaneous branch is responsible for the sensory innervation of the thenar eminence, and the thenar muscles (opponens pollicis, abductor pollicis brevis, and superficial flexor pollicis brevis head) are innervated by the recurrent motor branches (Pocock *et al*., 2013). Besides, the nerve provides sensory digital branches to the ring finger radial side, long finger, index finger, and the thumb. The ulnar nerve innervates the muscles for the hand's power grasp. Its origin is in the brachial plexus' medial cord, and sends out motor branches to the flexor digitorum profundus and flexor carpi ulnaris muscles (Shier *et al*., 2015). Its dorsal branch is sensory and innervates the small finger, part of the ring finger, and the hand dorsum's ulnar portion. The radial nerve innervates the wrist extensors responsible

for stabilizing the fixed unit and controlling the hand position (Maw *et al*., 2016). Its superficial branch sends sensory innervation to the long finger, dorsum of index finger, radial half of ring finger, dorsum of the hand, and the radial side of the hand's dorsum (Silverthorn *et al*., 2015).

The muscles of the hand are divided into extrinsic and intrinsic groups. The extrinsic muscles are proximal in the forearm, with insertion through long tendons into the hand skeleton, with the exception of the interosseous-lumbrical complex, a muscle responsible for the joint extension between phalanges. The intrinsic muscles are found within the hand, and are divided into hypothenar, thenar, interossei, and lumbrical muscles. The blood supply to the hand is achieved through the ulnar and radial arteries, which are brachial artery branches. Supplemental arterial circulation is achieved through the posterior interosseous, anterior interosseous, and the median arteries, all branching from the ulnar artery in the forearm (Standring, 2020).

An adequate hand function is defined by the ability of an individual to adequately use the hand in conducting day-to-day activities, depending on the sensation, anatomical integrity, strength, coordination, and dexterity. The development of hand function does not occur in isolation, but comes about as a result of physiologic maturation, neurologic development, and functional development of motor function and learned movement patterns (Pocock *et al*., 2013). The highest hand skill levels are achieved through the evolution of cortical mechanisms. Fine finger movements are potentiated by the sensory and motor cortices, which become assimilated continuously starting from childhood. The tactile perception enables integration of information from end organ sensory inputs, including coordinated movement achievement through proprioception (Duruoz, 2016). The functions carried out by the hands are very unique in normal day to day living as well as in occupation, especially those that require the use of hands. Fine movement can be achieved such as guiding a fine thread through the eye of a needle. Generally, there are three manipulative hand movement types. The first is the finger to palm, which can be demonstrated through movement of a coin from fingers to the palm (Poole, 2011). The second is the palm to finger movement, which can be depicted through movement of a coin from palm to fingers. The third is rotation, which can be complex or simple. Simple rotation entails rolling object ninety degrees between fingers, while complex rotation entails a one hundred and eighty degree rolling movement of an object between fingers (Poole, 2011). The ability to simultaneously integrate mobility and stability plays a fundamental role in hand manipulation, wherein one object requires stabilization as the other is moved around in the hand (Duruoz, 2016).

The vulnerability of the hand is quite evident since most of the structures making it up (slender bones, nerve fibres, tendons and blood vessels) are merely covered by a scanty layer of fat and muscle, positioned just under the dermal and epidermal layers of the skin. The human hand is also exposed to quite a number of potentially dangerous objects and undergoes a lot with each passing day. Hand trauma is one of the major causes of upper limb disabilities. Trauma to the hand can be generally categorized into six groups, including lacerations, amputations and soft tissue injuries, dislocations and fractures, infections, high pressure injuries, and burns. Other commonly encountered hand injuries may include finger injuries, nail injuries, broken hand, and wrist injuries (Maroukis *et al*., 2016). According to Capek *et al*., (2018) trauma to the hands may lead to a myriad of functional deficits as a result of loss of anatomy or function. In cases of complete detachment of parts of the hand (through amputation), the following impairments may result:

- Ring finger amputation or disarticulation leads to 10% deficit of the hand, 9% deficit of the upper limb and 5% impairment of the whole person.
- Index and middle finger amputation or disarticulation leads to 20% deficit of the hand, 18% deficit of the upper limb and 11% impairment of the whole person.
- Thumb amputation or disarticulation leads to 40% deficit of the hand, 36% deficit of the upper limb and 22% impairment of the whole person.
- Hand amputation or disarticulation leads to 90% deficit of the upper limb and 54% impairment of the whole person.
- Amputation or disarticulation of the entire upper limb leads to 60% impairment of the whole person.

Upper limb injuries caused by chaff cutter are very serious causes of morbidity and in extreme cases, mortality. Its prevalence in our setting is unknown. These injuries are mostly sustained by farmers as they use the machine to cut animal feeds or in the process of cleaning the machine hence posing as an occupational hazard to them. The risk of such injuries occurring is heightened by the fact that it is a machine found in many farms and used almost every day to cut feeds prior to feeding livestock. Most injuries occur when a part of the upper limb comes into contact with a sharp and/or movable part of the chaff cutter. Such injuries may require extensive treatment and rehabilitation to achieve full functionality of the injured limb. Since these machines are found in homestead, children are also exposed to such injuries while playing with them, imitating adults who use them (Mahajan, 2016). A chaff cutter, also known as a fodder cutter, is a mechanical device used in farms to cut hay and straw into small pieces which are then mixed with other feeds and fed to livestock. By cutting these feeds, there is consumption and palatability of the feeds by the

animal and also prevents the animals from rejecting any part of their food. These feeds played a vital role in most agricultural production as it was used to feed horses, which were used in farming operations until they were replaced by tractors in the 1940s (Kankal *et al*., 2016; Patil *et al*., 2016).

The earliest mention of a chaff cutter was in the sixteenth century in Europe. It was an indigenous and simple farm tool that was used by farmers to cut hay, straw chaff and oats into smaller pieces before mixing it with other forage and finally feeding the mixture to cattle as well as horses. This method of feeding proved more economical than any other feeding method used in the past as the animals ate their feeds without regurgitating the bigger pieces. It was also beneficial for animal digestion (McDonald, 2017). The framework of the chaff cutter constituted mainly wood with a bit of iron, therefore making it also cost effective. There were two types of chaff cutters by the eighteenth century: one, large and heavy, and another, small and portable. The large one was usually kept inside barns. Chaff forks of variable widths ranging from 230-260 mm were usually used to advance the bundles of feeds along the feeding trough. The dimensions of the forks depended on the dimensions of the feeding troughs. A metal plate, looping over the top front end of the cutter usually provided the framework. Below the metal plate was a large knife that connected diagonally to an arm (single or double-sided) whose extent was from the base of a single front leg and passing through the center of the opposing leg which was hollow. This mechanism facilitated the up and down motion of the knife. The types of knives used were derived from modified versions of scythe blades (McDonald, 2017).

Filling of the feeding troughs with feeds (hay or straw) was done using a sprung clamp. The left hand of the operator held the fork handle, pushing the tines within the bundle forward to about an inch away from the cutting edge. The left foot was usually on the treadle, pressing it down to compact the feed. The right hand, would hold the knife, raise it, and then suddenly bring it down, slicing the protruding straw into pieces, each about half an inch long. The work was to be done by three people: a man, a boy and another person whose work was to add more hay as more was being chopped. Once the operator took his left foot off the treadle the hay would be released and he would use the fork on his right hand to fill the feeding trough and the process would be repeated until they had enough cut feeds (McDonald, 2017). Because of the amount of coordination and skill that went into operating a chaff cutter, only experienced people were allowed to operate. Such people were able to make between fifteen and twenty cuts every minute and produce around forty bushels of chaff in a day. However, in the hands of the inexperienced worker, still unable to coordinate between the feed, cutting and treadle actions, the consequences of operating a chaff cutter were grave and resulted in many cases of personal injuries (McDonald, 2017).

According to the International Labor Office (ILO), there are an estimated 170,000 deaths every year directly linked to agricultural activities. Agricultural workers endure serious work-related injuries that involve farm machinery and agro-chemicals. In contrast to other sectors in the world economy where overall work-related mortality has decreased, agricultural mortality rates have been at an all-time high over the past decade. The figure might be much higher due to underreporting of both injuries and deaths. The overall fatality rate could be significantly higher (Hulshof *et al*., 2021). Workers in developing counties are at an increased risk of injuries related to agricultural activities as a result of inadequate safety training systems set up to provide employee education. However, the incidence of work-related injuries reported in the agricultural sectors is much higher in developed countries compared to developing countries. For example, in the United States (US), farmers only account for 3 percent of the total workforce but contribute to 8 percent of all work-related injuries. Further, Italy has only 7 percent of its workers being in the agricultural sector. However, they account for 28.7 percent of all work-related injuries (Kica & Rosenman, 2020).

Although almost half of the world's total workforce is either directly or indirectly involved in agricultural sector, only 9 percent of the total workforce in developed countries has ties to the sector. The larger proportion of workers is contributed by developing countries. At least 20 percent of the total workers in Eastern Europe are in agricultural production, 5.2% percent in European Union, and 25% percent in Latin America. In contrast, 63 percent and 62 percent of all workers in Africa and Asia, respectively, are in the agricultural sector (Hulshof *et al*., 2021). In the past, the agricultural production sector was largely made up of men. However, in the recent times, with urban migration of male workers in search of employment in industries, the proportion of women in agriculture is steadily increasing. Worldwide, women currently account for 43 percent of the total workforce in agricultural production. In most of the developing counties, the workforce mainly comprises of the vulnerable populations consisting of the poor, women and children. They are usually exposed to unsafe working environments with poor pay, unattainable targets and long working hours. They are therefore predisposed to injuries due to lack of enough training, fatigue and haste leading to mistakes. Most of the work is usually carried out in open air, where the workers are exposed to adverse weather conditions that make working more challenging (Weichelt *et al*., 2019).

The major agriculture-related injuries were from cutting tools and machinery such as combined harvesters as well as exposure to agro-chemicals. A study carried out in Brazil by the Institute of

occupational health and safety indicated that about 40 percent of work-related injuries were from manual tools, out of which cutting tools constituted 80 percent and machinery made up 12 percent. In the US, a survey by the Institute of Safety and Health recognized injuries due to machinery as among the top three causes of traumatic occupational injuries, with tractors having the highest fatality rates. In addition, the survey indicated a higher prevalence of machine-related injuries and fatalities in males (98 percent) compared to females (2 percent). The fatalities were also higher among young workers aged 25 to 34 years (Weichelt *et al*., 2019).

The agricultural sector is the mainstay of the Kenyan economy, contributing 26% of the Gross Domestic Product (GDP) directly and another 27% of GDP indirectly through linkages with other sectors. The agricultural sector employs more than 40% of the total population and more than 70% of Kenya's rural people. The sector provides more than eighty percent of the Kenyan population with livelihood, and contributes to sixty-five percent of the export earnings (Food and Agriculture Organization, 2014). Further, it contributes to nutrition improvement through production of diverse, safe, and nutrient-rich foods. It is the main non-agricultural economy driver, including input provision, manufacture, and non-agricultural operations markets such as tourism, transportation, education, construction, and other social services (Food and Agriculture Organization, 2014).

The United Nation's FAO, (2028) also operates under two primary sets of four pillars, depending on whether one is referring to their overarching strategic goals (betterment of: production, nutrition, environment and life- aimed at guiding FAO's global efforts to transform agrifood systems and achieve the sustainable development goals) or the definition of food security. Better production will ensure sustainable consumption and production patterns while accelerating inclusive and resilient agrifood supply chains. Better nutrition will end all forms of malnutrition and ensure safe, affordable, and healthy diets for everyone. Better environment will ensure protecting, restoring and promoting the sustainable use of terrestrial and marine ecosystems, while fighting climate change. Better life will ensure promoting inclusive economic growth, reducing inequalities, and ensuring equitable livelihood opportunities for rural populations. These four pillars for food security are essential and will ensure availability (quality and quantity), accessibility (resource entitlement to enable acquisition), utilization (proper biological use through adequate diet, clean water, sanitation and healthcare for state of nutritional wellbeing) and stability (buffer for economic crises or climatic events).

In statistics obtained by the National Profile on Occupational Safety and Health– Kenya (International Labour Organization (ILO), 2013), annual occupational accidents for the financial year 2010-2011 showed that agriculture and related activities had a total of 1,364 accidents, that is 14 fatal accidents and 1,350 non-fatal accidents.

According to 2014 estimates of the Food and Agriculture Organization of the United Nations, agricultural land occupied 27.63 million hectare of the total 58.037 million hectares of the country's area (Food and Agriculture Organization, 2014). This shows that a significant portion (approximately 48%) of Kenya's land is agricultural area. Livestock provide food and income, a means of diversifying risk and increasing assets. Draught power, fuel, manure and transport all contribute significantly to whole farm productivity and the consumption of animal protein improves human health and ability to work (IGAD, n.d.).

Figure 2: A hand powered chaff cutter (Source: Author, 2021)

Kenya does not have specific safety standards for power operated chaff cutter (Mwangi, 2018). This is unlike India which developed a standard for Power Operated Chaff Cutter – Safety Requirements which outlines specifications for materials used in constructing chaff cutters as well as general requirements to ensure safety of the machine (Bureau of Indian Standards, 2005). According to the Ministry of Health, Article 58 (1) of Kenya's Occupational Safety and Health Act of 2007 states, "Every dangerous part of any machinery, other than prime movers and transmission machinery shall be securely fenced: Provided that, in so far as the safety of a dangerous part of any machinery cannot by reason of the nature of the operation be secured by means of a fixed guard, the requirements of this subsection shall be deemed to have been complied with if a device is provided which automatically prevents the operator from coming into contact with the part".

According to The Work Injury Benefits Act, (2007) under article 10: (1) An employee who is involved in an accident resulting in the employee's disablement or death is subject to the provisions of this Act, and entitled to the benefits provided for under this Act. (4) For the purposes of this Act, an occupational accident or disease resulting in serious disablement or death of an employee is deemed to have arisen out of and in the course of employment if the accident was due to an act done by the employee for the purpose of, in the interests of or in connection with, the business of the employer despite the fact that the employee was, at the time of the accident acting: (a) in contravention of any law or any instruction by or on behalf of his employer; or (b) without any instruction from his employer. (6) For the purposes of this section, an injury shall only be deemed to result in serious disablement if the employee suffers a degree of permanent disablement of forty percent or more.

