EVALUATION OF OCCUPATIONAL NOISE EXPOSURE AMONG WORKERS IN METAL FABRICATING SECTOR IN KAMUKUNJI NAIROBI.

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Evaluation of Occupational Noise Exposure among Workers in Metal Fabricating Sector in Kamukunji Area Nairobi.

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DECLARATION

This thesis is my original work and has not been presented for a degree any other university.

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DEDICATION.

This thesis report is dedicated to my wife Wangari who has been there through the hard times and my mother Mumbi for her moral support.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

.

LIST OF APPENDICES

ABSTRACT

The effect of noise exposure on the auditory system is well known. The purpose of the present study was to determine the level of hearing loss, noise exposure levels and awareness towards noise induced hearing loss among the workers in metal fabricating sector in Kamukunji, Nairobi. A structured questionnaire was administered to 384 systematic, randomly selected workers to collect information relating to their awareness toward hazardous occupational noise and preventive measures. Noise mapping using sound level meter was carried out in various Kamukunji *Jua Kali* sheds and audiometric testing at frequencies 0.125-8 KHz were carried out.

The overall measured noise levels in the study area ranged from 72.0 dB (A) to 113.8 dB (A) and 93.8% of the workers were exposed to noise levels of 90 dB (A) and above for more than 8 hrs daily. From the study, it was established that 90.6% of the workers were aware that noise can cause deafness and 88.8 % of the workers were aware that it can be prevented, but only 2.9% of the workers possessed hearing protectors. The study also found that 35.2% of the workers had impaired hearing and 83% of those with impaired hearing had worked for more than 6 years. From the study, it was established that workers are exposed to hazardous noise levels and they recognize noise as a hazard, but they do not use hearing protective equipment.

From the results of the study, it was recommended that training programmes in occupational health and safety be made mandatory plus also the enforcement of occupational health and safety regulation in this set up. The study also recommended waving of taxes imposed on imported hearing protective equipments and a link between awareness and noise preventive strategies be further investigated.

CHAPTER ONE

1.0 INTRODUCTION

Hearing is one of the most important communication channels perhaps second to vision. While the eyes can be shut when there is too much light or unwanted scene, the ears remain open throughout life to unwanted sound and therefore, it is necessary to provide protection to hazardous sound. Sound is produced when there is vibration of bodies or air molecules and it is transmitted as a longitudinal wave. Noise corresponds to undesired sound and its present in every human activity and can be classified either as occupational noise or environmental noise.

Noise-induced hearing loss is the second most common sensorineural hearing loss, after age-related hearing loss (presbycusis) and has been recognized as the most prevalent irreversible industrial disease (Swuste, 2007) . Noise-induced hearing loss has been well recognized since the industrial revolution but methods of influencing attitude toward noise hazards and prevention had been poor (WHO, 1997). An early term for the condition was "boilermakers' disease," because so many workers who made steam boilers developed hearing loss (NIOSH, 1998). In today's noisy society, even children and young adults are at risk.

A health person usually has a normal hearing ability up to age of 60 years if his or her unprotected ears are not exposed to high noise levels above 85dB (A) which is the limit for hearing loss prevention (Darabont A., 1983). The median material hearing impairment at the age of 60 years is 17dB (A) for males and 12 dB (A) for females (Thayer and Sataloff, 2006).

Occupational noise is a major problem in all the countries in the world and there is little epidemiological information on prevalence of noise induced hearing loss. In Germany, 4-5 million people (12 % -15 % of the work force) are exposed to hazardous noise levels (WHO, 2001) and about 30 million workers in United State of America are exposed to hazardous noise levels (NIOSH, 1998., Tak and Calvert, 2008). Noise induced hearing loss is an important public health concern because as population lives longer and industrialization spreads, it adds substantially to the global burden of disability to the country (WHO, 2001). In developed countries, the risk from social noise is increasing for young people where in developing countries occupational noise and urban, environmental noise especially traffic noise are increasing factor for hearing loss. In developing countries, there is lack of both effective legislation against noise and programme to prevent noise induced hearing loss and where they exist, they are poorly enforced and implemented (WHO, 1997).

The hazards associated with exposure to hazardous noise levels are not always recognized because of the stigma attached to the resulting hearing impairment. People with hearing impairment are often thought of as elderly, mentally slow and generally incompetent. So, some of the affected individuals do not seek medical assistance. Another reason for lack of proper and efficient noise control and hearing conservation programme is that, noise is often accepted as a necessary evil, a part of doing business and an inevitable part of an industrial job. The hazardous noise causes no pain or bloodshed and exposed workers usually often get used to it. They develop a temporarily noise induced hearing loss which may progressive to permanent noise induced hearing loss. The loss of hearing is so gradual that individuals do not realize what is happening until impairment becomes handicapping. These individuals develop tinnitus (ringing in the ears), and other people do not seem to speak as clearly as they used to and they keep telling other people to repeat themselves. Also they tend to put sound volume of radio and television high.

Noise is one of the most common of all occupational hazards (WHO, 1997) and loss of hearing is certainly the most well-known adverse effect of noise with other health effects being tinnitus (Phoon et al., 1993) , headache, stress (Thayer and Sataloff, 2006), elevation of blood pressure (Willich S, 2005) and sleep disturbance. Noise also interferes with speech, communication and the perception of warning signals. This affects individual's safety and performance at work, at home and elsewhere (Akande and olonge, 2001). So, under most circumstances protecting workers from exposure to hazardous noise levels also protects them against many other health effects, increase safety at work and this consideration provides additional support for informal sectors to implement noise reduction control and hearing conservation programmes.

In Kenya, occupational noise and environmental noise (especially traffic noise) are increasing risk factors for hearing impairment. There is widespread ignorance of the hazards associated with noise so awareness must be increased about the harmful effects of noise and about the prevention and control of noise induced hearing loss. A positive image of hearing should be promoted, including its contribution to the daily quality of life.

The *Jua Kali* (Hot Sun Industries operating in open spaces, road side and in front of the buildings) industries especially metal fabrication, wood working and motor vehicle repairs generate a lot of noise which is the most common physical hazard (Atambo et al., 1989). The noise in *Jua Kali* metal fabrication is the result of high frequency vibrations produced as a result of hammering, riveting, grinding and improvised technologies.

In Kenya, there is no accurate epidemiological information on prevalence, risk factors and cost of noise induced hearing loss in the informal sector. This study focuses on evaluation of noise exposure among *Jua Kali* workers in metal fabricating sector in Kamukunji, Nairobi.

1.1 Statement of the problem.

The effect of noise generated in the metal fabricating *Jua Kali* industries to the hearing ability of the workers has not been investigated. The awareness of the workers on the impact of the noise is not known neither is the percentage of those affected by the noise.

1.2 Hypothesis

1.2.1 Alternate hypothesis

Workers in *Jua Kali* metal fabricating industries are exposed to hazardous noise levels.

1.2.2 Null hypothesis

Workers in *Jua Kali* metal fabricating industries are not exposed to hazardous noise levels.

1.3 Objectives of the study

1.3.1 Main objective

The main objective of the study was to evaluate the occupational noise exposure among workers in metal fabricating sector in Kamukunji *Jua Kali* sheds in Nairobi.

1.3.2 Specific objectives

a) To determine noise levels at various selected metal fabricating *Jua Kali* sheds in kamukunji area.

b) To determine the level of awareness and preventive measures towards noise induced hearing loss among the workers working in metal fabricating sheds in kamukunji *Jua Kali* sheds.

c) To conduct audiometric examinations on the workers working in the metal fabricating sheds in Kamukunji *Jua Kali* sheds.

1.4 Research questions

a) Do *Jua Kali* workers in metal fabricating sheds consider noise as occupational hazards?

b) What levels of noise are prevalent in metal fabricating sheds in *Jua Kali* industries?

c) Do *Jua Kali* workers in metal fabricating sheds use hearing protective equipments (earmuffs and ear plugs) in their workplace?

d) Do *Jua Kali* workers know the health effect associated with exposure to hazardous noise levels?

1.5 Justification of the study.

The informal sector constitutes more than 70% of the Kenya working population. It has grown by 43 % over the past five years to 7.0 million (Economic survey 2008) of which approximately 30-40 % are employed in the manufacturing section. The workers in manufacturing (metal fabrication) are exposed to various occupational hazards, especially noise. No research on noise exposure has yet been conducted in the informal sector metal fabrication; although similar research has been conducted in the formal sector in construction by (Richard Neitzel et al., 1999) and steel rolling mills by (Foluwasayo et al., 2005).

