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THE EFFECT OF OCCUPATIONAL NOISE LEVELS ON HEARING AMONG CEMENT FACTORY WORKERS IN TEMA

BY

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DECLARATION

I, Judith Arthur, do hereby declare that with the exception of references made to other people's work and textbooks which have been duly acknowledged, this dissertation is a result of my own effort. No material in this work has been presented either in whole or part to any other institution apart from the University of Ghana, for the award of any degree or certificate.

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DEDICATION

This work is dedicated to my dearest mother, Madame Nancy Andoh.

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It really has not been an easy journey but through it all, God has been there guiding and cheering me on, especially when the academic journey became demanding and difficult. For this I am eternally grateful.

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Lastly, to all who in diverse ways contributed to the success of this study, I say thank you and may the good Lord bless you abundantly.

ABSTRACT

Noise pollution is a global occupational health issue affecting the well-being of workers who are exposed to it. A common detrimental effect of work place noise exposure over time is noise induced hearing loss. Noise induced hearing loss is completely preventable, especially when safety measures are taken, however it becomes irreversible once acquired. The main aim of the study was to determine the effect of occupational noise levels on hearing among cement factory workers. A cross-sectional study design was employed in the study. A total of 132 male participants working at the production unit of the Ghana Cement Company were conveniently sampled. A modified questionnaire was administered to obtain scientific and personal data from the participants. Otoscopy and tympanometry were done to rule out ear pathologies of all the participants. Hearing acuity of participants was assessed using pure- tone audiometry. Data analysis and data entries were done using SPSS version 20.0 and Excel word. Results were presented in tables and a p-value < 0.05 was considered to be significant. From the study, all recruited participants (100%) were knowledgeable on the effect of occupational noise levels on hearing. Majority of the participants (56.1%) used hearing protection devices, however this was irregularly used at work. The prevalence of hearing loss was greater among workers from the milling unit than workers from the packing unit at PTA_{512} and PTA_{346}. The prevalence of loss in the right and left ears for workers from the milling unit were 23.5% and 29.4% respectively while that for the packing unit was 20.4% in both ears. There was no significant association between work duration and hearing loss ($p > 0.05$) for the right and left ears. Age was the only independent variable which significantly predicted hearing loss in both ears at PTA_{346} ($p < 0.05$). Regular audiometric testing of staff was necessary to identify individuals with threshold shifts.

Keywords: Noise-induced hearing loss, occupational noise-induced hearing loss, occupational noise, cement workers, personal protective equipment.

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LIST OF ABBREVIATIONS

ANSI: American National Standards Institute

CHL: Conductive Hearing Loss

dB: Decibel

EPA: Environmental Protection Agency

GHACEM: Ghana Cement Company

HPD: Hearing Protection Device

Hz: hertz

ISO: International Organization for Standardization

JHS: Junior High School

NHANES: National Health and Nutrition Examination Survey

NIDCD: National Institute on Deafness and Other Communication Disorders

NIHL: Noise induced hearing loss

NIOSH: National Institute for Occupational Safety and Health

NIPTS: Noise Induced Permanent Threshold Shift

NRR: Noise Reducing Rating

ONIHL: Occupational Noise Induced Hearing Loss

OSHA: Occupational Safety and Health Administration

PI: Private Investigator

PTA: Pure Tone Average

PTS: Permanent Threshold Shift

SHS: Senior High School

SNHL: Sensorineural Hearing loss

TTS: Temporary Threshold Shift

USA: United States of America

WHO: World Health Organisation

DEFINITION OF TERMS

Cochlea: The spiral organ of the labyrinth of the ear which is concerned with the reception and analysis of sound.

Decibel: One tenth of a bel: a unit for comparing levels of power ratios (especially sound) on a logarithmic scale.

Duration of exposure: This as used in the thesis refers to how long an individual has been exposed to noise with respect to length of service.

Hertz: Hertz (symbol Hz) is the SI unit of frequency defined as the number of cycles per second of a periodic phenomenon.

Occupational noise induced hearing loss: Hearing loss due to workplace exposure to continuous or intermittent loud noise.

Presbycusis: Hearing loss associated with ageing.

Pure tone audiometry: This is the measurement of an individual's hearing sensitivity for calibrated pure tones.