Locally in Kenya, among the food crops/livestock systems, chaff cutting had the highest level of mechanization at 40.9% (Wawire *et al.,* 2016). As a result, there has been an increase in cases of upper limb injuries sustained by farmers due to chaff cutter use during the maize harvesting season in the North Rift region in Kenya (November-December). This leads to a decrease in the working days of an individual as a result of their stay in hospital and in severe cases lifelong disability causing endless problems for the their own and their family such as the ability to cater to their family's daily needs. Such patients undergo several extensive debridements (as a result of dirty wounds in several cases) which result in a lengthy hospital stay. Farming outputs may also be reduced due to the loss of a worker as a result of the injury. The costs of treatment for upper limb injuries caused by chaff cutter machines are high, especially for farm workers. While attending to patients at the accident and emergency department, the researcher noted that there were several patients presenting with upper limb injuries caused by chaff cutter with the number increasing during the harvesting season (approximately 5 per week during this period). For those who were admitted, the duration of hospital stay varied from 2 days to 2 weeks depending on the severity of the injury and the complications that came about as a result of the injury or during management of the injury. The exact information on the degree of morbidity and mortality for cases of upper limb injuries caused by chaff cutters is currently not available at the records department due to poor documentation in the files and also a lack of a specific code to categorize injuries caused by chaff cutters. This study therefore brings forth the proper context of chaff cutter injuries and related challenges, and hence will help revolutionize the management of the patients in order to have favourable outcomes at the Moi Teaching and Referral Hospital (MTRH), Eldoret, Kenya.

The study is justified in that knowledge on the burden of upper limb injuries caused by chaff cutters and their management in our country is currently unknown among medical professionals (there are no publications on the same topic in our setting). Medical care professionals will be sensitized on proper documentation of these injuries and their management. This will enable proper monitoring of these injuries so as to curb any sudden increases, for example during the harvesting season. Farming is a neglected field both at government as well as social sector due to lack of regular check-up, repair or maintenance of agricultural machines as well as lack of safety features as compared to industrial sector. This neglect has led to deterioration in occupational health and safety in the agricultural sector and has resulted in increased occurrence of injuries during farming activities. The Kenya Bureau of Standards (KEBS) has several farm machinery related standards but lacks one for power operated chaff cutters (Mwangi, 2018). According to a report by the report released by ILO, (2013) the most effective way to ensure worker safety is to empower and equip workers with the necessary information. By looking at the extent of this issue, the data can be used to increase awareness of the burden of chaff cutter injuries of the upper limb at both the county and national levels in Kenya and also to inform the different levels of government and the public on measures (including public health policies and legislation) to decrease the incidence of these injuries. The chaff cutters will have to be certified for use prior to their sale. The companies that manufacture these machines will also have the knowledge that may enable them to install safety features to prevent these injuries. This may also necessitate the need for education on safe use of the chaff cutter at the point of sale.

By looking at the characteristics, treatment and outcomes of upper limb chaff cutter injuries, surgeons in our setting will have better scientific knowledge, attitude and practice on how to improve on the management of these patients and thereby shorten the duration of treatment of the injured hand and improve outcomes.

This will also show a need to train more hand and plastic surgeons who can improve on availability of the expertise for revascularization and replantation procedures for severed hands. Better physical and emotional rehabilitation services will also be set up.

In this research, the question that arises is: how is the management of patients with upper limb chaff cutter injuries at MTRH? The research objectives: *broad*- to describe the management of patients with upper limb chaff cutter injuries at MTRH, while the *Specific*- to describe the burden of upper limb injuries sustained while using a chaff cutter; to determine the demographic characteristics of patients with upper limb injuries sustained while using a chaff cutter; to describe the clinical characteristics of upper limb injuries sustained while using a chaff cutter; to describe the treatment of patients with upper limb injuries sustained while using a chaff cutter; and to determine the short term outcomes of treatment of upper limb injuries sustained while using a chaff cutter. The literature review is guided by these specific objectives, but starts with further look at the upper limb and the chaff cutter.

***Anatomy of the Upper Limb*:**

The upper limb is composed of increasingly mobile segments, the proximal three (shoulder, arm and forearm) serving primarily to position the forth (the hand), which is for grasping, manipulation and touch. Synchronized interplay occurs between the joints of the upper limb to coordinate the intervening segments to perform smooth efficient motion at the most workable distance or position required for a specific task. Efficiency of hand function results in large part from the ability to place it in the proper position by movements at the scapulothoracic, glenohumeral, elbow, radioulnar and wrist joints (Moore & Dalley, 2006). The upper limb of humans is built for prehension (grasping or seizing) and manipulation (conducts fine motor skills) and the range of movements available at the joints of the upper limb enhances the dexterity of the fingers. Four fingers flexing against an opposed thumb enable the hand to function as a grasping mechanism, in which the thumb is equal in functional value to all four fingers. The hand is furthermore the main tactile organ, with a rich nerve supply. The bones of the upper limb include the scapula, clavicle, humerus, radius and ulna, the 8 bones forming the carpus (wrist), five metacarpals (palm) and fourteen phalanges (fingers). There are two phalanges in the thumb and three in each finger (Sinnatamby, 2011). The upper limb exhibits an exceptional range of movement, which permits such wide positioning of the hand that it acts as a powered, mobile, sensory organ. The innervation of the upper limb is complex and rich. There is a particular concentration of specialized sensory organelles in the wrist and hand, not only in the skin but also in the deep afferent system from muscles, tendons and joints (Standring, 2016).

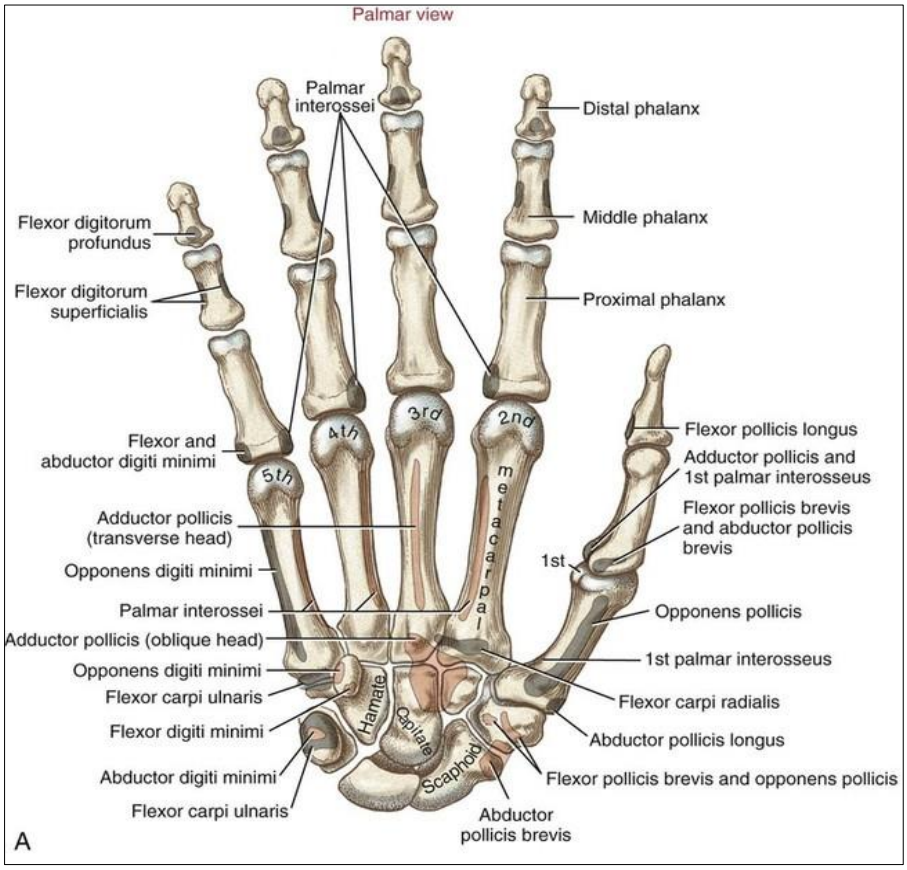

Figure 3: Bony anatomy of the hand (Source: Musculoskeletal Key website, 2016)

The beginning of the upper limb is at the shoulder joint which is categorized as a ball and socket joint (the ball is the head of the humerus while the socket is the glenoid cavity). The glenoid cavity is very shallow which leads to the alternative term, ball and saucer joint. The shallowness of the glenoid enables a wider range of movement but this is at the expense of stability of the joint. The next joint is the elbow joint, which is termed as a hinge joint (the articulation of the distal humerus and the olecranon fossa). The articulation between the head of the radius and the radial notch at the proximal-lateral part of the ulna creates a "pivot" joint. This allows movement of the radius relative to the ulna thus enabling supination and pronation movements of the forearm (Forro *et al*., 2021).

Chaff Cutter:

Chaff (fodder) cutter machines are widely used by farmers and their families in India in preparation of fodder to feed their livestock (Mahajan, 2016). They are mostly used in the rural setting and are either manual or power driven with electricity or diesel engine (Mohan *et al.,* 2004). Mechanization of agricultural sector led to an increase in agricultural productivity in Pakistan but at the expense of an increased incidence of traumatic injuries among agricultural workers. Injuries secondary to chaff cutters (Toka) are emerging as a leading cause of morbidity in agricultural workers, affecting both genders of all age groups with males being affected more (Rabbani *et al*., 2012). The injured victims are relatively young, and seasonal variation noted: two peaks being crop- related: April to June and October to December.

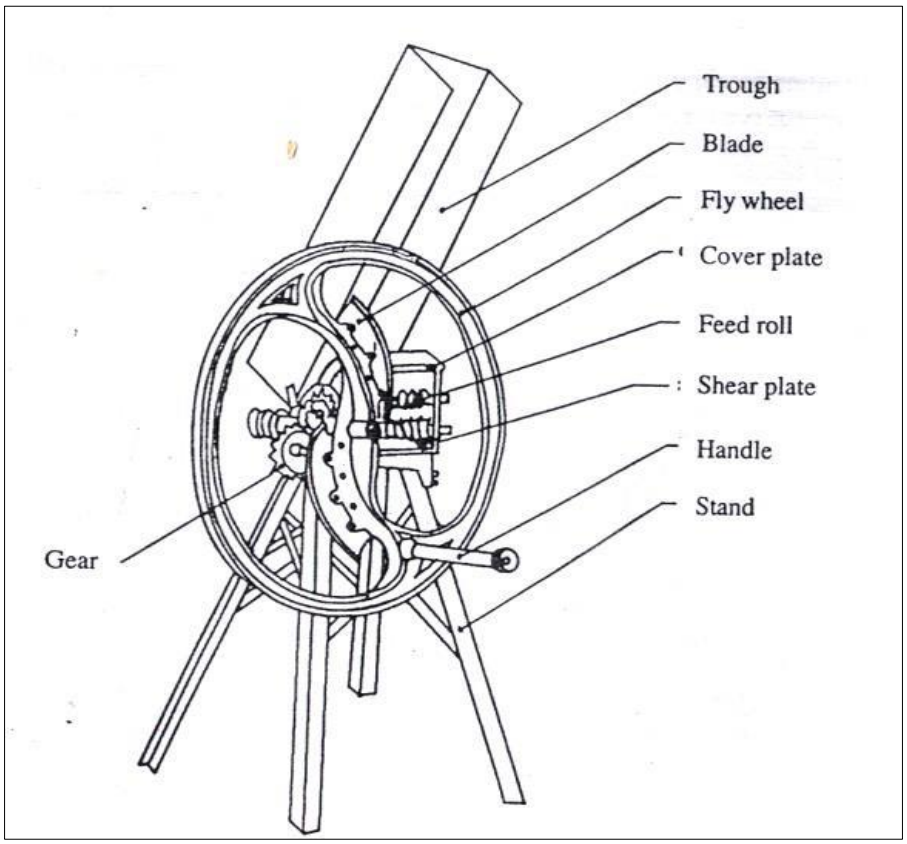

Figure 4: Components of a chaff cutter (manually operated) (Source: Centurion University, 2020)

According to Mondal, (n.d), Powerful Mantras, (2016) and Telang, (2016) the main components of a chaff cutter are:

- Flywheel: It is used for mounting blades and storing energy for cutting the chaff during operation. It is usually heavy (not less than 24 kg). A linchpin with a chain is used to lock the flywheel when not in use. This locks the movement of the chaff cutter blade so as to prevent injuries due to accidental rotation. A bolt is also fitted in the holes of the leg and the flywheel rim and tightened with a nut.
- Main shaft: One end of the main shaft shall be rigidly attached at the centre hole of the flywheel.
- Feed/spiked rollers: They drag the crop inside the cutting housing for preventing hazards to human being. A guard should be provided on the rollers and cutting housing to avoid accidents during feeding of the crop.
- Side plates: These are fixed on two sides of the stand. The spiked rollers are held in proper position by these plates.

- Feeding trough: This is attached on the rear side of the shear plate. Its total length should be a minimum of 900mm.
- Shear plate: A rectangular plate with top open attached at the front of the feed rolls. They act as a stationery member of the fodder cutting mechanism.
- Stand: It consists of four legs with braces in between the legs to make it firm and durable. It is fixed on the ground.
- Handle: It consists of a handle support of mild steel rod and a wooden grip placed over the rod.
- Worm and worm gear: The worm is fitted on the main shaft. They regulate the fodder cutting into small bits of desired length. They control the rate of feeding the fodder for chopping. The worm is fixed on the shaft which carries the flywheel.
- Blades: These are mounted onto the flywheel.
- Housing: This is found on some machines. It covers the cutting blade and protects the worker from touching the blades accidentally (Patil *et al*., 2016).

A paper published by Telang, (2016) described how a chaff cutter works. Blades are attached to the fly wheel through which the chaff or straw or hay can be cut. Chaff is feed through tin sheet metal into a feed roller, where worm gear is available. When fly wheel rotates, the fly wheel shaft is connected to the feed roller, by which the roller will rotate and it will move the chaff towards the blades. Then chaff will cut into small pieces. According to Mwangi, (2018) most chaff cutters used in Kenya have parts manufactured in India which are then assembled locally. During the use of the machine, the operator is usually safe since a steel mesh guard is provided which prevents them from getting into contact with the blades. However, there is a risk of injury to workers when feeding the fodder into the chute or during the process of cleaning or removing materials stuck in the chaff cutter. Chaff cutter are operated either manually or can be powered using electric or diesel engines. Injuries are more common and more severe with the electric driven types. For example, the incidence of Abbreviated Injury Score (AIS) 2 and more severe injuries was 5.1 per thousand of manual cutters and 8.6 of powered chaff cutter machines (Mohan, Kumar, Patel, & Varghese, 2004).