1.6 Significance of study

The study will reveal what noise levels are prevalent in *Jua Kali* metal fabricating sector in Kamukunji, the magnitude of hearing impairments among the workers and factors preventing the usage of hearing protectors. It will show whether it is necessary to introduce noise control and conservation programme and enforcement of the existing laws in the *Jua Kali* metal fabricating sector.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Sound production and measurement

Physically, there is no difference between sound and noise. Noise or unwanted sound may be defined as audible air-borne vibrations which produce a subjective impression of unpleasantness and discomfort in people who listen to it. The degree of unpleasantness and discomfort depends on sound pressure level, frequency, frequency distribution of complex sound fields, duration of exposure and susceptibility of individual to the feeling of discomfort. Noise is present in every human activity and it is usually classified as either occupational or environmental.

Sound is produced when there is vibration of bodies or air molecules and is transmitted as longitudinal waves. It is therefore a form of mechanical energy and is measured in energy related units called decibel (dB) which is a logarithmic unit that indicates the ratio of physical quantity relative to a specified reference level. Sound is measured using an instrument called sound level meter (Figure 3.1) which resembles human ear in sensitivity and dosimeter which provide time-weighted average over a period of time. (Thayer and Sataloff, 2006).

Sound consists of pressure variations that can be detected by human ear with two characteristics frequency and amplitude. The frequency of sound refers to the number of vibration per second, measured in hertz [Hz] and subjectively felt as pitch. The range frequency of sound is very large with audible sound ranging between 18Hz to 18,000 Hz. This range reduces with age and also due to some other subjective factors. Sound with frequencies below 18 Hz is called infrasound and more than 18,000 Hz is called ultrasound. For analysis, the audible frequency spectrum is divided into standard octave bands of 32 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 KHz, 2 KHz, 4 KHz, 8 KHz and 16 KHz (Thayer and Sataloff, 2006).

The ear has different sensitivities to different frequencies, being least sensitive to extremely high and extremely low frequencies. As a result of this varied sensitivity, different frequency weighting network are used in sound measurements. A-Weighting network is used in the measurement of workplace and environmental noise because it causes the sensitivity of the meter to vary with the frequency and intensity of the sound like the sensitivity of the human ear and the measurement are displayed as dB (A). Two other frequency weighting networks used for measurements are C-weighting network and Z- weighting network. The C-weighting network has a wider frequency range than A-weighting network and it is often used for measurements of noise levels from machinery as it emphasis more on low frequency sounds. Peak sound pressure measurements are made using C- frequency weighting and measurements are displayed as dB(C). The Z- weighting is linear or flat at 8Hz to 20 kHz and measurements are displayed as dB (Z) (Cirrus research plc, 2004).

The main purpose of noise measurement in occupational settings is to identify overexposed workers, quantify their exposure and assess the need for noise control and prevention methods as well as to evaluate the effectiveness of a particular noise control.

2.2 Hearing mechanism

Hearing depends on a series of events that change sound waves in the air into electrical signals which are carried to the brain by the auditory nerve. Sound waves from a source are directed by the pinna (outer ear) (Figure 2.1) down the auditory canal to the tympanic membrane (ear drum), causing it to vibrate. The sound wave is then transformed into mechanical energy by three bones (malleus, incus and stapes) known as ossicles within the middle ear which amplifies the vibration. These vibrations are passed along to a smaller vibrating membrane, the elliptical window on the surface of cochlea of inner ear. The mechanical energy of sound now in a physical vibration, creates a compression waves within the fluid filled spiral tube of cochlea moving the tiny hair cells lining the inside of cochlea. As the hair moves the nerve cells at their base change this motion into electrical signals that are passed along the auditory nerve to the auditory centres of brain which interprets the signal as recognised sound. Hair cell near the base of the cochlea detects higher pitched sounds and that near the apex detects lower pitched sounds (National Institute on Deafness and other Communication Disorder, 2006).

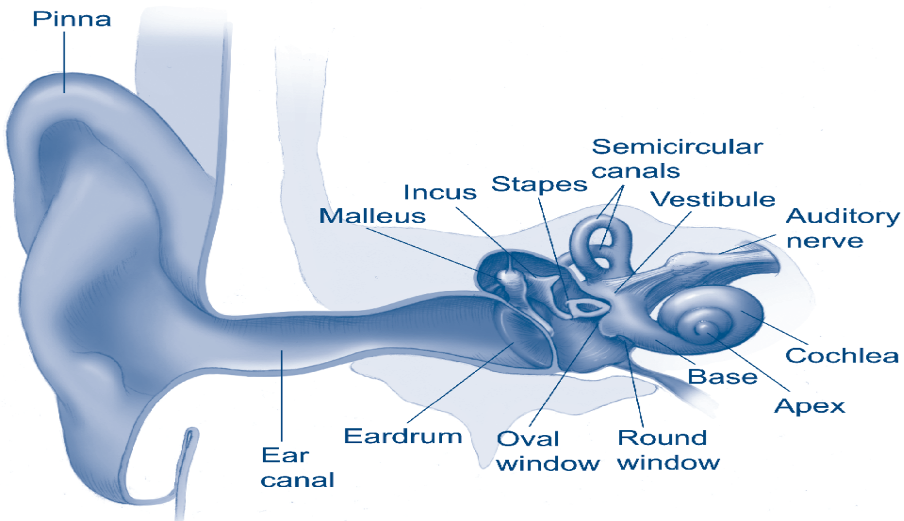

Figure 2.1: Human ear.

When the ear is exposed to excessive sound levels or loud sounds over time the force exerted on the stereocilia of the hair cells becomes damaging, producing abnormalities of the hair cells. Some of the abnormalities include metabolic exhaustion of the hair cells, structural changes and degeneration of structures within the hair cells. There are morphological changes of the cilia, ruptures of the cell membranes, complete degeneration of hair cells, neural cells and supporting cells (Gelfand, 2001).

2.3 Noise induced hearing loss.

Noise induced hearing loss is generally used to denote the cumulative permanent loss of hearing that develops gradually after months and years of exposure to high levels of noise . It has long been recognized as a problem in occupations associated with prominent noise (Subroto and Sarang, 2008)

Noise induced hearing loss occurs as a result of over stimulation of the sensory hair cells and supporting structures from one time exposure to excessive sound pressure (acoustic trauma) or from repeated exposure to loud sound over a period of time (gradual hearing loss) (Rabinowitz, 2000). The damages are initially temporally but with more exposure, they become permanent. Excessive sound damages the hair cells and the blood supply in the cochlea, usually affecting the higher frequencies (3kHz, 4kHz and 5kHz) and then spreading to other frequencies (NIH., 1990). The hair cells in the organ of Corti may be damaged directly by noise, or indirectly by very high levels of continuous sound which causes vasoconstriction of the vessels of the stria vascular in the cochlea blood supply. This renders the hair cells relatively anoxic and thus secondarily damaged. The threshold shift upwards is temporarily at first but with a higher sound dose becomes permanent.

Hearing losses from different causes are additive and noise induced hearing loss can be worsened by exposure to lead, chemicals solvents such as toluene, xylene, ethylbenzene and asphyxiants such as carbon monoxide (Morata T. C, 1994) or antibiotics such as the amino glycosides(John, 2000) . In the elderly, noise induced hearing loss may add to the hearing loss of presbyacusis to produce a hearing handicap sooner and worse than would occur from age alone (Onsenhall and Redsan, 1997). Excessive hazardous sound begins to kill cells in the inner ear. As the exposure time to loud noise increases, more and more hair cells are destroyed and these depend on intensity, duration and frequency composition of the noise. The presumed mechanism underlying the cochlear damage from noise exposure is metabolic exhaustion and mechanical injury. In metabolic exhaustion, the sensory cells are unable to increase their susceptibility to mechanical damage. The metabolic state of the hair cells is correlated with their ability to withstand or recover from physical stress. Different sensory hair cell responds to different sound frequency so when these cells are destroyed certain frequency of sound cannot be heard. Destroyed sensory hair cells cannot regenerate and their function cannot be restored by medical procedures. Hair cells transducing the higher frequencies are the most sensitive to noise damage, this relates to difficulties with speech perception experienced by those with noise induced hearing loss. The damage first affects the outer sensory hair cell before affecting the inner ones although the effect of hearing loss is more when the inner one is affected. Initially the hearing loss is perceptible in the early stages and may only be detected by audiometric tests with the continuous exposure to noise the loss of sensitivity spreads from higher frequencies to lower frequencies of speech (1000 to 3000 Hz). Factors affecting the risk of hearing loss associated with exposure to excessive noise are intensity of noise, band width, duration of daily exposure, total duration of exposure, age of individual, coexisting hearing loss, nature of environment in which exposure occurs, position of ears relative to the sound waves and distance of individual from the source of the noise.