Figure 5: A fuel powered chaff cutter (Source: Author, 2021)

There has been an increase in agricultural productivity as a result of mechanization of agricultural practices resulting in less time spent on some agricultural activities. Previously, animal feeds were cut using machetes, which took too much time and the resulting feeds would be of variable sizes and not the best for proper digestion by livestock upon ingestion.

Figure 6: An electrically powered chaff cutter in use (Source: Author, 2021)

The risk of getting injured while doing agricultural work in America (which is 52 per 100,000) is higher than that of workers in mining and building industries. The uniqueness of the agricultural workplace and the exposed population combine to increase risk of injury. These features include a wide range of activities, hazards and dispersed work places in agriculture; a seasonal hired work force that often has brief tenure, poor English skills and a distrust of officialdom; and a history of exemption regarding occupational health and safety regulations (McCurdy & Carroll, 2000).

Accidents due to farm machinery were more in the villages in Southern India with tractor incidents being highest (27.7%) followed by thresher (14.6%), sprayer/duster (12.2%), sugarcane crusher (8.1%) and chaff cutter (7.8%) accidents. Powered machinery was responsible for most of the fatalities with an annual fatality rate estimated at 22 per 100,000 farmers. Hand tools related injuries accounted for 8% of the total accidents and were non-fatal in nature (Nag & Nag, 2004). In another study by Tiwari *et al*., (2013) tractor-related incidents were highest (46.0%), followed by threshers (14.5%), sickles (10.5%), electric motors and pump sets (7.9%), snakes (5.3%), chaff cutters and wells (4.0% each), grain mills (2.6%) and pickaxe, self-propelled machines, sprayers and agricultural chemicals (1.3% each). Chaff cutters had an incidence rate 1.91/1000 machines/year in a farm; the work environment is informal compared to the industrial setting. Therefore, learning in a farm is informal (knowledge is obtained from the farmers' own family or through personal experience) as opposed to the industrial setting where learning is formal (regular check-up, repair and maintenance of agricultural machines). As a result, there is an increase in morbidity and mortality in the farm setting due to this neglect by both the government and social sector (Faisal, Lodhi, Yaqoob, Pervaiz, & Irfan, 2015). Manufacturers of chaff cutters need to adhere to optimum standards of safety for these machines. There is also a need to carry out awareness campaigns (through mass media), especially in rural areas, on measures to maintain safety while in possession of a chaff cutter such as locking of these machines. Chaff cutters are a very common cause of injuries particularly amputations of the upper limbs at different levels.

Unlike other economic activities, there is a high prevalence of injuries among the paediatric population secondary to farm activities due to the ease of access to machines as they are set up and used in homesteads (Kumar, Singh, & Singh, 2013). In most cases of paediatric injuries, the children's fingers were cut by the blade when another child rotated the flywheel while they were playing with the equipment (Mohan, Kumar, Patel, & Varghese, 2004). The events surrounding injuries caused by chaff cutters include playing with the machine, especially by children, slips while sharpening blades, cleaning the machine itself, removing grass from the gears of because of entanglement (Mohan, Kumar, Patel, & Varghese, 2004). Locally, there have been a number of cases of injuries to the upper limb secondary to chaff cutters. One case that was highlighted in the local dailies was that of Joseph Mbugua, a 17 year old boy from Kiambaa, Kiambu County, was cleaning a chaff cutter when the electric device chopped off his right hand at 11am on January 26, 2018. He rushed for help from a neighbour who quickly tied the wound, looked for the severed hand, put a cloth on it and rushed to hospital from where the hand was wrapped in a plastic bag and put in a cool box. Joseph was then referred to Kenyatta National Hospital. He was received 10 hours after the accident and the doctors took another 3 hours cleaning and planning for the reattachment. The operation lasted

around 7 hours in total (from 10pm on January 26th 2018 to 6am on January 27th 2018) and involved a team of 15 staff including plastic surgeons, anaesthetists, orthopaedic surgeons and nurses. One team prepared the hand while the other worked on the stump. Restoration of blood flow occurred after 3 hours (Health Business, 2018; Kabale & Kwamboka, 2018). Joseph stayed in hospital for two months prior to his discharge from hospital. The total hospital bill was Ksh.7 million, which was paid by KNH and well-wishers. He eventually regained sensation on his hand and was able to move his thumb. He attended physiotherapy sessions at KNH three times a week with each sessions costing Ksh.600. The dependence of manual labourers on their hands to be able to work is highlighted by a statement made by Joseph, "I was scared at the prospect of being an amputee. I imagined how hard life would be without my right hand. You know men are supposed to work and provide, and without the right hand, that would be difficult" (Aradi, 2018). According to Kaisha and Khainga (2007), the handedness of an individual was not predictive of the increased likelihood of one hand being injured. The most common causes of hand injuries were occupational (31.3%) and assaults (30.3%). It is only in falls that the risk of injury to dominant hand is significant.

Epidemiology of Upper Limb Chaff Cutter Injuries*:*

Hand injuries account for approximately 5.5% of all trauma patients seen at the emergency department and this leads to a significant degree of incapacity as 5% may not be able to use the injured hand at the end of one month (Makobore *et al*., 2015). This shows how burdening these injuries can be, and several studies are in support. Manley, Wormald and Furniss, (2019) in their study documented a 76% increase in the total number of hand injuries, with the overall incidence of the injuries increasing from 70 to 110 per 100,000. Hand and wrist injuries are the most expensive injury types, accounting for 740 million US dollars, ranking above knee, lower limb, hip and skull-brain injuries with 56% of the total cost attributed to productivity costs (that is time off work due to disability, illness or premature death). This high productivity cost is for people in the age group of 20 to 64 years (de Putter *et al*., 2012). Hand injuries comprise of 1.3% of all new attendances at the accident and emergency department of MTRH (Mwangi, 2012). Chaff cutters caused 6% of these hand injuries and were found only in the farm. Elsewhere in Kenya, Wairegi, (2019) at Kenyatta National Hospital documented that the high number of cases managed for chaff cutter injuries were closely dependent on the age, literacy level and time of the day. Wanjara and Oduor, (2022) on the other hand documented in 47 patients a positive correlation between age and severity, being more likely in the 21-40 year- age group (70%), and majority (98%) of the injured were males. Shrestha *et al*., (2018) found that 31.7% of hand injuries attended to at the casualty department was caused by fodder cutters. Males are the more commonly affected gender when it comes to injuries due to chaff cutters or other agricultural machines in the farm. In a study by Faisal *et al*., (2015), more than 90% of the cases injured by agricultural machines were male most of them being young with a mean age of 24.4 years, with a range of 5-60 years. In a study by Mehmood *et al*., (2015), 60.6% of the patients were male. Ch *et al*., (2016) however documented more females and children (41; 56%) than males (32; 44%). The age range was 13-61 years, with a mean age of 34.15 years (Mehmood *et al*., 2015). According to Hansen and Cartensen, (1986) agricultural injuries are highly gender specific with 90-97% of these injuries occurring in male. They found a mean age 39.4 years with a range of 3-68 years among patients with hand injuries caused by agricultural accidents. According to Mwangi in 2012, for patients who sustained hand injuries, the male to female ratio was 3.63:1. A study in India noted a higher prevalence of agricultural injuries in the young and older members of the community between 21-40 years. Another study done by Mucci *et al*., (2020) on the overall upper limb injuries due to agricultural activities noted the mean age of those inflicted between the ages of 34 and 43 years. Most of the injuries were sustained by males. Allen *et al*., (2015) noted an equal distribution based on gender and age but reported a higher prevalence of open wounds in the upper limbs among males with no difference in terms of age.

According to Shrestha *et al*., (2018) males who had hand injuries caused by fodder cutter accounted for 60 per cent of the study participants. In the same a study done in Nepal, 175 patients presented with hand injuries. Of these, 55 cases (31.7%) were caused by fodder (chaff) cutter machines. Most of the injuries were noted among children under 15 years old, with a mean age of 15.755 years (2-57 years) contributing to 72.7 percent of the total cases. Most of the patients reported having been playing in the farms when the incidences occurred. Moreover, 25.5 percent of the injuries took place on Saturday, when all children and parents are off school and work, respectively, to enjoy weekend activities. In addition, 60% of the cases were males; the rest were females. In 49.1% of the cases, there were bone fractures, with the right hand (52.7%) being affected more than the left hand at 47.3 percent. Most of the cases with fractures (51.8%) were of the Gustilo II variety, and 90% of the patients had minor to moderate degree of hand damage on grading with HISS grading (Shrestha *et al*., 2018). Another study done in Pakistan on the risk factors for chaff cutter amputations involved 73 patients. Out of this number, 44 percent were males, the rest being females and children. Upper limb injuries were noted in 69 patients, with four patients having the involvement of both limbs (Muhammad *et al*., 2016). Another study in Pakistan that aimed to evaluate the demographic features and patterns of injuries sustained from chaff cutters involved fifty-six patients, 68 percent of them being males and 32 percent being females. The mean age was 24+/- 12 years. Most of the injuries (86 percent) occurred while operating the machines at home, 14 percent while working on the farms. A majority (75 percent) sustained injuries while operating machines that were electric

motor driven, and in 25 percent of the cases, they were manually operated (Tunio *et al*., 2021).

Another study noted a higher risk of injury in those with little to no education. Patel *et al*., (2018) stated the prevalence of injury among illiterate workers to be at 59.9 percent. According to Wang *et al*., (2011), workers with less than twelve years of education contributed to 79.2 percent of injuries. According to Khuram *et al*., (2015), it was noted that majority of the workers were illiterate or semi-illiterate. Having lower family income, having poor hearing, being in debt and feeling stressed were significant risk factors for injuries caused by agricultural machinery in northern China, with majority (46.6%) of the injuries occurring in farmlands. Safety training was not identified as a major component of injury risk (Zheng *et al.,* 2014). According to them, the overall annual prevalence of agricultural machinery-related injuries among the operators was 13.1 per 100 workers. The highest injury prevalence was among those 30-39 years of age. Faisal *et al*., (2015) found that wearing loose clothes is one of the common risk factors for injuries caused by agricultural machines. According to Jadhav *et al*., (2015), the risk factors for agricultural injury were as follows: male gender (versus female), full-time farmer (versus part-time), owner/operator (versus family member or hired worker), regular medication use (versus no regular medication use), prior injury (versus no prior injury), health problems (versus no health problems), stress or depression (versus no stress or depression), and hearing loss (versus no hearing loss). All selected factors except health problems significantly increased the risk of injury. In a meta-analysis by Jadhav *et al*., (2016), It was discovered that the risk for agricultural injuries increased in people with higher education (better recall), shorter working experience, people residing in farms (greater exposure to farm work/environment), challenging social conditions (compromised inter-personal relationships), animal production (versus crop/other production), greater co-operation between farms (borrowing malfunctioning machine from other farmers without knowing its condition), unsafe practices conducted (hurrying when working, less frequency of turning off machinery) and poor machine maintenance. The study was inconclusive for alcohol and safety training as risk factors for agricultural injury and it was recommended that their association with agricultural injury be conducted. Under injuries caused by agricultural machines, those caused by chaff cutter vary significantly: 65% of the patients were injured by chaff cutters while 43.5% of injuries were on the upper limb, which was the most commonly affected part of the body, with amputations at different levels being the most common injury (Faisal *et al*., 2015). About 51.5% of patients were injured by a fodder cutter with other causes of agricultural injuries being tractor (18.18%) and wheat thresher (15.15%) (Mehmood *et al*., 2015). Individuals working in the agricultural sector have an injury risk of approximately 5%- 10% per year, though this may differ from region to region (McCurdy & Carroll, 2000). The timing of the injuries was mainly in the morning, followed by afternoon cases at 41 percent, and lastly, evening at 10.7 percent (Tunio *et al*., 2021). Bhattarai *et al*., (2016) noted that the incidences occurred in the morning. In general, agricultural injuries were influenced by seasonal patterns, with fewer injuries noted in January and February (Bhattarai *et al*., 2016). The study indicated that most of the patients received treatment for injuries related to agricultural activities between January and June, the first half of the year. Further, a similar study found that the prevalence of agricultural injuries to be higher in the summer, between June and August (Voaklander *et al*., 2020). Another study, however, noted the prevalence to be higher in the second half of the years, between October and December (Mucci *et al*., 2020). Bhattarai *et al*., (2016) noted that injuries were more common in the rainy period.

Characteristics of Patients with Upper Limbs Chaff Cutter Injuries*:*

Injury is defined as physical damage occurring to an individual due to an acute exposure to energy levels outside the normal tolerance bands for human tissue (Robertson, 1998). Agricultural machinery-related injuries were defined as injuries that occurred during agricultural activities involving agricultural machinery that resulted in reduction of usual activities for at least half a day or required professional medical treatment, having been diagnosed with an impairment, or receiving emergency nursing care from family, colleagues, teachers or partners (Zheng *et al*., 2014). In a study by Mwangi, (2012) chaff cutters caused 32% of Gustillo type III open fractures. Most of the traumatic amputations, which accounted for 11.6% of all hand injuries, were caused by the chaff cutters which caused 22% of extensor tendon injuries. Traumatic amputation, most commonly of the upper limb, was the commonest type of injury inflicted by fodder cutters (57.57%) (Mehmood *et al*., 2015), followed by crush injuries (12.12%). Other injuries sustained while using agricultural machines include avulsion injuries of the genital and scalp (6.06%), fracture (6.06%), soft tissue laceration (6.06%), multiple injury (6.06%), dislocation (3.03%) and sprain (3.03%).

According to Dinesh *et al.,* (2020), the part of the hand that was most commonly involved in trauma was the little digit at 25.6% followed by the ring digit at 21.1% with the distal phalanx being the most injured part of the digit. At the same time, combined injuries associated with open fractures and dislocations made up majority of injuries observed in the same study. In the same study, there were cases of bilateral hand injuries. According to Hansen and Cartensen, (1999) the most common injuries to the upper extremity due to farming accidents were lacerations and amputations (45%) followed by fractures (36%). Amputations and lacerations of the hand and fingers were commoner in accidents with machinery and fractures were commoner in injuries from animals. Traumatic injuries of the fingers

and high energy open fracture of the radius and ulna are among the commonest upper extremity injuries caused by entanglement in farm machinery (Copuroglu *et al*., 2012).

According to Ahmed *et al*., (2016), in 100% of the patients, the upper extremity was affected in the study. In the upper limb, the sequence of patients sustaining injuries in order of maximum to minimum are digits, mid carpal, at wrist, forearm and arm respectively. In agriculture-related injuries, trauma to hand and upper extremity are extremely common representing from 40% to 70% of total admissions that occur on a farm yard (Jawa *et al*., 2013). According to Hansen and Cartensen, (1999), the most common injuries to the upper extremity due to farming accidents were lacerations and amputations (45%) followed by fractures (36%). Amputations and lacerations of the hand and fingers were commoner in accidents with machinery and fractures were commoner in injuries from animals. Traumatic injuries of the fingers and high energy open fracture of the radius and ulna are among the commonest upper extremity injuries caused by entanglement in farm machinery (Copuroglu *et al*., 2012).

In another study (Ihekire, Salawu & Opadele, 2010) hand injury in the developing country such as Nigeria, are commonly due to road traffic collisions and machine accidents, and the injuries are usually severe. Hand injuries are commonly seen among technicians and civil or public servants; these people constitute the economic work force.

In a study by Giladi *et al*., (2014) single finger only amputations accounted for 51.2% of all traumatic finger and thumb amputations. Other amputations involved multiple finger (28.6%), thumb only (13.1%) and multiple fingers plus thumb (7.1%). A study done in Pakistan on chaff cutter injuries was carried for six months. The total number of patients was 30, out of which 23 were males, and 7 were females. The median age was 25. 26 of these had upper limb injuries, 2 with lower limb injuries, and one with an injury to the head and neck region together with the genitals. In 16 patients, the injuries were in the right hand, while ten patients had the injuries in their left hands. The most common site of injury on the upper arm was the wrist 9, digits 8, forearm seven, and arm 2. Because the patients presented late, none of them received replantation. Other factors included lack of the amputated part and multilevel avulsion as well as crushing injuries. After resuscitation, there were 18 cases that were amputated, eight had stump formation, and four cases had debridements (Muhammad *et al*., 2016).

Another study found that out of 214 patients with open wounds in upper limbs due to agricultural accidents, 40 became contaminated after injury. Seventeen were superficial wounds, 16 were deep infections involving the soft tissue of the upper limbs, 7 cases were complicated with osteomyelitis, 6 underwent amputation due to secondary infection. The study also found patients with severe tendon, nerve, and muscle injuries at the level of the elbow or forearm, all of whom developed infections (Shabir, 2018).

In a retrospective study done in India among 73 patients, 32 percent had an injury to the digit, 30 percent had palm level injuries, 20 percent had distal forearm injuries, 15 percent had proximal forearm injuries, and 4 percent with arm injuries. Treatment options for the patients included stump formation for those with crush injuries; revascularization was successful in 4 percent of the patients (Ch *et al*., 2016).

In a study in Pakistan that aimed to evaluate the demographic features and patterns of injuries sustained from chaff cutters, all patients had injuries involving the upper limbs. The most common injuries were severing of the distal phalanges 13 percent, followed by the palm and dorsum of the hand and the severing of the carpometacarpal joints, both at 11 percent (Tunio *et al*., 2021).

In the more recent study shedding light on the insights into agricultural machine injuries in Pakistan, being an orthopedic surgeons survey (Raza *et al*., 2024), the fodder cutter was a primary source of injuries with 201 injuries documented, accounting for approximately 40% of all injuries. Majority of the injured were male, who were relatively young. This research advocated for safety regulations, accident reduction measures, and increased safety awareness among farmers, aiming to foster a safer and more sustainable agricultural environment in Pakistan.

Open wounds and fractures are usually the commonest reason for hospital admission due to the risk of infection, with injuries to the upper limb being the majority of cases. The types of injuries included lacerations and amputations. The commonest organisms isolated from the wounds were *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Klebsiella* species (Ravikumar *et al*., 2017). Another study isolated *Salmonella* and *Staphylococcus* from open minor wounds (Pate & Nummer, 2013).

***Risk Factors*:**

Personal factors including physical and mental exhaustion, overworking without taking breaks, hastiness to finish earlier, and overconfidence in operating the machine contribute to injury. In addition, the majority of the equipment consists of various parts such as gears and pulleys onto which loose-fitting clothes may be entangled (Tunio *et al.,* 2021). Jadhav *et al*., (2016) in their meta- analytical study documented several varying risk factors, including and not limited to sociodemographic, environmental, residential and conditions of the machinery being used. Eighteen of the 25 risk factors were significant. The identified risk

factors should be considered when designing interventions and selecting populations at high risk of injury.

***Treatment of Patients with Upper Limb Chaff Cutter Injuries**:*

Hand and fingers tolerate injury and immobilization poorly and thus accepted protocol for treatment for hand injuries is immediate reconstruction of all injured tissue structures because the quality of primary treatment often determines the maximal potential for recovery (Ahmed, 2010). Sterling Bunnell (Newmeyer, 2003) considered the founding father of hand surgery, stated that a "bad hand" is functionally better than a "good amputation". Replantation of amputated limbs as a result of operating a chaff cutter injury is now a standard and is the treatment of choice. This has been done in specialized hand and microvascular surgeons in units using high end microsurgical techniques and equipment. There is a need for knowledge by the public on proper preservation of amputated parts and transport to a surgical centre for replantation/revascularization. This involves wrapping the amputated part in a clean, moist cloth before putting it into an ice box. Note that the part should not come in direct contact with ice. The higher the level of amputation, the shorter the time limit for replantation (up to 24 hours for finger level and up to 6 hours for mid-arm level) (Mahajan, 2016). According to Mehmood *et al*., (2015), refashioning of the amputated limb and stump formation is the most common form of surgical management (63.6%). About 12.12% of the patients were referred to plastic surgeons for further management. Other forms of surgical interventions include debridement/antiseptic dressing/skin grafting (15.15%), fixation of fracture (6.06%) and manipulation under anaesthesia for shoulder dislocation (3.03%). According to Rabbani *et al*., (2012), 18.9% of patients with hand injuries due to fodder cutters were not offered replantation due to late presentation, multi-level injuries or element of avulsion and as a result, they underwent stump formation or wound closure by fasciocutaneous flap. The rest of the patients were offered replantation (69.9%) and revascularization (11.32%). Due to inadequate access to care in many regions in the world, replantation rates are less than 5% (Omoke *et al*., 2012) with stump refashioning and revision accounting for 70% of the definitive treatment. Dinesh and colleagues in 2020 found that 65.5% of all hand injuries were managed non operatively through immobilization using plaster and strapping while 34% were managed through surgical intervention. In a study by Mwangi (2012), none of the partial amputations or completely amputated appendages had revascularization or replantation done. As the severity of injury increased, the difficulties in the treatment of the hand were magnified and options were limited. According to Friedrich *et al*., (2011), 73% of thumb and 88% of finger traumatic amputations were treated with revision amputation in the United States.

Management:

Patients were resuscitated according to the advanced Trauma Life Support (ATLS) protocol. After being stabilized, they were referred to plastic surgery for evaluation and further management. Initial management also involved antibiotic prophylaxis administration, tetanus prophylaxis, wound cleaning, and debridement, which should be done aggressively to minimize prolonged hospital stay resulting in secondary infections, complicating wound healing. The surgery included amputations flap coverage and stump formation together with grafting, reimplantation, and reconstructive surgery. Most of the injuries involved the right upper limb. Injuries ranged from amputated arms, distal phalanges, hands, forearms, and arms (Shabir, 2018). The majority of the injuries involved shearing, compression, and thermal injuries, which were usually contaminated, coupled with degloving injuries as well as amputations of hands or phalanges (Ali *et al*., 2021). Sixty-one percent of patients were admitted within 12 hours of the incidence and 39 percent 12 hours or more later. Thirty-eight patients were admitted after 24 hours, a poorer prognosis was noted in these patients. Patients were treated with Kirschner wire fixation, nerve repair, shortening and repair, flaps, cross finger flap, skin grafting and primary closure of the wound. Postoperative complications included infections, wound dehiscence, necrosis, edema, stiffening of hands and fingers. Eighty percent of patients went back to work between 3-4 months. The rest developed complications and had to be admitted longer (Ravikumar *et al.,* 2017).

***Preoperative*:**

Several factors are usually considered before surgical intervention. The period prior to presentation at the emergency department plays a crucial role in further patient management. It determines whether reimplantation will be successful in the case of an amputated part, keeping in mind the duration and extent of ischemia of the tissues. This time frame must not exceed 8-10 hours for the upper extremity. Past this small window, the chances of reimplantation being successful dramatically reduce. In addition, the mechanism of injury gives insight into possible wound contamination, the extent of tissue injury, and deficiency in function (Mucci *et al*., 2020). Accidents related to agricultural activities are more likely to have debris lodged in the depth of the wound. In addition, crush injuries that result cause decreased tissue viability, especially if the upper limb is involved, coupled with neurovascular damage. Nerve damage and repair result in poorer outcomes because it is dependent on the distance between the damaged neuron and the motor end-plate (Mucci *et al*., 2020). There are other factors such as whether the dominant hand was involved and its viability, presence of comorbidities, and whether they are controlled all influence patient outcomes. They influence the decision on the timing of soft tissue coverage (Mucci *et al*., 2020).

***Intraoperative*:**

The injured extremity is first thoroughly irrigated to remove gross contamination. Next, a tourniquet is applied to facilitated tissue debridement with an aim to prepare the bed for wound closure. The debridement process is characterized by the removal of necrotic and contaminated tissue, taking great care to preserve all viable struggles, thus maintaining functionality. Removal of dead tissue is coupled with generous irrigation of the wound with either normal saline or Ringers lactate. The tourniquet is then removed to ensure adequate debridement. Radical debridement is preferred over serial debridement for the primary setting (Ravikumar *et al*., 2017). The next step after debridement is providing a stable bony framework. Fixation of a fracture is done using external fixators supplemented with Kirschner wires or by plating for rigid internal fixation. Autografts from the fibula, radius, and iliac crest are used in bone defects. If there is a need to minimize the operative time, especially if the patient is unstable, a bridge plate or external fixator may be used. The fixation can be converted to a plate once the patient is more stable (Ravikumar *et al*., 2017). Vessel reconstruction follows next. It involves trimming proximal to healthy edges before primary repair. Vein grafts derived from the great saphenous can be used to bridge vascular gaps in which primary anastomosis are not possible. Repair of flexor tendons should be done in the primary stage. Repair of extensor tendons can be delayed, however. Nerve reconstruction can be done with the use of bridging veins, silicone, or any other material as long as it is absorbable. If debridement is done too extensively so that tissue function is lost, the next step is primary amputation followed by prosthesis fitting, if available and possible. In addition, once the level of amputation reaches the radius, chances of maintaining function are extremely slim. The severed part can provide soft and skin tissue for the amputation stump (Ravikumar *et al*., 2017). A free flap has been recommended in many studies as it has been shown to cause shorter hospitalization and early commencement of rehabilitation for mobilization. The use of vacuum-assisted closure has been recommended for reconstruction in the delayed setting. It improves blood flow to the wound bed with the earlier formation of granulation tissue (Mucci *et al.*, 2020). Once the surgeon deems the wound bed ready for closure, the process of reconstruction can be addressed using the reconstructive ladder. VAC decreases wound size, making reconstruction easier. The choice of flap depends on pedicle length. The types of flaps that can be used are perforator-based, local, or random patterns. In addition, tissue transfers can be done by designing mucocutaneous, chimeric, fasciocutaneous, or fascia-only flaps (Mucci *et al*., 2020).

Postoperative:

Extreme care should be taken if free flap reconstruction is done for the protection of the pedicle. The patient should be started on a rehabilitation program because patients with upper limb injuries are predisposed to stiffened joints following long periods of immobility. The patients often require secondary procedures such as the release of contractures, corrective osteotomies, tendon, and muscle transfers, among others, to prevent sequelae associated with decreased joint mobility like contracture formation and tendon adhesions (Mucci *et al*., 2020).

***Prevention*:**

Prevention mainly aims to reduce direct contact between the machine and the machine operator and cutting blades. Some of these protective measures may include shielding the cutting edges as well as the introduction of a fodder feeding tunnel. In most cases, the chaff cutters are in an open field where anyone can easily access them (Tunio *et al*., 2021). This could be tackled by building unique houses where this equipment can be kept away from the reach of those unaware of how to operate them and the introduction of emergency brakes and automatic switches (Ali *et al*., 2021).