Tinnitus, health effects of noise describes perceived sounds that originate within the person rather than from outside and serves as an early sign of auditory injury frequently accompanies both temporary and permanent hearing loss from noise as well as other types of sensorineural hearing loss (Clark and Bohne 1999). Other health effect includes increased anxiety, annoyance, fatigue and irritability (Gomes et al., 2002. Akande and Olonge, 2001). Extra-auditory effects e.g. elevation of blood pressure (Peterson et al., 1978, 1981 and 1983). Current thinking holds that the extra-auditory effects of noise are most likely mediated psychologically, through aversion to noise, making it very difficult to obtain dose-response relationships (Ising and Kruppa, 1993). Noise also causes stress (Lennart, 1981), sleep disturbance and affects the progression of sleep stages as well as frequency of awakening. Acoustic shock is physiological and psychological symptoms a person may experience after hearing a sudden unexpected loud sound. Noise can also interfere with perception of warning signals and therefore interfere with safety (Wilkin and Acton, 1992; Azizi, 2010).

Due to hazardous effect of noise there are agencies/bodies such as the Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), Noise at work Regulations (1989), American National Standard Institute [ANSI] 1991, Control of noise at work regulations 2005 [UK],International Standard Organization [ISO] 1990,EEC directive on occupational noise exposure [CEC 1986] National Institute for Occupational Safety and Health [NIOSH 1998],World Health Organization [WHO] and International Labour Organization [ILO 1976] which have established regulations for maximum allowable noise exposure. These regulations describe the duration per day one can be exposed to certain noise levels before damages to the hearing structure can occur (see appendix 3) for permissible noise levels. The ILO recommended noise limits (Occupational Exposure Level) to reduce hearing loss in workplaces (occupational deafness) as 90 dB (A) for 8 hours daily. The table below shows other recommended limits.

Table 2.1**:** Recommended noise exposure limit

Location/position	Threshold Limit Values (Standards)
Speech, comfort and work interference	60 dB(A)
Workshop and plant area where occasional communication is required.	75 dB(A)
Workshop office, control room, laboratories and workshops where easy communication is required.	55 dB(A)
Offices, mess rooms and canteen.	50 dB(A)
Prestigious offices and conference rooms.	35 dB(A)
Industrial and commercial area at day time.	70 dB(A)
Industrial and commercial area at night.	55 dB(A)
Residential area at day time.	55 dB(A)
Residential area at night.	45 dB(A)

[WHO, 1999]

Noise of various levels produces both psychological and physiological effects. See table below.

Table 2.2: Health effect of exposure to noise

Noise level limits	Effects
Up to 65 dB (A)	Creates annoyance, but its results are only psychological (nervous effect).
Above 65 but less than 90 dB (A)	Results to mental and bodily fatigue.
Noise levels of 90 dB (A)	Many years of exposure normally causes hearing loss
Noise levels of 100 dB (A)	Short periods of exposure the aural acuity may be impaired temporarily and prolonged exposure will likely cause irreversible damage to auditory organ.
Noise levels of 120 dB (A)	Causes pain
Noise levels of 150 dB (A)	Causes instantaneous loss of hearing.

In Kenya "The Factories and Other Places of Work Act" currently (Occupational Safety and Health Act 2007), Noise Prevention and Control Rules Legal Notice No 25 of 2005 was established and took effect on March 2005. The objectives of the rule were to set limits for noise exposure and requirements for noise control and hearing conservation programme to prevent noise induced hearing loss in workplaces. The permissible noise levels set were that no worker should be exposed to noise levels above 90dB (A) for more than eight hours in a duration of twenty four hours, no worker should be exposed to noise level of 140 dB (A) at any given time and where noise is intermittent, noise exposure should not exceed the sum of the partial noise equivalent to continuous sound level of 90 dB (A) in eight hours duration within any twenty four hours duration. Where noise in workplace exceeds 85dB (A), an effective noise control and hearing conservation has to be put in place. Methods adopted included: - noise measurements, education and training, engineering noise control measures, use of hearing protectors, posting of notices in noisy area, hearing test, and annual review of the programme. Other enforcement law regulating emissions of noise in Kenya are the traffic Act which prohibits hooting near places like schools, hospitals and law courts. Environmental Management Coordinating Act control regulation 2009 legal notice number 61 gives provision relating to noise from certain sources and provision relating to licensing procedure for certain activities like fireworks, demolitions and any other activities likely to generate noise which will be a nuisance or affect people in the surroundings.

Noise is the most common workplace hazards in the world (WHO 1997) and is the major avoidable cause of permanent hearing impairment worldwide (WHO 1997). The current global labor force stands at about 2600 million and is growing continuously. Approximately 75% of these working people are in developing countries. The officially registered working population constitutes 60–70% of the world's adult male and 30–60% of the world's adult female population. Each year, another 40 million people join the labor force, most of them in developing countries. Workplace environmental hazards are therefore a threat to a large proportion of the world population (WHO, 1997). According to the National Institute on Deafness and other Communicable Disorder (NIDCD, 2006) more than 30 million Americans are regularly exposed to hazardous sound levels and about 10 million Americans can attribute contribute their hearing loss to noise. The Occupational Safety and Health Administration [OSHA, 2007] estimates that more than 9 million workers in United State of America are exposed to daily average noise levels of 85dB (A). These noise levels are hazardous to their hearing and can produce other effects as well. There are a further 5.2 million workers exposed to noise above these levels in manufacturing and utilities which represent about 35% of the total numbers of workers in US manufacturing industries. One out of four workers exposed to noise level of 90 dB(A) over a working lifetime will develop hearing loss that can be attributed to occupational noise exposure (NIOSH, 1972). The largest numbers of workers exposed to levels of noise that are potentially damaging to their hearing are employed in manufacturing industries (NIOSH, 1974). In developing countries it is estimated that between 7% to 10% of the population have diminished hearing, and 50% of this is preventable (WHO 2006). Survey by US Department of Labour indicates that more than half of industrial machines emit noise levels between 90dB (A) and 100dB (A) and approximately 50% of industrial work environments have noise levels between 85dB (A) and 95dB (A) and less than 6% of the machines surveyed produce noise levels less than 85dBA. Estimate of various noise levels produced by various objects/machine are given in appendix 2. The levels are likely to be higher in less developed countries, where engineering control measures are not used widely and lower in developed countries where we have strong noise control programme.

Although this study focuses on evaluation of occupational noise exposure among workers in metal fabricating sector in the *Jua Kali* industries, it should be noted that workplace chemicals can cause hearing loss (Morata et al., 1994), some drugs e.g. antibiotics and cancer chemotherapy are toxic to ear and increase the damaging effect of noise (Boettcher et al., 1987), increased mechanization has caused hearing loss from recreational activities in the community. Noise refers to all sounds which can result in hearing impairment or be harmful to health especially where levels of exposure exceed the prescribed threshold limit values [TLV]. International Standard Organization (ISO, 1990) has documented the amount of continuous noise that causes varying degree of hearing loss. The periods of noise that are interrupted by periods of silence can offer the ear an opportunity to recover from temporary hearing loss and may therefore be somewhat less hazardous than continuous noise. Impulse noise, such as the noise from gunfire or metal stamping damages the hearing more severely than other types of noise (Dunn et al., 1991). The amount of damage will depend mainly on the level and duration of the impulse, and it may be worse when there is continuous noise in the background. There is evidence that high frequency sources of impulse noise are more damaging than those composed of lower frequencies (Hamemik et al., 1991). During the course of a noisy day, the ear become fatigued and the workers will experience a reduction in hearing known as temporary threshold shift. At the end of one work shift and the beginning of the next shift, the ear normally recovers but there is some hearing loss left and after several days, months and years of exposure, the temporary threshold shift leads to permanent loss of hearing (Dunn et al., 1991) and the new amount of temporary threshold shift begin to build onto the now permanent losses.

The severity of a hearing impairment is classified according to the loudness a sound must be before being detected by an individual. The WHO classification classifies hearing impairment according to the pure tone average in the better hearing ear. Categories of hearing impairment ranges from no impairment to profound impairment according to threshold level obtained from audiometric test done at frequencies 500,1000,2000 and 4000 Hz. The different grades of hearing impairment and their impact in performance are presented in below.

Table 2.3: WHO grades of hearing impairment

Grade of impairment	Hearing threshold levels.	Impairment description.
0 (no impairment)	25 dB hearing loss or less (better ear)	No or slight problem. Able to hear whispers.
1 (slight impairment)	26-40 dB hearing loss (better ear)	Able to hear and repeat words spoken in normal voice at 1 metre.
2 (moderate impairment)	41-60 dB hearing loss (better ear)	Able to hear and repeat words using raised voice at 1 meter
3 (severe impairment)	61-80 dB hearing loss (better ear)	Able to hear some words when shouted into better ear
4 profound impairment including deafness)	81 dB hearing loss or greater (better ear)	Unable to hear and understand even a shouted voice

Source: (WHO 1991), Wikipedia, (2009)

2.4 Overview of Kenya *Jua Kali* Sector

The term "informal sector" was popularized by a 1972 study of Kenya, (ILO, 1972) but Kenyans have another term for the sector: *Jua Kali*, literally "under the hot sun." It is indicative of the severe conditions under which micro-entrepreneurs and their employees labor. This unstructured sector has emerged as a result of the incapacity of formal, regulated industries to absorb new entrants. The *Jua Kali* sector encompasses small scale entrepreneurs and workers who lack access to credit, property rights, training and good working conditions. The informal sector provides low cost goods and services that are affordable to both low and middle income citizens who cannot afford to pay high prices. The sector plays a big role in economy of most of the developing countries. Originally restricted to artisans, the term has come to include a number of professions, including auto mechanics and market vendors.

The informal sector in Kenya has been growing faster than formal sector and consequently providing more opportunities for employment. Most *Jua Kali* firms require workers with skills that school leavers do not have and therefore the sector is unlikely to solve Kenya's unemployment problems (Ongila et al., 1996). According to the economic survey 2002 published by Kenya Central Bureau of Statistics, employment within the sector increased from 4.2 million in 2000 to 5.1 million in 2002, accounting for 74.2% of total employment and contributes about 18.4 % of gross domestic products (Economic survey 2002), currently it has about 6.4 million people. Between 1993 and 2001, the informal sector grew at an annual rate of 10%, with urban areas absorbing two thirds of the micro and small enterprises workers and Nairobi alone absorbing about (24%) of the employment in the sector (Economic survey 2002).

In the informal sector, workers are exposed to occupational health hazards which includes physical hazards (noise, heat, dust and poor working platforms), chemical hazards, mechanical hazards (cuts, bruises), biological hazards and poor access to clean water and toilets. These workers in the informal sector are not covered by any insurance or Work Injury Benefit Act and therefore most of the victims of injury just leave the informal sector and the whole burden of treatment is borne by their families.

A study done by (Atambo et al., 1989) showed that 90 % of the equipment in *Jua Kali* industries in Kenya are improvised and therefore more time consuming and with a lot of hazards, noise been among the most common hazard identified. The survey showed that majority of the workers were not using personal protective equipments and workers were not aware of occupational health hazards they were exposed to. Another study carried out in Nairobi on strategy for improving occupational health and safety, working conditions and environment in metal working *Jua Kali* sector in Nairobi (Baumann et al., 1995) identified noise as among the major hazards present.

2.5 literature review conclusion

Noise-induced hearing loss is the second most common sensorineural hearing loss, after age-related hearing loss (presbycusis) and also one of the most common occupational diseases in the manufacturing industries.. Noise exposure, whether occupational or recreational, is the leading preventable cause of hearing loss. By preventing noise-induced hearing loss, patients can reduce the impact of age-related changes on their hearing.

Workers in the manufacturing industries both the informal and the formal sectors are exposed to hazardous noise levels. In the formal sector the occupational safety and health regulations are enforced unlike in the informal sector. Most of the researches that had been carried out on occupational noise exposure had been carried out in the formal sector .The literature review opened up many areas of research in the informal sector. The informal sector workers like any other workers in the formal sector requires to be protected from occupational noise induced hearing loss. No research has yet been conducted on occupational noise induced hearing loss in the informal sector metal fabrication, although similar research has been conducted in the formal sector in construction by (Richard Neitzel et al., 1999) and steel rolling mills by (Foluwasayo et al., 2005). This research study was for academic purpose and hence aimed at getting the actual situation on the ground.

CHAPTER THREE

3.0 RESEARCH MATERIALS AND METHODOLOGY.

3.1 Introduction

The study was conducted in Nairobi city, Kamukunji *Jua Kali* sheds between June 2008 and March 2009. The primary data was collected in three phases; first phase involved noise measurements at various metal fabricating *Jua Kali* sheds, second phase involved gathering basic information using the questionnaire and finally carrying out audiometric tests. The major economic activities identified for the study were metal fabrication /engineering work which entails making of chisels, hoes, crow bars, metal boxes, buckets, basins, rakes, frying pans and other blacksmith activities. The other activities which were going on within the vicinity were, fruits vending, hawking of assorted goods including scrap metal, hotel and kiosk operations. The study was limited to metal fabrication/engineering works because these activities generate a lot of noise and operators are busy all the time as the demand of these goods are high. Hence, they are exposed to occupational noise most of their time during the daytime. Unlike the other activities where each individual works on his or her own, the work here is usually done in groups under their leader, hence it is easier to handle them through their leader. Some of the *Jua Kali* associations in Kenya includes Kamukunji *Jua Kali* Association which is considered as the pioneer of *Jua Kali* movements in Kenya formed in February 1986, Machanganyiko Craft Association of Kakamega formed in 1987, Kisumu Centre *Jua Kali* Artisan Association started in 1986 and Kayole *Jua Kali* Association which was formed in 1992.

3.2 Study area

Nairobi is the capital city of Kenya and was designated a town in 1899 by the British colonial administrators. By that time the population was 10,000 and it gradually rose to 266,800 in 1963 and currently the population is about 3 million. The rapid increase of population was as a result of people migrating from rural areas to Nairobi because there were thriving formal and informal industries which offered employment, and these resulted to Nairobi city having about 24% of the total people employed in the informal sector. In 1986, the government of Kenya recognized the important role played by the *Jua Kali* sector and erected sheds to shelter *Jua Kali* workers at Shauri Moyo estate. The area where sheds were erected is now referred as Kamukunji *Jua Kali* after the famous political meeting ground adjacent.

The study was conducted in Kamukunji *Jua Kali* sheds which are located about two to three kilometers from Nairobi town centre on the eastern side of the Nairobi city. Nairobi province is in the south west part of Kenya (see appendix1). It has an altitude of between 1,500 and 2500 meters above sea level and lies on latitude of 1^0 25'south and 1^0 12'south. These latitude bearing encourage people to describe Nairobi as the green city in the sun because it seems to be below the tropical sun. It lie on longitude 34^0 40' east and 37^0 07' east. The kamukunji *Jua Kali* shed lies between landhies Road on the south, Sakwa Road on the west and Kericho Road on the east. The sheds can also be approached from Jogoo Road round about through Undungu Society Limited at Delta House (see appendix 1). The Kenya-Uganda railway and an up country bus station popularly known as Machakos bus station are within the vicinity to the kamukunji *Jua Kali* sheds, so the transport network adequately serves the demand and supply markets (Ofafa 1999; McCormick and ongila, 1998). This area is densly populated. Other areas visited by the researcher where similar study could have been conducted but are far from Nairobi city centre, with less population of workers and not convenient for the researcher are, NCCK *Jua Kali* shed in Buruburu, Kayole *Jua Kali*, Kariobangi Light Industries, Dagoretti *Jua Kali*, Kangemi *Jua Kali*.