***Outcomes of Management of Patients with Upper Limbs Chaff Cutter Injuries**:*

Physiological outcomes measured by clinicians offer important information on the recovery status of the patient. However, patient-reported outcome measures are increasingly used to assess patients' experience with illness and disability (Horng *et al*., 2010). This is to enable assessment of the patient's ability to perform most of their day-to-day activities. If they are unable to do so, the management process is considered a failure. Hudak *et al*., (1996) first described the DASH (Disabilities of the Arm, Shoulder and Hand) score whose main objective was to develop a regional outcome measure which conceptualizes the upper limb as a single functional unit. It gave greater relevance to the input from the patient himself rather than relying on other factors, such as radiographs, range of motion and grip strength. DASH is self-administered by patients and aims to capture the patient's own perception of upper extremity function. A study by Dacombe *et al*., (2016) showed that the Disabilities of the Arm, Shoulder and Hand (DASH) Questionnaire is the most commonly used Patient-Reported Outcome Measure (PROM) for hand and wrist trauma. It has shown good reliability, validity and responsiveness but its validity has been questioned in as a measure tool in a hand and wrist population. In the same study, Patient-Rated Wrist Evaluation showed the best demonstrated reliability and validity in a wrist trauma population. It was also the most responsive measure for distal radius fracture population though it is specific for the wrist and has little use in assessing hand injury patients. The DASH score is the best instrument for evaluating patients with disorders involving multiple upper limb joints (Changulani *et al*., 2008). Mehmood *et al*., (2015) found wound infection to be the most common complication (33.3%) after agricultural related injuries. Wound infection was the most common complication at 56.6% after traumatic amputation

(Omoke *et al*., 2012). In a study done by Rabbani *et al*., (2012) there was a 75.6% success rate in replantation after upper limb injury secondary to a fodder cutter and all re-vascularized hands/digits survived. In the same study, most injuries involving various parts required plastic surgical intervention with availability of microsurgical skills which were not available in most tertiary care hospitals. This, coupled with patients coming from far-off places (reduced chances of getting timely plastic surgery intervention) reduced the chances of better functional outcome. According to Ng *et al*., (2014) patients with major upper extremity re-plantations after traumatic amputations continued to experience reduction in range of motion, even after follow up of four years, by 59.4% for the mean total active range of motion for the best digits in the replanted extremity compared with the non-affected extremity and in grip strength (reduced by 87.4% compared to the non-affected extremity). The mean DASH score of seven patients was 75.4±14.2 of 100 (range 59.2 to 91.1). In the first 2 months, the DASH score may decrease due to the rehabilitation protocol used in tendon injuries where a hand injury patient should not use his hand in the first 4 weeks post-surgery and the hand is also splinted till approximately the sixth week. Afterwards, as the range of motion and strengthening exercises are done, the disability score decreases markedly (John & Verma, 2011). The Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) questionnaire is an 11-item version of the Disabilities of the Arm, Shoulder and Hand questionnaire and has been validated for use after hand trauma. The Quick DASH centers on evaluating function and activities of daily living. Scores range from 0 (no disability) to 100 (most disability) (Beaton *et al*., 2005). The QuickDASH is as effective as the full DASH in detecting meaningful change or responsiveness in patients with hand pathologies (Derks, 2014). Similarly, according to Gummesson *et al.,* (2006) QuickDASH can be used instead of the DASH to measure disability/symptom severity with similar precision in a variety of arm disorders. According to Aasheim and Finsen, (2014), QuickDASH should be preferred over DASH as it gives the same information, is more convenient and more often responded to. In a study on major upper limb amputation (amputation at the forequarter, shoulder disarticulation, transhumeral, elbow disarticulation, transradial, or wrist disarticulation level) on war veterans by Resnik *et al*., (2019), the mean perceived disability (measured by QuickDASH) scores were 49.5 (SD 20.7) for unilateral and 34.7 (SD 22.0) for bilateral major upper limb amputation. According to Giladi *et al*., (2014), the mean ± SD QuickDASH scores of traumatic finger and thumb injuries more than a year after revision amputation were 11.4 ± 14.6 (single finger only), 9.1 ± 11.9 (thumb only), 17.9 ± 18.0 (multiple fingers) and 18.6 ± 20.6 (multiple fingers plus thumb). Rosenberg *et al*., (2013) looked at the costs and outcome of serious hand and arm injuries during the first year after trauma and found that the DASH score decreased significantly over time with median (interquartile range) of 30 (2-80) at three months, 17 (1-61) at six months and 12 (0-57) at 12 months. Delayed reconstruction of an acutely injured hand leads to a high incidence of complications such as joint stiffness, persistent pain, infection and late amputation and poor outcome reflect poor or delayed management and poor rehabilitation (Ahmed, 2010).

METHODOLOGY

***Study Site**:*

This study was carried out at Moi Teaching and Referral Hospital situated in Eldoret, Uasin Gishu County in Kenya. MTRH is located 320 kilometres Northwest of Nairobi. It is the second largest referral hospital in Kenya and has a bed capacity of 1000 patients. As per the central statistics of the hospital, MTRH has an average attendance of 600 outpatients per day, with the Accident and Emergency Department receiving over 10,000 outpatients per year. The Orthopaedics Department attends to over 1300 inpatients per year. The hospital serves a population of approximately 24 million, receiving patients on referral from other private and public hospitals or institutions, patients from western Kenya, parts of Eastern Uganda, and the southern Sudan for specialized health care. It also provides facilities for medical education for Moi University College of Health Sciences and other health institutions like Kenya Medical Training Centre (KMTC), University of Eastern Africa, Baraton, and the ECN (Enrolled Community Nurse) upgrading programme as well as international students on exchange programmes courtesy of Moi University (AMPATH, 2016). The study was conducted in the Accident and Emergency department, the orthopaedic wards and the consultant clinics.

***Research Design**:*

This was a hospital based prospective study in which the patients were followed up for 3 months, with contacts on admission then at 2, 6 and 12 weeks after discharge for treatment of upper limb chaff cutter injuries. The patient's regular follow up is partly per their treatment schedule at MTRH Orthopedic department.

Study Population:

The study population was all patients who were managed at MTRH due to chaff cutter injuries involving any part of the upper limb between March 2019 and February 2020. Inclusion criteria- the study included patients of all ages and gender who presented with upper limb injuries sustained while using a chaff cutter. Exclusion criteria- patients with previous injury or surgery on the affected upper limb, patients who were unable to give consent including minors and patients who are mentally incapacitated or disabled who did not have a parent or legal guardian present, minors who declined to give assent, irrespective of their guardian consent.

***Sampling Technique and Sample Size**:* This was a census type of study targeting patients with upper limb injuries secondary to chaff cutter who present at MTRH.

Data Management:

Once informed consent was obtained, the data was collected using a structured questionnaire at the first visit to hospital after the injury and then the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) Questionnaire was administered at weeks 2, 6 and 12 of follow up from the first meeting. The Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) questionnaire was used to assess the patient reported outcome measures. The principal investigator carried out the data collection. Upon collection, data was kept in a cabinet under lock and key by the principal investigator. The end point of the study was after 3 months of follow up of the patient from the time of discharge.

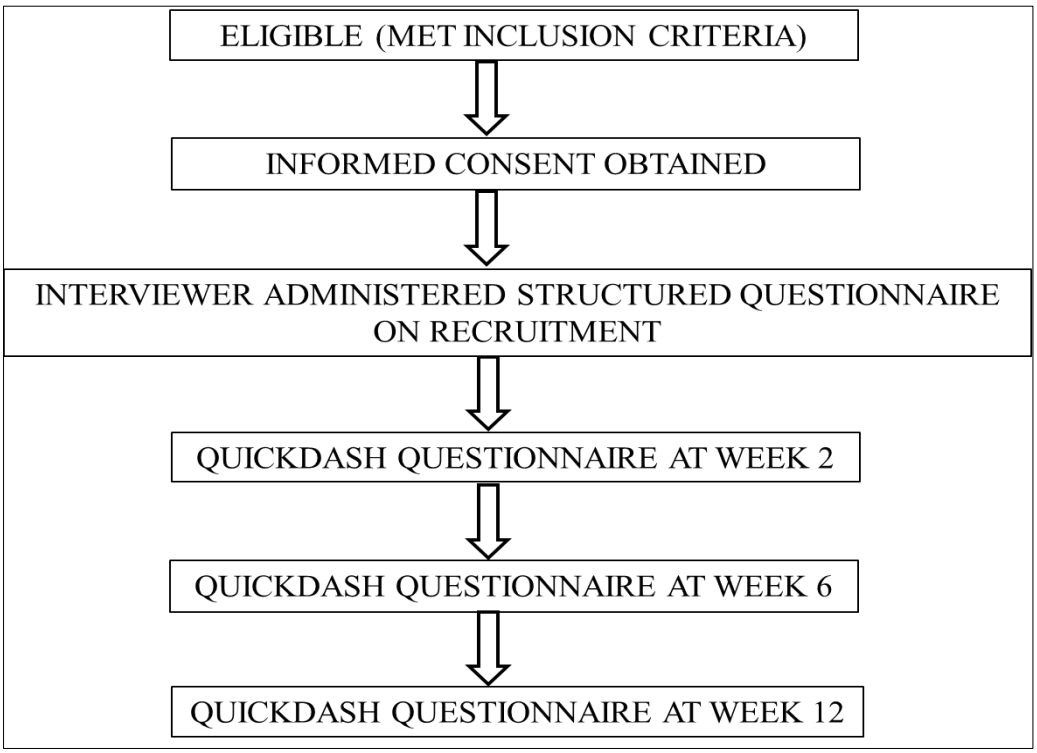

Figure 7: Data collection process (Source: Author, 2021)

Completed questionnaires were checked for completeness and coded accordingly. The data was entered into a computer using data entry software. It was exported to RCore for analysis. The analyzed data was presented in prose form, pie charts, histograms, bar charts and diagrams. Descriptive statistics such as mean, median and interquartile range was used for continuous data. Frequency listings were used for categorical data. Kruskal-Wallis test was used to assess the QuickDASH scores. The burden of injuries was calculated as a percentage with the numerator as the total number of participants in the study and the denominator as the total number of patients admitted to the orthopaedic wards during the study period with upper limb injuries of any etiology.

***Ethical Considerations**:*

Permission to carry out the study was sought from IREC of Moi University and Moi Teaching and Referral Hospital (Reference IREC/2018/311; FAN: IREC 3256, dated 14/3/2019). Permission was also granted by the MTRH Chief Executive Officer (Reference ELD/MTRH/R&P/10/2/V.2/2010, dated 18/3/2019). The purpose of the study was fully explained to all patients. In cases of language barrier, an interpreter was used to explain the purpose of the study. Thereafter, informed written consent was obtained from each patient. For those below 18 years of age, consent was obtained from their parents or legal guardians but they were also required to give verbal assent. Confidentiality was maintained during and after the research. The patients were allowed, for their own reasons and at any stage of the study to withdraw if they wished to. There was no monetary reward to the patients for participating in the study. Patients found to have significant findings during assessment were duly counseled and intervention carried out to manage complications. Dissemination of findings of this study was done through an oral defense to the university, conference presentations and publishing in peer reviewed journals.

Study Limitation and Mitigation Strategies:

There was loss of follow up of 2 patients during subsequent visits. Follow up phone calls were done to mitigate this but the phone numbers given were out of service. Chaff cutter related injuries may have been

under reported. This study captured only those who presented to hospital with severe injuries with the possibility of minor injuries being managed at home or in smaller facilities. Another study may be done to widen the scope to other hospitals and the community.

RESULTS

The Burden:

There were a total of 44 participants in the study. All the participants (100%) had injuries on their upper limbs. Over the course of the study period, no participant (0%) was encountered who had had injuries caused by a chaff cutter affecting other parts of the body. During the study period, according to data collected from the in-patient records, there were a total of 214 cases of upper limb injuries of various etiologies admitted to the Orthopaedics Wards for further management. Therefore, the burden of chaff cutter injuries of the upper limb was 20.56% of all in-patient upper limb injuries.

Demographic Characteristics of Patients with Upper Limbs Chaff Cutter Injuries:

Male participants comprised 95.5% of injuries to the upper limb caused by chaff cutter. The mean age of the participants was 29.42 years with the eldest being 46 years old and the youngest was 3 years old (a pre-school girl) at the time of the interview. Part-time farmers were 52.2% of the participants in the study while 45.5% were full time farmers. There was also a young female child (2.3% of all participants) who was injured who had not yet started formal education who sustained her injury while playing with the machine which was off during a blackout and started working after electricity came back. Upper limb injuries involving the right side were 59.1% while the rest 40.9% were on the left side. There were no (0%) bilateral injuries of the upper limb. No formal training on how to use chaff cutter was received in 97.7% of the participants while only one participant (2.3% of the participants) had received formal training on chaff cutter use. Factors that could have led to injury were assessed and 29.55% had been using the machine while wearing a long sleeved shirt, 18.18% were under the influence of alcohol and 13.63% were not attentive while operating the machine. The remaining 38.64% of the participants did not have the aforementioned risk factors.

Clinical Characteristics of Patients with Upper Limbs Chaff Cutter Injuries:

The most common clinical finding was amputation/disarticulation at varying levels with the most common being finger traumatic amputation/disarticulation accounting for 50% of the injuries to the study participants. This was followed by injuries at any level without traumatic amputation/disarticulation accounting for 20.45% of the study participants. Wrist and forearm traumatic amputation/disarticulation accounted for 13.64% and 11.36% respectively while palm traumatic amputation/disarticulation was the least common accounting for 4.55% of the study participants.

Table 1: Demographic Characteristics

Parameters	Results
Total number of participants	44
Gender:	Male (95.5%) Female (4.5%)
Age (years): Mean (SD)	29.42 (9.27)
Occupation	Part-time: 23 (52.2%) Full-time: 20 (45.5) Child: 1 (2.3%)
Side injured:	Right: 26 (59.1%) Left: 18 (40.9%)
Formal Training	No: 43 (97.7%) Yes: 1 (2.3%)
Risk	None:17 (38.64) Inattentive: 6 (13.63%) Under the influence of alcohol: 8 (18.18%) Wearing a long sleeve shirt: 13 (29.55%)

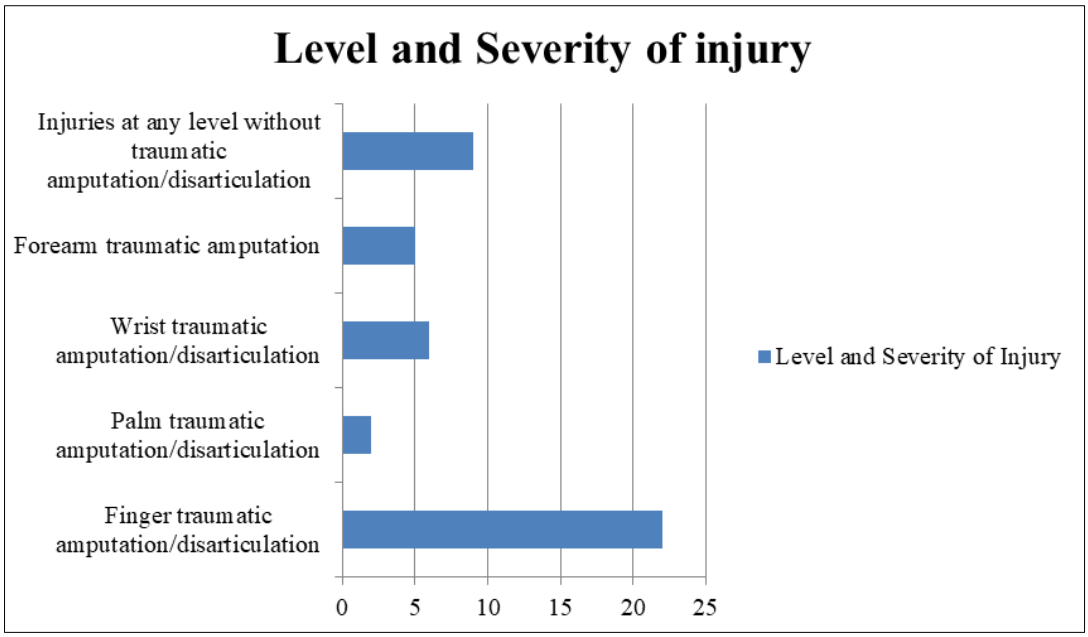

Figure 8: Level and severity of injury

There were a total of 102 different types of injuries affecting the different parts of the upper limb of the 44 participants. There was a minimum of 1 injury per participant and a maximum of 10 injuries per participant. The different types of injuries were based on the different bones of the upper limb traumatized by the chaff cutter. Amputations or disarticulations at different levels leading to loss of a part of the upper limb accounted for 68% of all injuries. The remaining 32% of the injuries were open fractures of different bones of the upper limb.