3.3 Study Population

The study populations were workers working in micro-enterprises established by entrepreneurs dealing with metal fabrication /metal engineering. The population was purposively selected because it had the required characteristics for the study.

3.4 Sample size determination.

The Sample size determination formular used was:

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

Where:

n = the desired sample size for a target population of 10,000 and above.

Z = the standard deviation at 95% confidence level

p = the proportion in the target population estimated to have characteristics being measured, since there is no estimate available of the proportion in target population assumed to have the characteristic of interest then an estimate of 50% was used.

d = the error of estimate which is 5%

3.5 Sampling technique

The sampling methodology involved selection of samples from the population of workers in metal fabrication who had worked for a period of one year and above. The sampling frame was the Kamukunji *Jua Kali* Association register of the year 2007 for workers in metal fabrication section. Those who have worked for less than one year were removed from the list and the final list had 1644 workers. Systematic random sampling was used to select a total of 384 participants. The sampling interval was determined by dividing the total population by the sample size (1644 / 384=4.28125). A smaller number than four, in this case one was selected. Starting the first name, every fourth name was selected from the list of population which was written down randomly. In this case, the sample population was reasonably representative of the target population.

3.6 Data collection

Data collection included completion of questionnaires by the selected subjects, noise mapping of the sheds and hearing evaluation of the workers.

3.6.1 Materials and Equipments

Materials and equipment, description and their purpose in the research.

Figure 3.1: Noise level meter. Equipment for measuring noise levels.

Figure 3.2: Hearing evaluator – Fonix type 1A, Model FA-12 Digital Audiometer :-Equipment for measuring the level of hearing .

Figure 3.3: Diagnostic kit: - for ear examination.

Syringing set:- Syringes and normal saline for cleaning the middle ear

Micro ear forceps: - For removing debris and foreign bodies from middle ear

Disinfectant solution (surgical spirit):- For disinfecting used equipments

Swabs and cotton wool:- For drying up the equipments.

Disposable latex gloves: - For protecting the researcher while cleaning the ears.

Hearing evaluation questionnaire: - For obtaining demographic data and information related to noise exposure.

3.6.2 Methods

A number of visits were made to the research site and the researchers were acquainted with the processes in the Kamukunji *Jua Kali* metal fabricating sheds and identified the risks and hazards posed to the persons working in the setting.

A number of meetings were conducted initially with the management committee. Through their leaders, members were sensitized about the research and potential benefits of participating in the same. A list of all members of the workplace who had worked in the setting for more than one year was availed to the research team and through systematic random sampling, a total of 384 participants were selected

Dates and timings were then scheduled and announced to the selected participants.

3.6.3 Noise level measurements.

A Cirrus sound level meter type CR - 263 Serial No. A20081FE with omni-directional microphone set at a slow response was used in measuring the environmental noise at the workplace. The instrument was calibrated using an Acoustic Cirrus calibrator model CR: 515, Serial No. 46701, at 93.9dB (A) and 1000 Hz. The calibration was used to check the sensitivity of the instrument immediately before and after the measurement period. The sound meter level was set to measure the A-weighted noise level which varies with the frequency intensity like the sensitivity of the human ear. The sound level meter was held at 1 meter from the ground and the Leq (the continuous equivalent sound pressure level) sample measurements were taken at various sheds. The Leq is indicative of average noise levels over a given period. Where noise levels was found to be above 85dB (A) a frequency analysis was done to determine at what frequency the level of high noise was resulting from.

3.6.4 Hearing evaluation

Hearing evaluation was done in three stages and was done in the morning before the workers started working.

Stage 1

The participant was briefly informed about the process he was to undergo. The participant was then assisted in filling the questionnaire including his bio-data and questions relating to his occupational and other relevant noise exposure as well as any other illness affecting the ears and general.

Stage 2

The participant then would undergo examination which included general examination and specific examination of the ear. Examination ear was carried on using otoscope and where wax was found the participant would then undergo ear syringing prior to audiometric tests.

Stage. 3

The participant was then ushered into a quiet room where ambient sound pressure levels was found to be 38.9dB (A) and audiometric test done. The table below shows the maximum allowable octave band pressure levels for audiometric tests room. (Thayer and Sataloff, 2006).

Table 3.1: Maximum allowable octave band sound pressure levels for audiometric test room

Octave–band frequency (HZ)	500	1000	2000	4000	8000
Maximum sound pressure levels (dB)	40	40	47	57	62
Actual levels during the study	Between 38dB (A) and 38dB (A)				

The participant hearing thresholds was assessed through the different frequencies from 125Hz to 8 KHz and different sound pressures levels. A threshold shift at the 3000, 4000 and 6000 Hz frequency on an audiogram is often an indicator of noise induced hearing loss. A threshold shift at these frequencies commonly follow exposure to hazardous noise. The results were then plotted in an audiogram and finally the participants were informed of the findings and advised appropriately (appendix 4 for an audiogram showing bilateral moderate hearing loss).

3.7 Ethical consideration.

The study carried a minimal risk to the subject and participation was voluntary through informed consent. Permission to carry out the research was sought from the Ministry of Labour and Human Resources Development, Directorate of Occupational Health and Safety Services. The researcher works with the Directorate of Occupational Health and Safety Services.

CHAPTER FOUR.

4.0 RESULTS AND DISCUSSIONS.

4.1 Introduction

The Kamukunji *Jua Kali* workers were selected to participate in the research, the participants were mainly those working in the metal engineering and metal fabrication section. A total of 384 workers were selected, a questionnaire administered to them and audiometric examination done. Noise survey was conducted using noise level meter. Frequency tables, pie charts, bar graphs and percentages were then used to present the findings upon which interpretations and conclusions were derived.

4.2 Results of questionnaire

Table 4.1: Participants age and sex.

Age	Sex	Frequency	Percentage (%)
Below 25 yrs	Male	75	19.5
25-35 yrs	Male	168	43.8
36-45 yrs	Male	126	32.8
Over 45 yrs	Male	15	3.9
Total	Male	384	100

Table 4.2: Participants highest level of education attained

Level of education	Frequency	Percentage (%)
No education	26	6.7
Primary	127	33.1
Secondary	187	48.7
Tertiary	32	8.3
No response	12	3.2
Total	384	100

. Table 4.3: Participants duration at current job.

Duration	Frequency	Percentage (%)
5 years and below	101	26.3
6-10 years	201	52.3
11-15 years	52	13.5
16-20 years	17	4.5
Over 20 years	13	3.4
Total	384	100

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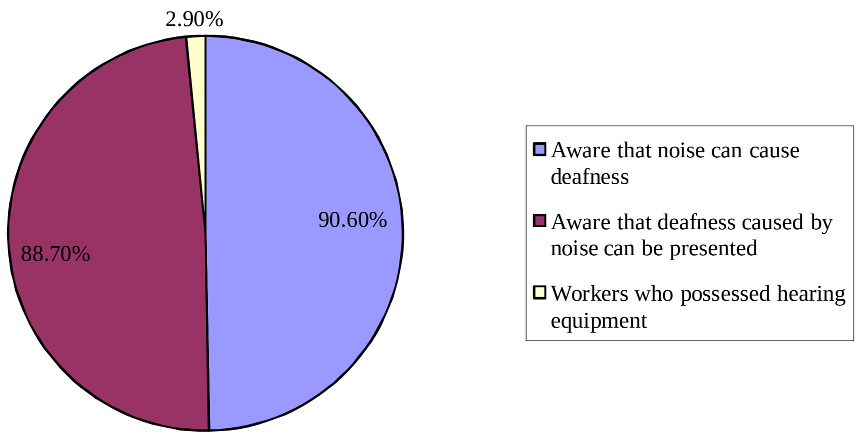

Figure 4.1: Participant awareness toward noise induced hearing loss and use of hearing protective equipment.

Table 4.4: Participants awareness toward noise induced hearing loss and use of hearing protective equipments

	Frequency	Percentage (%)
Aware that noise can cause deafness	348	90.6
Aware that deafness caused by noise can be prevented	341	88.7
Workers who possessed hearing protective equipments	11	2.9
Workers who possessed hearing protective equipments and uses them regularly	5	45.5

Table 4.5: Participants reason for not using hearing protective equipment

Reasons for not using hearing protectors.	Frequency	Percentage (%)
Not provided.	176	45.8
There was no need to use hearing protective equipments	102	26.6
Not aware of the hearing protective equipments	50	13.0
No reason	39	10.2
Expensive and not available in local shops	9	2.3
Not comfortable	8	2.1
Total	384	100

Table 4.6: Participants view about noise in their workplace.

Participants response about noise in their workplace.	Frequency	Percentage (%)
Normal	260	67.7
High	110	28.6
Low	14	3.7
Total	384	100

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Table 4.7: Participants complain on noise related induced health effect.

Noise related complains of the participants.	Frequency	Percentage (%)
Headache	46	12.0
Inability to hear well	15	3.9
Ringing in the ears	59	15.4
Stress and irritation	12	3.1
Sleep disturbance	38	9.9
Fatigue	23	6.0

Table 4.8: Participants sign of working in a noisy environment

Sign of working in a noisy environment	Frequency	Percentage (%)
Have to shout while talking to workmate	206	53.6
Have difficulties in hearing conversation after work shift	42	10.9
People seem to mumble while speaking	35	9.1
Neighbouring people accusing them of playing loud music or the volume of radio/television too high at home	70	18.2
Have to ask people to repeat themselves	64	16.6

4.3 Results of noise measurements

Table 4.9: Noise survey report of various *Jua Kali* sheds

Location/Shed number	Measured levels dB(A)
Chairman's office	72.0
Metal box making area –shed No 1	101.1
Metal/iron sheets sales /weighting –shed No2	90.3
Light pan/general cover shed No 3	94.0
Backsmith area-shed No 4	88.8
Window /door making area – shed No 5	103.2
Jembe /hoe making area-shed No 6/7/8	100.8
Pan making area 1-shed No 9	106.8
Pan making area 2 -shed No 10	104.4
Pan making area 3 -shed No 15	113.8
Metal cutting area -shed No 16	93.2
Tank and other water carrying instruments making area –shed No 17	97.2
Cooking instruments ('jiko', 'sufurias', chips cooking instruments etc) -shed No 19	98.4
Cooking instruments ('jiko', 'sufurias', chips cooking instruments etc) -shed No 20/21	93.2
Cooking instruments ('jiko', 'sufurias', chips cooking instruments etc) -shed No 23	97.9
Shed No 24 :sales men	87.1
General metal work eg making cement carrying container ('kalai'),shaping metal sheets to different shapes according to demand -shed No 25	99.9
Metal work general e.g shaping ,cutting, -shed No 26	99.1
Metal work cutting-shed No 27	94.4
Women section (sales shop) –shed No 28	89.6
Women section (sales shop) –shed No 29	84.1
Shed No 30 (sales men)	85.9
Women section (sales shop) –shed No 31	86.8
Women section (sales shop) –shed No 32	81.0

Table 4.10. Frequency analysis of noise measurements above 85 dB (A) ,

Frequency (Hz)	31.5	62.5	125	250	500	1000	2000	4000	8000	16000
Leq dB(Z) Shed No 1	73.9	73.3	69.1	64.0	75.6	76.7	84.4	93.3	97.8	78.0
Leq dB(Z) Shed No 2	75.7	72.1	74.9	74.4	75.8	78.9	84.2	74.9	73.2	61.1
Leq dB(Z) Shed No 5	65.7	69.2	82.5	84.6	83.6	83.3	95.0	99.0	99.7	89.5
Leq dB(Z) Shed No 6/7/8	63.5	69.5	70.6	71.9	73.4	75.5	91.7	96.3	91.2	83.3
Leq dB(Z) Shed No 9	81.5	76.5	81.7	91.6	98.3	97.5	97.4	95.5	90.4	83.9
Leq dB(Z) Shed No 10	76.3	76.8	91.0	92.0	99.1	95.4	100.0	95.9	91.9	84.7
Leq dB(Z) Shed No 15	70.8	73.8	83.3	96.8	98.4	103.4	107.4	104.9	97.0	81.5
Leq dB(Z) Shed No 16	75.4	78.7	78.1	78.3	85.3	82.9	85.9	89.0	83.2	77.8
Leq dB(Z) Shed No 17	66.2	61.9	61.6	63.8	76.8	89.3	92.4	92.8	91.2	76.6
Leq dB(Z) Shed No 19	63.0	71.4	62.9	78.9	67.6	67.2	82.0	75.6	66.4	76.0
Leq dB(Z) Shed No 20/21	75.9	65.8	70.6	73.1	78.0	82.3	86.1	89.2	85.7	76.8
Leq dB(Z) Shed No 23	69.9	71.9	71.8	80.2	85.4	87.6	90.5	94.4	87.9	82.8
Leq dB(Z) Shed No 25	73.5	76.4	86.5	90.4	98.1	94.1	93.9	93.6	82.4	81.1
Leq dB(Z) Shed No 26	61.9	64.0	68.0	67.6	73.8	64.0	91.1	96.6	82.6	96.3
Leq dB(Z) Shed No 27	57.2	63.1	58.6	73.2	78.5	87.5	86.2	82.1	78.5	72.0

4.4 Hearing evaluation

Table 4.11: Ear examination. (Otoscopic examination).

Condition of ear	Right ear		Left ear	
	No of workers	Percentage (%)	No of workers	Percentage (%)
Normal	360	93.8	367	95.6
Wax	20	5.2	12	3.1
Perforated ear drum	0	0	2	0.5
Foreign body in middle ear	3	0.8	3	0.8
Canal sternosis	1	0.3	0	0

Table 4.12: Audiometric tests.

Grade of impairments	Hearing threshold	Number of workers	Percentage (%)
Grade 1 (slight impairment)	26-40 dB hearing loss (better ear)	69	18.0
Grade 2 (moderate impairment)	41-60 dB hearing loss (better ear)	30	7.8
Grade 3 (severe impairment)	61-80 dB hearing loss (better ear)	27	7.1
Grade 4 profound impairment including deafness)	81 dB hearing loss or greater (better ear)	9	2.3
Total		135	35.2

Table 4.13: Number of workers examined, number of years worked and the percentage of workers with hearing impairments.

Number of workers examined	Number of years worked	Number of workers with hearing impairments	Percentage (%) of workers with hearing deficit in that group
101	1-5	23	22.8
201	6-10	63	31.3
52	11-15	28	53.8
17	16-20	12	70.6
13	0ver 20	9	69.2

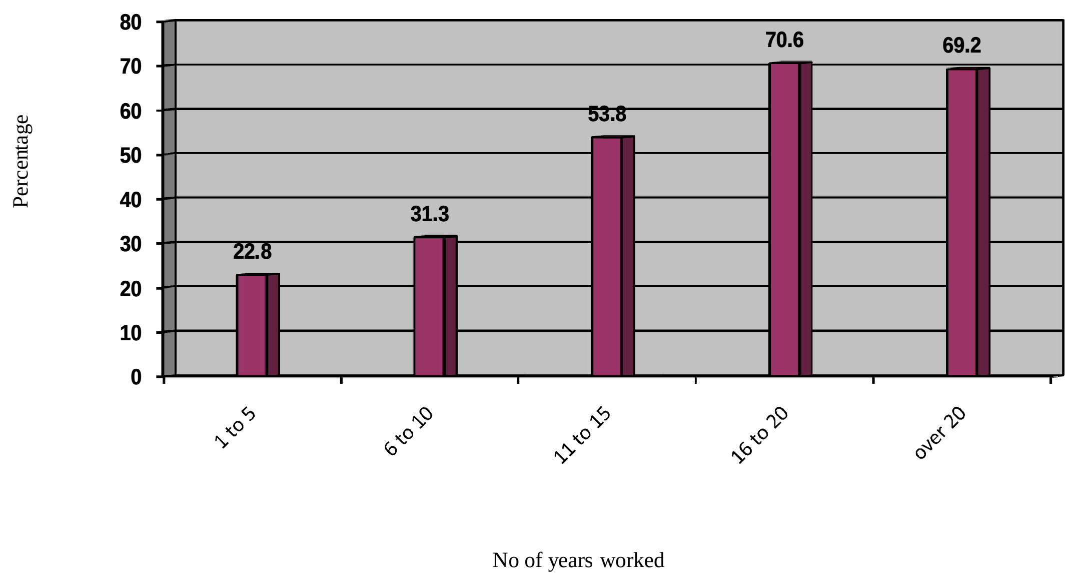

Figure 4.2.Participants with hearing deficit and the number of years worked.