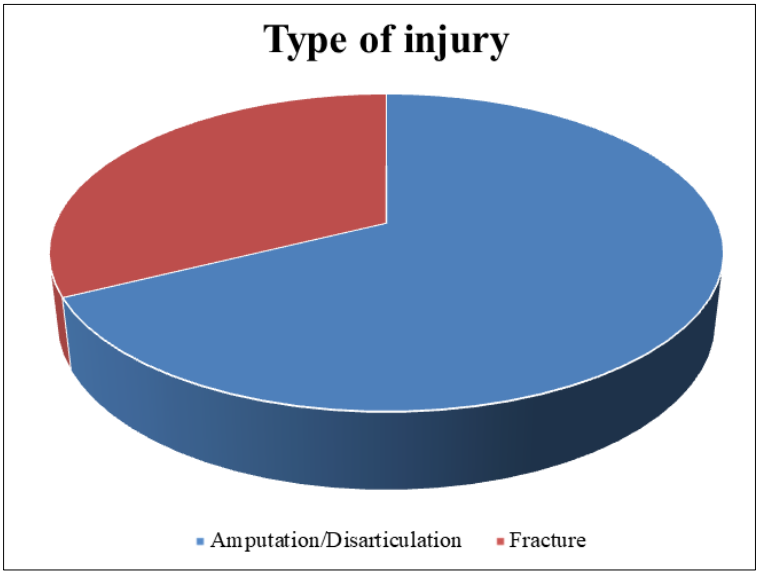

Figure 9: Type of injury

Treatments of Patients with Upper Limbs Chaff Cutter Injuries:

All participants (100%) received tetanus toxoid injections intramuscularly upon reaching the hospital as part of the protocol for prevention of tetanus. They all (100%) received prophylactic antibiotics and analgesics both pre and post operatively as part of the protocol for management of open fracture management in Moi Teaching and Referral Hospital. They were all (100%) taken for debridement in theatre where necrotic tissues were excised and thorough washout with normal saline was done (this was also done as part of the protocol for early surgical management of open fractures. Of the surgical procedures, 88.24% of the injuries underwent formal amputation/disarticulation and 11.78% had fixation of fractures commonly with percutaneous pinning while distal radial fractures were managed with open reduction and internal fixation using distal radius locking plates. No revascularization or replantation (0%) was done for any of the participants of the study.

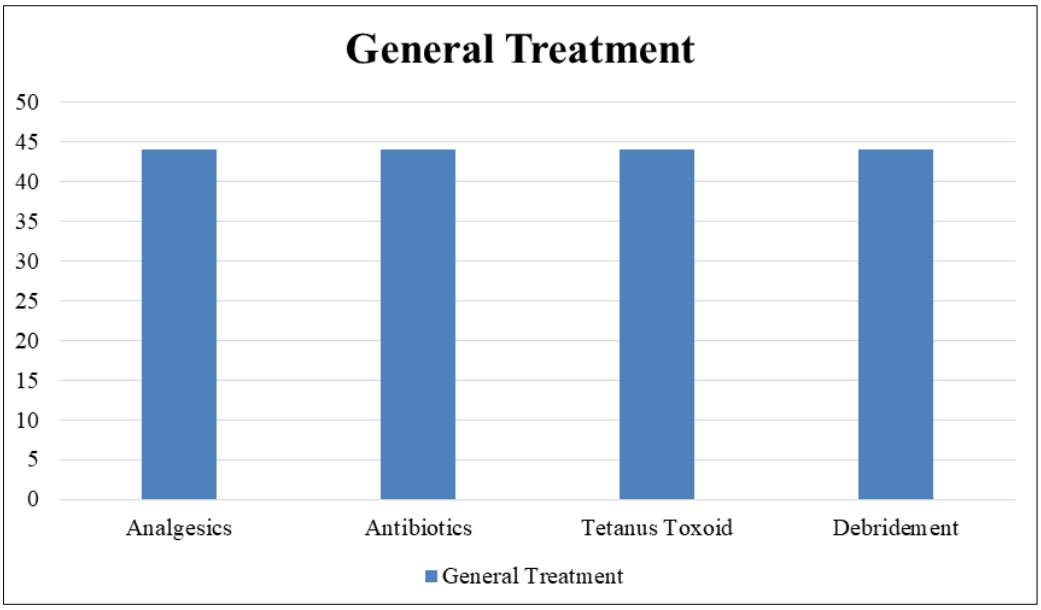

Figure 10: General treatment

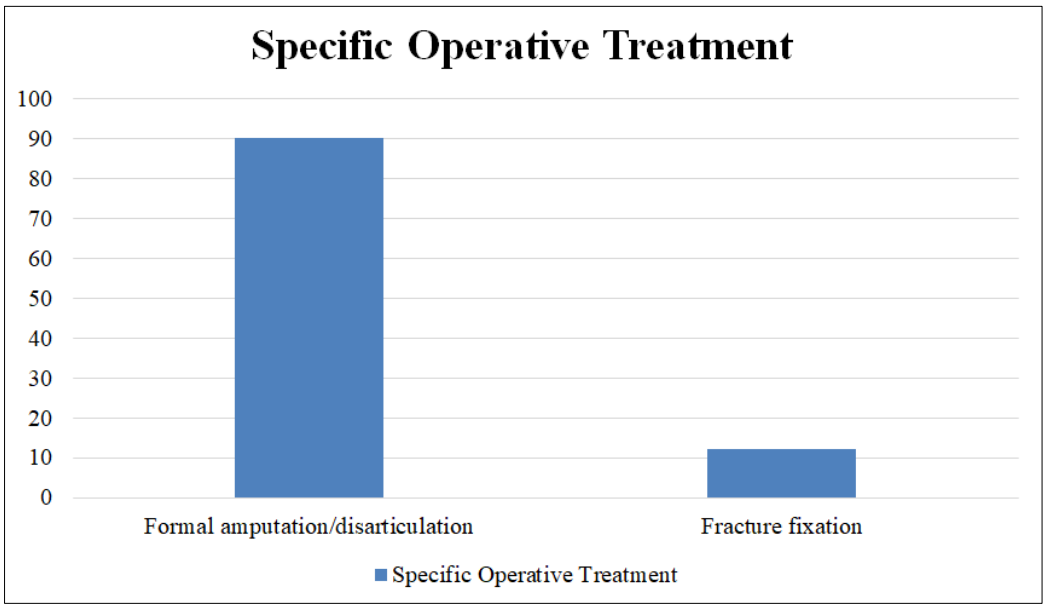

Figure 11: Specific operative treatment

Functional Outcomes of Management of Patients with Upper Limbs Chaff Cutter Injuries:

The median QuickDASH over the course of the follow up period varied based on time and the level of injury. The best outcome was for the participants who did not have traumatic amputation and managed for fractures, tendons or laceration with a median (interquartile range, IQR) QuickDASH score initially of 38.6 (27.3-45.5) at week 3 going down to 4.5 (2.3-13.6) at week 6 then finally a score 0 (0-0) at week 12. Those who had finger amputation had scores of 54.5 (42.0-73.9) at week 3, 21.6 (11.4-31.3) at week 6 and 4.545 (2.3-11.4) at week 12. Palm level amputation QuickDASH scores were 60.2 (49.4-71.0) at week 3, 23.9 (13.1-34.7) at week 6 and 9.1 (5.7-12.5) at week 12. Wrist level amputation QuickDASH scores were 79.5 (72.7-79.5) at week 3, 38.6 (36.9-47.2) at week 6 and 36.4 (29.5-41.5) at week 12. Forearm level amputation QuickDASH scores were 86.4 (70.5-97.7) at week 3, 63.6 (36.4-93.2) at week 6 and 47.727 (31.8-79.5) at week 12. The QuickDASH score for the study participants who did not sustain any amputation and had either tendon injury, other soft tissue laceration or fracture was 38.6 (27.3, 45.5) at week 3, 4.5 (2.3, 13.6) at week 6 and 0.0 (0.0, 0.0) at week 12 showing the best recovery from the injuries sustained while using a chaff cutter machine. From these results, it can be seen that the higher the level of injury, the higher the QuickDASH score. The QuickDASH score also reduced for all groups over the course of the study period. The functional outcomes on follow up were statistically significant ($p<0.05$).

Table 2: Functional outcomes

QuickDASH score	Finger amputation (N=22)	Palm amputation (N=2)	Wrist amputation (N=6)	Forearm amputation (N=5)	No amputation/tendon injury/laceration/fracture (N=9)	Kruskal Wallis *p* –value
Week 2						0.005
Median	54.5	60.2	79.5	86.4	38.6	
Q1,Q3	42.0, 73.9	49.4, 71.0	72.7, 79.5	70.5, 97.7	27.3, 45.5	
Week 6						0.002
Median	21.6	23.9	38.6	63.6	4.5	
Q1,Q3	11.4, 31.3	13.1, 34.7	36.9, 47.2	36.4, 93.2	2.3, 13.6	
Week 12						< 0.001
Median	4.545	9.1	36.4	47.727	0.000	
Q1,Q3	2.3, 11.4	5.7, 12.5	29.5, 41.5	31.8, 79.5	0.0, 0.0	

DISCUSSION

The Burden of Upper Limbs Injuries Due to Chaff Cutter in the Patients:

Chaff cutter injuries accounted for about 20.56% of all injuries inflicted on the upper limb over the duration of the study. This is in keeping with Shrestha *et al*., (2018) who found that 31.7% of hand injuries attended to at the casualty department were caused by fodder cutters. This is in contrast with Mwangi, (2012) where injuries caused by chaff cutter accounted for 6% of all injuries to the hand of participants in the study. This may be due the increased use of chaff cutters.

Demographic Characteristics of Patients with Upper Limbs Chaff Cutter Injuries:

Most of the participants (95.5%) in this study were males. This is in keeping with most studies where males were the most commonly affected by injuries caused by chaff cutter and other farmyard machinery. Agricultural machinery caused more than 90% of injuries to males in studies by Hansen *et al*., (1986) and Faisal *et al*., 2015. Even though males still predominated, the percentage of males injured was less in a study by Mehmood *et al*., (2015) at 60.6%. This was attributed to presence of a high number of females working in the agricultural sector. This is also in contrast with Shrestha *et al*., (2018) who found that 60% of participants in his study looking into injuries caused by fodder cutter were males. This may also be due to that fact that many females also used the fodder cutter machine. According to Mwangi, (2012) the male to female ratio was 3.63:1. Jadhav *et al*., (2015) noted that there was an increased risk of agricultural injuries in males. The mean age of participants who were injured by chaff cutter was 29.42 years. This is consistent with study findings by Faisal *et al*., (2015) who got a mean age of 24.4 years and Mehmood *et al*., (2015) who got a mean age of 34.15 years. Hansen and Cartensen, (1999) found that the mean age of participants who has hand injuries caused by agricultural accidents was 39.4 years. This is in contrast with study findings by Shrestha *et al*., (2018) who got an average age of 15.755 years for participants in their study who were injured by a fodder cutter. This could be attributed to the fact that chaff cutter were used by children to play since they were found in the home setting. The study findings by Ch *et al*., (2016) documented that males were (32; 44%) while the remaining (41; 56%) were females and children. This implies more female involvement; children being carelessly playing with or trying to use the machine imitating their parents who were not in vicinity that particular time. The most commonly injured occupation is part-time farmers at 52.2%. This is in keeping with 2 studies reviewed in a meta-analysis by Jadhav *et al*., (2015) where part-time farmers had a higher risk of injuries compared to the full time farmers. This was speculated to be due to part-time farmers with off-farm employment being tired when performing farm-related tasks during evenings and weekends. However, it was noted at the end of the meta-analysis that working full-time on the farm was a risk factor increasing the odds of injury by 2.17 times comparing with working part-time. This study found that almost all participants who had upper limb injuries caused by a chaff cutter had not had any formal training on how to safely use the chaff cutter. In a meta-analysis by Jadhav *et al*., (2015) and a separate study by Zheng *et al*., (2014) safety training courses and material were found inconclusive in making an impact on the occurrence of agricultural injuries. Wearing of a long sleeved shirt was found to increase the risk of getting an injury caused by a chaff cutter. This is consistent with study findings by Faisal *et al*., (2015) who found that wearing loose clothes is one of the common risks for injuries caused by agricultural machines.

Clinical Characteristics of Patients with Upper Limbs Chaff Cutter Injuries:

This study found that the most common type of injury caused by chaff cutter was traumatic amputation/disarticulation at 67.65%. This is in consistent with what Mehmood *et al*., (2015) found, where traumatic amputation was the most common type of injury inflicted by chaff cutters at 57.57%. Hansen and Cartensen, (1999) found that the most common injuries inflicted on the upper extremity caused by farming activities were lacerations and amputations at 45% which is in contrast to this study. In this study, the highest level of injury inflicted by a chaff cutter was at the fingers (50%). This was followed by the wrist (13.6%), then the forearm (11.4%) and then the palm/metacarpal level

(4.5%). According to Ahmed *et al*., (2016) there is a slight contrast in the sequence of frequency of patients sustaining injuries caused by fodder cutters with the order being digits (maximum), mid carpal, wrist, forearm and arm (minimum). Ch *et al*., (2016) documented that upper limbs were involved in 69 patients and bilateral limbs in only 4 patients, implying that the right side was more involved.