4.5 Discussion of the results.

The purpose of this study was to evaluate occupational noise exposure among workers in metal fabricating sector in kamukunji *Jua Kali* sheds. The findings of this study could lay a foundation for the development of strategies to prevent noise induced hearing loss among *Jua Kali* workers.

The first section of the results defines the characteristics of the Kamukunji metal fabricating *Jua Kali* workers. The research sample was composed of 100% male workers, majority of them 63.3% were below the age of 35 years (Table 4.1). The sample of participants was drawn from those who were involved in production section only, although other people were exposed to high noise levels like hawkers, customers, those selling food in kiosks and sales shops which were mainly dominated by female as seen in (Table 4.9). The research was mainly limited to those involved in production so as to get the actual status of hearing deficit of these *Jua Kali* workers in metal fabricating sector. From the study 48.7% of the workers had secondary school education followed by those with primary school education 33.1% (Table 4.2). 52.3% of the sample had worked for 6 to 10 years while 26.3% had worked for 1 to 5 years. The statistics show that on the average, the workers are educated up to secondary school level and they had been working for a considerable period of time.

The first objective of this study was to determine noise levels at various selected *Jua Kali* sheds in Kamukunji. It was shown that the overall measured noise levels in the study area ranged from 72dB (A) to 113dB (A) (Table 4.9). The lowest measured noise level was at chairman’s office which is located within the Kamukunji *Jua Kali* sheds and the highest noise level was recorded in the pan making section. The measured noise levels are above the recommended daily exposure (appendix 3). The recommended exposure limits set by World Health Organization and International Standard Organization (Table 2.1). The International Labour Organization recommends noise limits (Occupational Exposure Level) to reduce hearing loss in workplaces (occupational deafness) as 90 dB (A) for 8 hours daily. Where noise level was found to be 85dB (A) and above, frequency analysis was done to determine at what frequency the level of high noise was resulting from. When damage first occurs, it affects the part of the ear corresponding to the mid-frequency range of 3 to 5 kHz and it is seen on an audiogram as a notch (appendix 4). The area where noise level was recorded as below 85dB (A) occupational noise induced hearing loss could not occur but workers in these areas develop health effects related to exposure to high noise levels (Table 2.2).

From the study, it can be seen that *Jua Kali* workers were exposed to hazardous noise levels as it is evident from (Table 4.7), which is showing various noise induced health effects the participants were experiencing. Also 53.4% of the participants had to raise their voices or shout while talking to their workmate at workplace an indication that they are working in noisy environment. Other signs of working in a noisy environment includes, workers were having difficulties in hearing conversations after work shift, people seems to mumble while speaking, neighboring people in the residential area were complaining that their volume of radio/television was too high and while talking they kept telling people to repeat what they are saying.(Table 4.8).

The second objective of the study was to determine the level of awareness and preventive measures toward noise induced hearing loss among the *Jua Kali* workers. The study revealed that 90.6% of the participants were aware that noise can cause hearing loss, 88.8% of the participants were aware that hearing loss can be prevented but only 2.8% were having hearing protective equipment and only 45.5% of those with hearing protective equipment were using them regularly (Figure 4.1 and Table 4.4). The results indicate that the majority of the *Jua Kali* workers were aware of the noise hazards they were exposed to and the consequences of been exposed, but they had not taken any measures to protect themselves. Majority of the participants, 45.8%, gave reasons of not using hearing protective equipments as not been provided by their employer, 26.6% did find the need to use hearing protective equipments, 13% were not aware of the personal protective equipments, 2.3% complained that they were too expensive, 10.2% did not respond to the question, 2.1% complained that the hearing protective equipments were uncomfortable (Table 4.5). These finding correspond to an indication that the participants lack the knowledge of noise induced hearing loss. Noise induced hearing loss occurs gradually over a long period and initially it does not prevent one from performing his/her duties. Another reason for not using hearing protective equipment could be due to the fact that few people had worked in that sector for a long time to have effects which can create awareness to the other workers (Table 4.3).

The third objective of the study was to carry out hearing evaluation of the *Jua Kali* workers in metal fabricating sector. The report of noise survey (Table 4.9) shows high noise levels in *Jua Kali* shed, but 67.7% of the *Jua Kali* workers said the noise levels were normal, 28.6% said it was high and 3.7% said it was low (table 4.6).

This results indicates that 67.7% of the workers had their hearing threshold shifted up an indication of early sign of noise induced hearing loss, 3.7% of the workers had already developed noise induced hearing loss and 28.6% of the workers, their hearing had not been affected by noise.

Hearing evaluation involved ear examination and audiometric tests. Ear examination showed that some of the workers were having ear wax and foreign bodies in the middle ear, these were removed before the audiometric tests since they causes some hearing loss. (Table 4.11). Audiometric test results showed that 35.2% of the workers were suffering from various grades of noise induced hearing loss (Table 4.12).This figure is higher than World Health Organization figure of 7-10% of people with hearing deficit in a normal population in developing countries. There was a positive relationship between the number of workers examined with hearing deficit and the number of years they had worked, the more the number of years worked the higher the percentage of workers suffering from noise induced hearing loss (Table 4.13 and Figure 4.2).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study has found that *Jua Kali* informal workers in metal fabricating sector are mostly young men below 35 years of age with majority of them having attained secondary school of education.

Environmental workplace noise is a significant problem in Nairobi kamukunji *Jua Kali* metal fabricating sector as the measured noise levels ranged from 72.0 to 113.8dB (A), causing noise induced hearing loss to 35.2 % of the workers plus other wide range of noise related health effects. Majority of the *Jua Kali* workers are aware that noise can cause deafness plus other health effects and can be prevented but they do not use hearing protective equipment.

5.2 Recommendations.

The Directorate of Occupational Safety and Health Services, the body given the mandate to enforce occupational safety and health regulations should device a means of enforcing the occupational health and safety regulation in the metal fabricating *Jua Kali* sector in order to reduce the exposure of workers to occupational hazardous noise levels.

There is need for training programme on health and safety to be developed to ensure workers in this set up are trained so that they understand the risks they are exposed to and possible preventive measures. This training program should not be optional but be a pre- condition of working in the informal sector.

It is a recommendation of this study that noise control and preventive programme be incorporated in the primary health care services and issues to be addressed includes the importance of usage of hearing protective equipments, posting of warning notices in noisy places and medical examinations (audiometric tests).

The high cost of hearing protective equipments was one of the factors hindering the workers from wearing hearing protective equipments. The cost could be brought down if the department of Directorate of Occupational Safety and Health Services lobbies the treasury to exempt duty from imported hearing protective equipments. . Statutory financing should be developed to assist in procurement of the appropriate technology. These will encourage the *Jua Kali* workers to use work processes that reduces occupational noise e.g. hammering and forging are among the main process which can be substituted by hydraulic press and riveting can be substituted by welding, brazing and soldering. These will enable the *Jua Kali* workers to minimize the hazards at the expense of economic gain.

A research should be carried out to determine the cost of noise induced hearing loss. The study also recommends a link between awareness and noise preventive strategies be further investigated.