Treatments of Patients with Upper Limbs Chaff Cutter Injuries*:*

Surgical intervention was carried out for all participants of this study who sustained chaff cutter injuries of the upper limbs. All (100%) received analgesics, antibiotics and tetanus toxoid injections as well as having debridement done on them. Formal amputation/disarticulation was done in 88.24% of the all injuries. This was done for all traumatic amputation/disarticulations and the fractures that had inadequate soft tissue coverage. Fracture fixation with tendon repair was done for the remaining 11.76%. No replantation or revascularization was done on any participant. This is in keeping with what Mwangi, (2012) found where none of the participants had replantation or revascularization done on them for partially or completely amputated appendages. This is in contrast with what was found by Mehmood *et al*., (2015) where stump formation (formal amputation/disarticulation) was done in 63.6% of the study participants and is consistent with findings where fracture fixation was done in 6.06% of the participants. There was no report of replantation or revascularization done in this study. While looking at traumatic amputation in extremities, Omoke *et al*., (2012) found that stump refashioning and revision accounted for 70% of the definitive treatment. This is in contrast with what was found in this local study where Researchers looked at management of individual injuries. Only less than 5% had replantation, in contrast with this local study where no participant had replantation done. This is in contrast to what Rabbani *et al*., (2012) found, where only 18.9% of the participants had stump formation after amputation of their upper extremity. Majority (69.9%) had replantation done while 11.3% had revascularization. This contrasts the findings by Dinesh *et al*., (2020) where most of the participants in their study at 65.5% had injuries of the hand managed nonoperatively while 34% were managed through surgical intervention. This could be attributed to the fact that all the participants who had chaff cutter injuries had open wound with fractures that should be managed operatively through surgical debridement, among other procedures. Ch *et al*., (2016) on the other hand performed stump formation in 70 (96%) patients as crushing did not allow re-plantation and in 03(4%) patients revascularization was done which was successful.

Functional Outcomes of Management of Patients with Upper Limbs Chaff Cutter Injuries:

The QDASH scores of all levels of injury decreased significantly over time. This is consistent with what Rosenberg *et al*., (2013) found in their study where the median (interquartile range) QDASH score of the 45 patients decreased significantly over time that is: at three months 30 (2–80), at six months 17 (1–61) and at 12 months 12 (0–57). Mwangi, (2012) found that 80% of patient who sustained hand injuries had a QDASH score of 25 and below, indicating that majority of the hand injuries have acceptable short term outcomes and were expected to make smooth recovery with minimal disability. Wu, Edgar and Wood, (2007) confirmed the validity, repeatability and responsiveness of the QDASH outcome measure in patients with upper limbs injuries. The outcome scores seem dependent on presence or absence of amputation and on the level of injury. Presence of amputation and a higher level of injury increased the QDASH score meaning outcome was worse.

CONCLUSION

This study shows that chaff cutter injuries to upper limbs are very severe and disabling and account for a big number of admissions to MTRH. These injuries, which are preventable, lead to an increase in the use of resources in the hospital that may be directed towards other diseases. Young adult males who were part-time farmers within the most productive years of their lives were the most affected. They are usually the bread winners of their families and these result in a bigger impact in society as these families must struggle to fend for themselves as a result of life-long disabilities. There is also an increase in time for recovery as the injured may have to retrain themselves on how to use their hands, especially for those with severe injuries. Most injuries resulted in traumatic amputation/disarticulation at different levels of the upper limb with most at the level of the fingers. Amputation leads to a decrease in the function of the affected limb causing a decrease in productivity in manual labourer thereby affecting the output of the individual. All patients received the required pre-operative treatment (antibiotics, analgesics and intramuscular tetanus toxoid injection) prior to surgical management. This shows good adherence to practices of initial management of these injuries. Formal amputation was the most common form of surgical management since most injuries were traumatic amputations. Considering the injuries may have been crush injuries due to the structure of the chaff cutter machines (gear mechanism with no clean cut), no patient would have benefitted from replantation or revascularization with microsurgical skills. Another reason for no replantation or revascularization being done could also be due to the fact that no participant of the study came with the amputated appendage for consideration for replantation to be done. Over the course of follow up, the QuickDASH outcome scores decreased meaning the recovery of the patients improved. This could be a result of healing and recovery from the injury and the surgeries performed with increased ability to use the affected or the unaffected upper limb.

RECOMMENDATIONS

The best solution is prevention. With the aim of decreasing the burden of chaff cutter injuries, designers of these machines should be educated on the impact of these machines so as to ensure that they fit these machines with parts that prevent such disabling injuries for example parts that shield the moving parts (mostly the blades and gears). The Kenya Bureau of Standards (KEBS) should develop local guidelines on the minimum requirements on safety parts that companies need to adhere to in order to ensure the safety of chaff cutter users while they are using the machine. Also, the chaff cutters should also undergo safety tests and scrutiny. Education of the individuals on proper use of chaff cutters should be mandatory at the point of purchase of the device. A study should be done that looks into risk factors that increase chances of injuries caused by chaff cutters. This would help inform farmers on how to prevent the occurrence of such injuries. The risk of injury caused by a chaff cutter may be reduced by avoiding wearing long sleeved shirts or any other loose fitting clothes that may get entangled by the moving parts of the machine. Operative management of injuries of the upper limb should involve salvage procedures (such as replantation and revascularization) where indicated so as to save the amputated parts of the limb and improve chances of functionality of the upper limb being reattached. Inclusion of other specialties such as plastic surgeons in management of these injuries may improve the outcome in functionality of the affected limb. Another study can be done to look at the rehabilitation of people who sustain these kinds of injuries so as to assess whether the patients go through rehabilitation programs and if these programs help in improving the eventual outcome of upper limb function. The use of the QDASH questionnaire should be encouraged for all cases of upper limb injury so as to assess recovery of functionality of patients. This data may also be used in future studies.

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REFERENCES

- Aasheim, T., & Finsen, V. (2014. The DASH and the QuickDASH instruments. Normative values in the general population in Norway. *The Journal of Hand Surgery (European Volume) 39*(2) :140–144.
- *Academic Model Providing Access to Healthcare (AMPATH).* (2016). http://www.ampathkenya.org/our-partners/mtrh/ retrieved on 23/07/18.
- Ahmed, E. (2010). The Management Outcome of Acute Hand Injury in Tikur Anbessa University Hospital, Addis Ababa, Ethiopia. *East and Central African Journal of Surgery, 15*(1): 48-56.
- Ahmed, N., Azeem, M., Iqbal, M.Z., & Ali, A. (2016). Fodder Cutter Amputations Evaluation of Risk Factors. *Journal of Pakistan Orthopaedic Association 28*(2): 46-49.
- Ali, D., Kaiser, M. A., Khokhar, M. I., Zeb, A., Zaheer, H., & Afzal, M. F. (2021). Fodder cutter (Tokka) injuries: A preventable morbidity. JPMA. *The Journal of the Pakistan Medical Association, 71*(3): 1022-1024.
- Allen, D. L., Kearney, G. D., & Higgins, S. (2015). A descriptive study of farm related injuries presenting to emergency departments in North Carolina: 2008 2012. *Journal of agromedicine, 20*(4): 398-408.
- Aradi, G. (2018, June 5). *Teenager on recovery path after cut hand is reattached.* Standard Digital, p.3. Retrieved from https://www.standardmedia.co.ke/health/article/2001282879/boy-on-recovery path-after-cut-hand-is-reattached.
- Beaton, D, E., Wright, J.G., Katz, J.N. (2005) Upper Extremity Collaborative Group. Development of the QuickDASH: Comparison of three item-reduction approaches. *The Journal of Bone and Joint Surgery 87*:1038–1046.
- Bhattarai, D., Singh, S. B., Baral, D., Sah, R. B., Budhathoki, S. S., & Pokharel, P. K. (2016). Work-related injuries among farmers: a cross-sectional study from rural Nepal. *Journal of occupational medicine and toxicology, 11*(1): 1-7.
- Bony anatomy of the upper limb (Source: Med syndicate website). **In**: TeachMeAnatomy. Available at:https://teachmeanatomy.info>The Upper Limb.
- Bureau of Indian Standards. (2005). *Power-operated chaff cutter - safety requirements.* IS 15542:2005. Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002. Printed at Simco Printing Press, Delhi. Available at website: http://www.bis.org.in/
- Capek, K. D., Hughes, B. D., & Warden, G. D. (2018). *Functional sequelae and disability assessment.* **In:** Total burn care (pp. 673-678). Elsevier.
- Ch, N. A,. Azeem, M., Iqbal, M. Z. & Ch, A. A. (2016). Fodder cutter amputations- Evaluation of risk factors. *Journal Pak. Orthop. Assoc.* 28: 46- 49. [Google Scholar].
- Changulani, M., Okonkwo, U., Keswani, T. & Kalairajah, Y. (2008). Outcome evaluation measures for wrist and hand – which one to choose? *International Orthopaedics; 31*(1): 1-6.
- *Components of a chaff cutter (manually operated)* (Source: Centurion University, 2020). Available at: https://courseware.cutm.ac.in.

- Copuroglu, C., Heybeli, N., Ozcan, M., Yilmaz, B., Ciftdemir, M & Copuroglu, E. (2012). Major extremity injuries associated with farmyard accidents. *The Scientific World Journal* 2012;2012:314038. doi: 10.1100/2012/314038. PMCID: PMC3353295 PMID: 23002385.
- Dacombe, P.J., Amirfeyz, R. & Davis, T. (2016). Patient-Reported Outcome Measures for Hand and Wrist Trauma: Is There Sufficient Evidence of Reliability, Validity, and Responsiveness? *American Association of Hand Surgery 11*(1): 11-21.
- de Putter, C.E., Selles, D.W., Polinder, S., Panneman, M.J., Houvis, S.E. & van Beeck, E.F. (2012). Economic impact of hand and wrist injuries: health-care costs and productivity costs in a population-based study. *Journal of Bone and Joint Surgery 94*(9): e56. doi: 10.2106/JBJS.K.00561. PMID: 22552678.
- Derks, E. (2014). *The Responsiveness of the Quick DASH Versus The full DASH in Patients with Hand Pathologies.* Critically Appraised Topics (CAT). 8. Available at: http://dune.une.edu/pt_studcat/8.
- Dinesh, D. & Karadawi, N. (2020). Traumatic Hand Injuries presenting to Orthopaedic Unit of a Regional Referral Hospital, Oman. *International Journal of Orthopaedics 7*(1): 1232-1235.
- Duruoz, M. T. (2016). *Hand function*. Springer-Verlag New York.
- Faisal, M., Lodhi, B., Yaqoob, M., Pervaiz, K., & Irfan, S. (2015). Agricultural Machine Injuries - A Significant Cause of Morbidity. *Pakistan Journal of Medicine and Health Sciences 9*(2): 685–688.
- Food and Agriculture Organisation. (2014). *Food and Agriculture Organisation Country Programming Framework for Kenya 2014-17.* Retrieved from http://www.fao.org/countryprofiles/index/en/?iso3=KEN.
- Food and Agriculture Organization. (2018, May 8). *GIEWS - Global Information and Early Warning System.* Retrieved from http://www.fao.org/giews/countrybrief/country.jsp?code=KEN.
- Forro, S.D., Munjal, A. & Lowe, J.B. (2021). *Anatomy, Shoulder and Upper Limb, Arm Structure and Function.* Treasure Island (FL): StatPearls Publishing. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK507841/
- Fragaszy, D. M., & Crast, J. (2016). *Functions of the hand in primates.* In: The evolution of the primate hand (pp. 313-344). Springer, New York, NY.
- Friedrich, J.B., Poppler, L.H., Mack, C.D., Rivara, F.P., Levin, L.S. & Klein, M.B. (2011) Epidemiology of upper extremity replantation surgery in the United States. *The Journal of Hand Surgery 36*:1835–1840.
- Giladi, A. M., McGlinn, E. P., Shauver, M. J., Voice, T. P., & Chung, K. C. (2014). Measuring Outcomes and Determining Long-Term Disability after Revision Amputation for Treatment of Traumatic Finger and Thumb Amputation Injuries. *Plastic and Reconstructive Surgery, 134*(5): 746e–755e.
- Gummesson, C., Ward, M.M. & Atroshi, I. (2006). The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. *BMC Musculoskeletal Disorders 7*:44. doi: 10.1186/1471-2474-7-44. PMID: 16709254 PMCID: PMC1513569.
- Hansen, R.H. (1986). Major injuries due to agricultural machinery. *Annals of Plastic Surgery 17*(1): 59-64.
- Hansen, T.B. & Cartensen, O. (1999). Hand injuries in agricultural accidents. *Journal of Hand Surgery (British and European Volume) 24B*: 2: 190-192.
- Health Business. (2018, February 9). *History made as KNH doctors re-attached boy's chopped hand.* Health Business. Retrieved from http://www.healthbusiness. co.ke/?p=553.
- Horng, Y., Lin, M.C., Feng, C., Huang, C., Wu, H. & Wang, J. (2010). Responsiveness of the Michigan Hand Outcomes Questionnaire and the Disabilities of the Arm, Shoulder, and Hand Questionnaire in patients with hand injury. *Journal of Hand Surgery; 35A:* 430-6.
- Hudak, P.L., Amadio, P.C. & Bombardier, C. (1996). Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand). *American Journal of Internal Medicine; 29*:602-608.
- Hulshof, C. T., Pega, F., Neupane, S., van der Molen, H. F., Colosio, C., Daams, J. G., ... & Frings-Dresen, M. H. (2021). The prevalence of occupational exposure to ergonomic risk factors: A systematic review and meta-analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury. *Environment international, 146:* 106157. doi: 10.1016/j.envint.2020.106157. Epub 2020 Dec 14. PMID: 33395953.
- Ihekire, O., Salawu, S. A., & Opadele, T. (2010). Causes of hand injuries in a developing country. *Canadian journal of surgery, 53*(3): 161-166. PMCID: PMC2878993 PMID: 20507787.
- Intergovernmental Authority on Development. (n.d.). *IGAD's Livestock Policy Initiative*.
- International Labour Organization (ILO). (2013). *National Profile on Occupational Safety and Health: Kenya.* ILO Country Profiles. Retrieved from http://www.ilo.org/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/policy/wcms_187632.pdf .
- Jadhav, R., Achutan, C., Haynatzki, G., Rajaram, S. & Rautiainen, R. (2015). Risk factors for

agricultural injury: A systematic review and meta-analysis. *Journal of Agromedicine 20*(4): 434-449.

- Jadhav, R., Achutan, C., Haynatzki, G., Rajaram, S. & Rautiainen, R. (2016). Review and meta-analysis of emerging risk factors for agricultural injury. Journal of Agromedicine 21(3): 284-97.
- Jawa, R.S., Young, D.H., Stothert, J.C., Yetter, D., Dumond, R., Shostrom, V.K., Mercer, D.W. (2013). Farm machinery injuries: The 15-Year experience at an urban joint trauma centre system in a rural state. *Journal of Agromedicine, 18*(2): 98-106.
- John, R & Verma, C.V. (2011). Changes in the health status and functional outcomes in acute traumatic hand injury patients, during physical therapy treatment. *Indian Journal of Plastic Surgery 44*(2): 362-367.
- Kabale, N. & Kwamboka, L. (2018, February 8). *KNH doctors reattach teenager's hand that was stored in a cool box for 10 hours.* Standard Digital.
- Kaisha, W., & Khainga, S. (2007). Hand injury: association of handedness with cause and site of injury. *Annals of African Surgery, 1*(1): 29–32.
- Kankal, U.S., Karale, D.S., Khambalkar, V.P. and Thakare, S.H. (2016). Performance evaluation of power chaff cutter. *Engineering. & Technology in India, 7* (1): 18-25.
- Khurram, M.F., Masoodi, Z., Yaseen, M., Bariar, L.M. & Haq, A. (2015). Hand amputations: Epidemiology, management and resurfacing options for soft tissue coverage. *J. Wound Care, 24*:452–458. [Google Scholar] [CrossRef] [PubMed].
- Kica, J., & Rosenman, K. D. (2020). Multisource surveillance for non-fatal work related agricultural injuries. *Journal of agromedicine, 25*(1): 86-95.
- Kumar, A., Singh, J.K., & Singh, C. (2013). Prevention of chaff cutter injuries in rural India. *International Journal of Injury Control and Safety Promotion 20*(1): 59 67.
- Mahajan, R.K. (2016). Fodder (chara) cutting machine injuries in children. *Current Medicine Research and Practice, 6*(5): 179–180.
- Makobore, P., Galukande, M., Kalanzi, E. & Kijjambu, S.C. (2015). The burden of hand injuries at a tertiary hospital in Sub-Saharan Africa. *Emergency Medicine International.*2015:838572. doi: 10.1155/2015/838572. Epub 2015 Jun 1. PMID: **26124964** PMCID: PMC4466388.
- Manley, O. W., Wormald, J. C., & Furniss, D. (2019). The changing shape of hand trauma: an analysis of Hospital Episode Statistics in England. *Journal of hand surgery (European volume), 44*(5): 532-536.
- Maroukis, B. L., Chung, K. C., MacEachern, M., & Mahmoudi, E. (2016). Hand trauma care in the United States: a literature review. *Plastic and reconstructive surgery, 137*(1): 100e- 111e.doi: 10.1097/PRS.0000000000001879. PMID: **26368327** PMCID: PMC5073352.
- Maw, J., Wong, K. Y., & Gillespie, P. (2016). Hand anatomy. *British Journal of Hospital Medicine, 77*(3): C34-C40.
- McCurdy, S.A. & Caroll, D.J. (2000). Agricultural injury. American Journal of Industrial Medicine 38: 463–480. https://doi.org/10.1002/1097 0274(200010)38:43.0.CO;2-N.
- McDonald, J. (2017). The chaff cutters: The Gribbles of Ginninderra. *Canberra Historical Journal, 79*: 11-19.
- Mehmood, R., Aziz, S., Jehan, S. & Ateeq, M. (2015). Agricultural related injuries; Spectrum & management outcome in General Surgical Unit. *The Professional Medical Journal; 22*(2):175-180.
- Ministry of Health. (2007). *Kenya's Occupational Safety and Health Act of 2007.* Kenya Gazette Supplement.
- Mohan, D., Kumar, A., Patel, R., & Varghese, M. (2004). Development of safer fodder-cutter machines: A case study from North India. *Safety Science 42*:43- 55. Available at: https://doi.org/10.1016/S0925-7535(03)00003-1.
- Mondal, P. (n.d). *Study of the Design of Chaff Cutter, Chaffing and Grinding.* Your article library. Retrieved July 18, 2018, from http://www.yourarticlelibrary.com/dairy-farm-management/study-of-the design-of-chaff-cutter-chaffing-and-grinding/36519.
- Moore, K. & Dalley, A. (2006). Clinically Oriented Anatomy, (5th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.
- Mucci, N., Traversini, V., Lulli, L. G., Baldassarre, A., Galea, R. P., & Arcangeli, G. (2020). Upper limb's injuries in agriculture: A systematic review. *International journal of environmental research and public health, 17*(12): 4501. doi: 10.3390/ijerph17124501.PMID: **32585878** PMCID: PMC7345507.
- Muhammad Azeem, Muhammad Zafar Iqbal, Asghar Ali Ch., N. A. C. (2016). Fodder Cutter Amputations-Evaluation of Risk Factors. *Journal of Pakistan Orthopaedic Association, 28*(2): 46–49.
- Mwangi, I. (2018, February 17). *The safety of farm machinery in Kenya.* Health, Safety, Environment – East Africa.
- Mwangi, P.N. (2012). *The outcomes of treatment of hand injuries at Moi Teaching and Referral Hospital, Eldoret, Kenya.* Master of Medicine (Orthopaedic Surgery) Thesis. Moi University, Eldoret, Kenya.
- Nag, P.K., & Nag, A. (2004). Drudgery, accidents and injuries in Indian agriculture. *Industrial Health 42:* 149-162.
- Newmeyer, W.L 3rd. (2003). Sterling Bunnell, MD: the founding father. *J Hand Surg Am. 28*(1):161-4. doi: 10.1053/jhsu.2003.50019. PMID: 12563656.
- Ng, W.K.Y., Kaur, M.N. & Thoma, A. (2014). Long-term outcomes of major upper extremity replantations. *Plastic Surgery 22*(1):9-13.

- Omoke, N.I., Chukwu, C.O., Madubueze, C.C. & Egwu A.N. (2012) Traumatic extremity amputation in a Nigerian setting: Patterns and challenges of care. *International Orthopaedics; 36*:613–618.
- Pate, M. L., & Nummer, B. (2013). Hand safety for specialty crop production workers: A pilot study investigating frequencies of minor open-wound hand injuries and presence of pathogenic bacteria. Journal of agricultural safety and health, 19(4), 227-236.
- Patel, T., Pranav, P. K. & Biswas, M. (2018). Nonfatal agricultural work-related injuries: A case study from Northeast India. *Work 59*(3):367-374. DOI:10.3233/WOR-182693 [Google Scholar] [CrossRef] [PubMed].
- Patil, S., Jain, H., Raut, J., Kalikate, T., & Gandhi, V. (2016). Design & Modification of Chaff Cutting Machine. *International Research Journal of Engineering and Technology 3*(4): 2384–2388.
- Pocock, G., Richards, C. D., & Richards, D. A. (2013). *Human physiology.* Oxford university press.
- Poole, J. L. (2011). Measures of hand function. *Arthritis Care Res (Hoboken), 63*(S11): S189-99.
- Powerful Mantras. (2016, February 6). *Study of chaff cutter with 3D model and drawings.* Inculcate You. Available at: https://balram04.blogspot.com/2016/02/
- Rabbani M.J., Haq, A.U.., Aslam, F., Khan, H., & Tarar, M.N. (2012). Fodder Cutter (Toka) Injuries, a Preventable Tragedy. Our Experience at Jinnah Hospital Lahore. Pakistan: *Pakistan Journal of Plastic Surgery 1*(3): 13-20.
- Ravikumar, G., Manoharan, R., Sugapradha, G. R., & Jenifer, P. (2017). A clinical and epidemiological study of upper limb injuries resulting from agricultural accidents. *International Surgery Journal, 4*(11): 3622-3626.
- Raza, M.M.S., Tunio, Z.H., Ujjan, I.D. & Issa, S.F. (2024).Insights into Agricultural Machine Injuries in Pakistan: An Orthopedic Surgeons Survey (2022–2023). *Safety*, *10*(55): 1-14. https://doi.org/10.3390/safety10030055.
- Available at: https://www.mdpi.com/journal/safety.
- Resnik, L., Ekerholm, S., Borgia, M. & Clark, M. A. (2019).A national study of Veterans with major upper limb amputation: Survey methods, participants, and summary findings. *PLoS ONE 14* (3): e0213578. https://doi.org/10.1371/journal.pone.0213578.
- Robertson LS. (1998) Injury epidemiology. 2nd Ed. New York: Oxford University Press, 1998:265.
- Rosenberg, H.E., Carlsson, K.S., Cederlund, R.I., Ramel, E & Dahlin, L.B. (2013). Costs and outcome for serious hand and arm injuries during the first year after trauma – a prospective study. *BMC Public Health 13*:501. doi: 10.1186/1471-2458-13-501. PMID: **23706070** PMCID: PMC3681586.
- Shabir, S. A. K. H. F. (2018). Pattern of Fodder Cutting Machine Injuries in Sialkot Region. P *J M H S 12*(4): 1368-1370. Available at: https://pjmhsonline.com/
- Shier, D., Butler, J., & Lewis, R. (2015). Hole's essentials of human anatomy & physiology. New York: McGraw-Hill Education.
- Shrestha, K. M., Shrestha, B., Kandel, P. R., Baral, R., Pandey, A., & Singh, G. P. (2018). FODDER CUTTER MACHINE INJURIES OF HAND. *Journal of Universal College of Medical Sciences, 6*(1): 14–18.
- Shrestha, K., Shrestha, B., Kandel, P., Baral, R., Pandey, A., & Singh, G. (2018). Fodder cutter machine injuries of hand. *Journal of Universal College of Medical Sciences, 6*(1): 14-18. https://doi.org/10.3126/jucms.v6i1.21693 .
- Silverthorn, D. U. (2015). *Human physiology*. Jones & Bartlett Publishers.
- Sinnatamby, C. (2011). *Upper limb.* **In:** Last's Anatomy, Regional and Applied, (12th ed.). Churchill Livingstone Elsevier.
- Solomon, E. P. (2015). Introduction to human anatomy and physiology. Elsevier Health Sciences.
- Standring, S. (2016). *Pectoral girdle and upper limb.* **In:** Gray's Anatomy, The Anatomical Basis of Clinical Practice, (41st ed.). Elsevier.
- Standring, S. (Ed.). (2020). Gray's anatomy e-book: the anatomical basis of clinical practice. Elsevier Health Sciences.
- Telang, A.K. (2016). Design and modal formulation of power operated chaff cutter. *International Journal of Emerging Technologies 7*(2):181-187.
- *The Anatomy of the Hand* (2016). Available at: https://musculoskeletalkey.com>the-anatomy-of - the-hand .
- *The Work Injury Benefits* http://www.health.go.ke/wp Act, 2007 (2007). Retrieved from content/uploads/2015/09/Work%20Injury%20Benefits%20ACT%202007.pdf .
- Tiwari, P.S., Gite, L.P., Dubey, A.K., & Kot, L.S. (2013). Agricultural Injuries in Central India: Nature, Magnitude and Economic Impact. *Journal of Agricultural Safety and Health 8*(1): 95-111.
- Tunio, Z. H., Jhatiyal, R. A., Jokhio, M. F., Ali, S. M., Baloch, R. A., & Makhdoom, A. (2021). Fodder Cutter Machine Injuries: An Unsafe Household Item in Rural Sindh in Pakistan. *Journal of Liaquat University of Medical & Health Sciences, 20*(2): 96-99.
- Voaklander, D. C., Rudolphi, J. M., Berg, R., Drul, C., Belton, K. L., & Pickett, W. (2020). Fatal farm injuries to Canadian children. *Preventive medicine, 139:* 106233.doi: 10.1016/j.ypmed.2020.106233. Epub 2020 Aug 12. PMID: **32800973.**
- Wairegi, A. (2019). *Pattern of Hand Injury in Patients seen at Kenyatta National Hospital.* Master of Medicine Thesis, University of Nairobi. Available at: erepository.uon.ac.ke

- Wang, S., Myers, J.R. & Layne, L.A. (2011). Injuries to hired crop workers in the United States: A descriptive analysis of a national probability survey. *Am. J. Ind. Med. 54*: 734–747. [Google Scholar] [CrossRef].
- Wanjara S, & Oduor P. (2022). *Chaff Cutter Hand Injuries from Nakuru Kenya*.[DATASET].2022. 10.6084/m9.figshare.21213293.v1 - DOI - PMC – PubMed.
- Wanjara, S. & Oduor, P. (2022). Hand injuries in Kenya: a chaff cutter menace.
- F1000Res. 2022 Nov 4:11:1255. doi: 10.12688/f1000research.126590.1. eCollection 2022. PMID: 37928806**.**
- PMCID: PMC10620478.
- Wawire, N.W., Bett, C., Ruttoh, Wambua, J., Omari, F.G., Kisilu, R…Ketiem, P. (2016). *The status of agricultural mechanization in Kenya.* KALRO. RDA. KAFACI. Available at: file:///C:/Users/USER/Downloads/
- Weichelt, B., Gorucu, S., Murphy, D., Pena, A. A., Salzwedel, M., & Lee, B. C. (2019). Agricultural youth injuries: a review of 2015-2017 cases from US news media reports. *Journal of agromedicine, 24*(3): 298-308.
- Wu, A., Edgar, D.W. & Wood, F.M. (2007). The QuickDASH is an appropriate tool for measuring the quality of recovery after upper limb burn injury. *ScienceDirect 33*(7): 843-849.
- Zheng, L., Zhao, N., Chen, D., Hu, M., Fu, X., Stallones, L., … Wang, Z. (2014). Nonfatal work-related injuries among agricultural machinery operators in northern China: A cross-sectional study. *International Journal of the Care of the Injured, 45*(3): 599–604.

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