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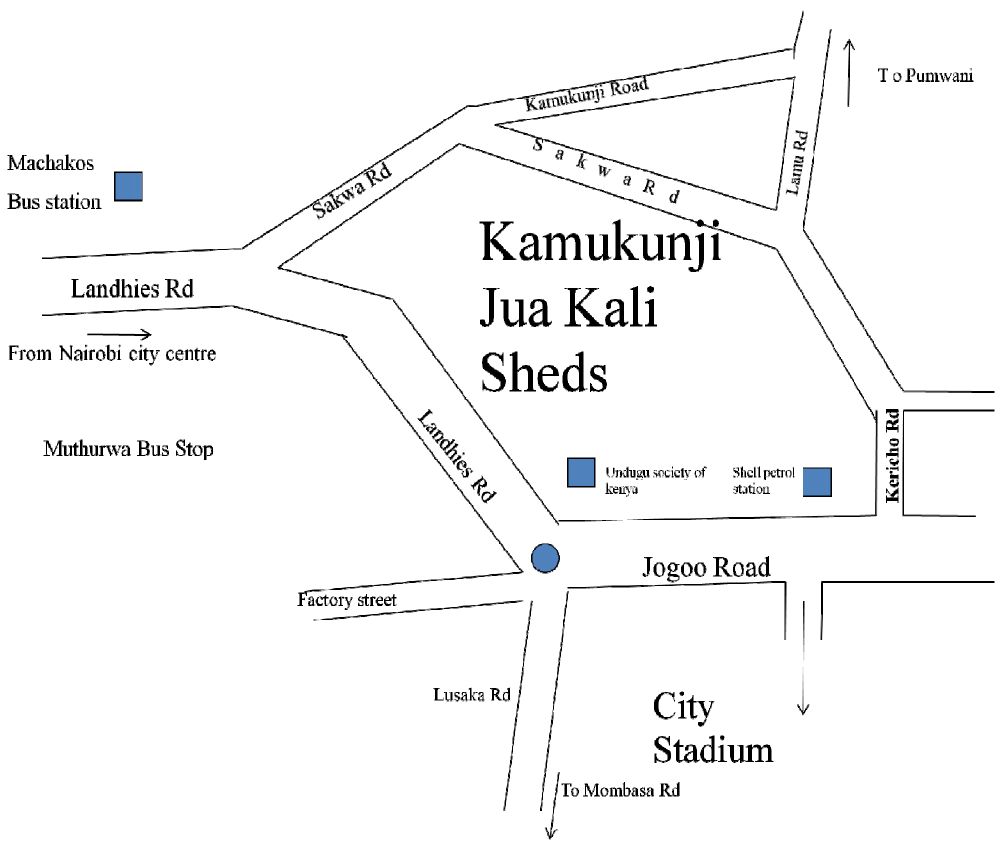
APPENDIX 1

1.1 Map of Kenya showing location of Nairobi

1.2 Map showing location of kamukunji *Jua Kali* sheds



APPENDIX 2

Typical noise levels

Source of sound	Sound level in dB
Convectional or Nuclear bomb explosion at 5 m .	250
Rocket engine at 30m; Krakatoa explosion at 160km in air	180
Jet engine at 30m.	150
Rifle been fired at 1m	140
Chain saw at 1m	110
Accelerating motorcycle at 5m	110
Sheet metal workshop	100
heavy truck at 1m	90
Busy traffic road at1m	70
Normal conversation/office	60
Low conversation	50
Quiet radio music	40
whispering/theatre	30
quiet urban apartment	20
Rustling leaves/human breathing at 3m	10
Threshold of human hearing (with healthy ears)	0

From hearing foundation of Canada-2007

APPENDIX 3

Permissible Noise Exposure

Duration Per Day Hours	Sound Level slow response dB (A)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

Source: CCH 1998; Planning Occupational Health and Safety. Sydney. CCH Australia.

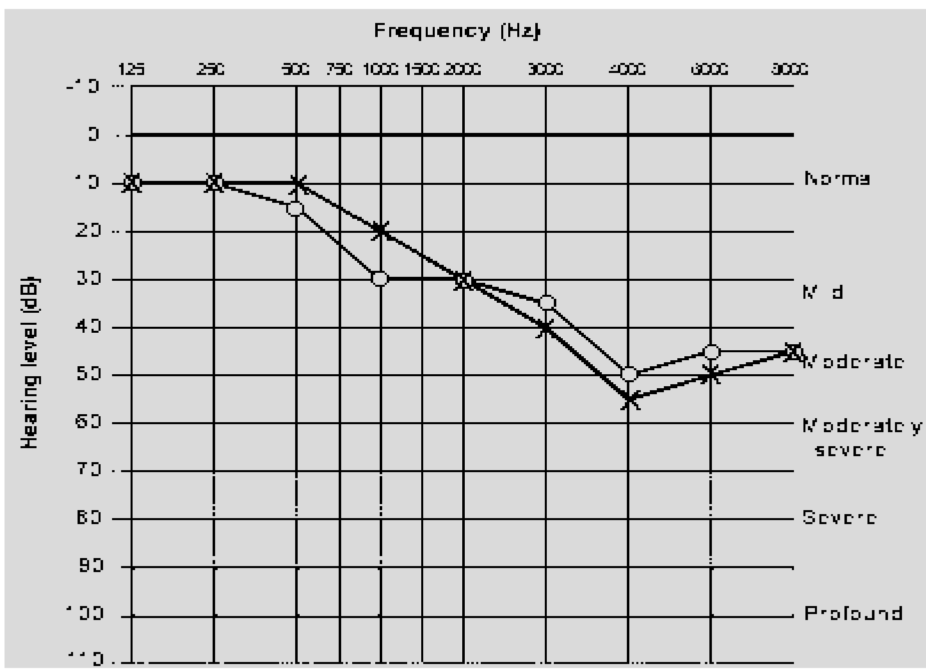
APPENDIX 4

Audiogram

Name: XXXXXXXX Age 27yrs Date 10th August 2009

Ambient sound 38.9 dB (A)

Frequency (Hz)	125	250	500	1000	2000	3000	4000	6000	8000
Hearing level (dB)-right ear	10	10	15	30	30	35	50	45	45
Hearing level (dB)-left ear	10	10	10	20	30	40	55	50	45



EXAMINER: Dr kimani

Comments: The graph shows sensorineural hearing loss, probably caused by excessive noise exposure. The area below the curves represents sound levels that the participant could still hear. (X = left ear; O = right ear).

APPENDIX 5

Questionnaire

Introduction note

Dear sir/madam,

My name is John. M. Kimani and I am a student at Jomo Kenyatta University of Agriculture and Technology. I am conducting a health and safety survey in fulfilment of master degree in occupational safety and health at Kamukunji *Jua Kali* metal fabricating industries and I would appreciate your assistance. The information you give will be treated privately and confidential. You are free to ask any question.

Thanks.

I………………………. …………………………………………………………...

being a person 18 years and over do hereby give consent/permission to Dr John kimani to include me in the intended research. I have read and understood the contents of this form. I do also understand that at any time of the study, I may revoke my consent and withdraw myself from the study without prejudice. This has been explained to me in a language that I do understand.

Volunteer's signature …………..……………………………………………….

Investigator's signature ……………………………………………………….

Date………………………………………………………………………………

Name ……………………………………...……...…Age…..…Gender……………

Name of workplace.. Nature of work...............................

Duration at current job……………………...................DATE…..……..…………….

Questionnaire on assessment of noise exposure

The following questions focus on exposure to hazardous sounds. Please answer all of the questions carefully and to the best of your ability. Please be specific as you can

1. What is the level of your education?

    a) None ☐
    b) primary ☐
    c) secondary ☐
    d) Tertiary ☐
    e) No response ☐

2. Are you aware that exposure to noise can cause deafness?

    yes ☐ No ☐

3. Are you aware that one can be protected from becoming deaf?

    Yes ☐ No ☐

4. Have you ever had any health problem from exposure to noise?

    Yes ☐ No ☐

5. State which health problems?

a) Headache ☐

b) Ringing in the ears ☐

c) Inability to hear well ☐

d) Sleep disturbance ☐

e) Stress and disturbance ☐

f) Fatigue ☐

6. Do you shout at your workplace to be heard by your workmate?

Yes ☐ No ☐

7. Do you have trouble hearing conversation after work shift?

yes ☐ No ☐

8. Do many people you talk to seems to mumble (or not to speak clearly)?

Yes ☐ No ☐

9. Do people complain that you turn T.V/Radio volume too high?

Yes ☐ No ☐

10. Do you find yourself asking people to repeat themselves?

Yes ☐ No ☐

11. Do you use hearing protective equipment? YES ☐ NO. ☐

12. If the answer to question no 11 is No, then why do you not use hearing protectors?

a) Not provided ☐

b) Not aware of protection equipment. ☐

c) I have not found the need to use. ☐

d) Not comfortable. ☐

e) No reason. ☐

a. Expensive to buy ☐

13. If the answer to No 11 is yes, then how often do you use?

a) Always ☐

b) Sometimes ☐

14. Have to ever gone to hospital due to problems related to exposure to noise?

YES ☐ NO ☐

15. If no to question no.14, what are the reasons?

a) I have no time to go ☐

b) Financial problem ☐

c) Not necessary ☐

d) No reason ☐

16. Would you like your hearing tested /examined and advised accordingly?

YES ☐ NO. ☐

17. What is your comment about noise in *Jua Kali*?

a) Normal ☐

b) Low ☐

c) High ☐