Pure tone average: This refers to the average of hearing threshold levels at a set of specified frequencies

Tympanogram: A graph that shows the results of tympanometry

Tympanometry: An objective assessment of middle ear mobility and pressure by using a low frequency sound.

Work duration: The number of hours spent at the work place

CHAPTER ONE

INTRODUCTION

1.1 Background

The introduction of contemporary pre-set machines in industries, factories and work places has significantly lessened the physical workload on workers and led to a profound increase in productivity. Nonetheless a consequence of industrial mechanisation is noise pollution (Bedi, 2006). Noise is described as an unwanted sound (Ahmed & Awadalkarim, 2015). Noise pollution is defined as any undesirable electromagnetic signal that yields upsetting results thus meddling with communication, wellness and contentment (Taneja, 2014). Noise is therefore considered an adverse physical environmental factor affecting the wellness of human beings in today's world (Atmaca et al., 2005).

Due to the fact that noise is considered a part of most human endeavour, in evaluating its influence on human welfare, it is frequently catalogued into occupational noise, which is noise from the workplace and environmental noise, comprising of all other locales either from municipal or domestic levels (Concha-Barrientos et al., 2004). Noise exposure can cause adverse effects on our auditory system. The commonest auditory effect is noise-induced hearing loss (Concha-Barrientos et al., 2004). Azizi (2010) states that, noise induced hearing loss (NIHL) is permanent. It is usually caused by an injury to the cochlea hair cells of the inner ear. The degree of damage of such nature may either be partial or total in one or both ears, therefore the complexities associated with work place noise levels primarily depend on sound type, sound intensity, frequency and exposure time (Duarte et al., 2015).

Occupational noise has been documented to have negative effect on both psychological and physiological wellbeing of humans, especially workers. It is known to cause changes in blood pressure and lower work place performance (Rao et al., 2015). The psychological impact of noise which manifests as annoyance, stress, concentration disorders and restlessness is conventional compared to the physiological effects which are hypertension, cardiovascular disorders and gastric disorders (Cheung, 2004). NIHL is second to presbycusis in terms of prevalence of acquired hearing loss. Studies indicate that people subjected to noise levels above 85 dB suffer from NIHL (Goplani et al., 2014).

Occupational noise induced hearing loss (ONIHL) happens to be the leading cause of infirmity worldwide. It is the commonest cause of sensorineural hearing loss (SNIHL) which is defined as hearing loss caused by damage to the sensory cells of the inner ear. The World Health Organisation (WHO) reports that 16% of adult hearing loss is attributed to occupational noise levels (OiSaeng et al., 2013). The correlation between noise and NIHL has been severally documented since the 18th century (LuAnn et al., 2002). In urban environs, noise emission is usually from manmade sources and further epidemiological studies show that workers from the printing press, textiles factories, cement manufacturing factories, transport, food processing companies, chemical / petrochemical companies and mining industries are at risk of acquiring NIHL (Azizi, 2010).

A study among workers in Goiania, Brazil detected 187 metallurgists with hearing disorders with 21% diagnosed with ONIHL. In a similar survey among 152 workers in a marble manufacturing company also in Brazil, 48% were diagnosed with ONIHL with higher degree of loss pegged at 6000Hz (Duarte et al., 2015).

The International Organization for Standardization (ISO) sets the maximum permissible occupational noise levels at 85dB for an 8 hour work shift in developing countries in order to regulate the impact of high level occupational noise levels. In the United States of America (USA), the regulating body for Occupational Safety and Health Administration

(OSHA) allows 90dB for 8 hours work shift, with a halving rate of 5dB (Bedi, 2006). The Environmental Protection Agency (EPA), the government agency for ensuring the judicious management of the environment in Ghana, sets permissible noise levels of heavy industrial areas at 70dB during the day and 70dB at night. EPA has only statutory regulations to curb hazardous noise levels but there are no mandatory laws to protect workers exposed to elevated noise levels from the work place (Asamoah-Baidoo, 2011). There is evidence that a great number of workers are susceptible to acquiring NIHL due to uncontrolled work place noise (Atmaca et al., 2005). This study therefore seeks to determine the prevalence of this public health issue among cement factory workers in Ghana.

1.2 Problem statement

Excessive noise is a prevalent occupational menace with myriads of adverse effects which continues to be a public health issue globally. Among such adverse effects are tinnitus, NIHL, difficulties in sleeping and decreased work function. NIHL has the most severe health implication on workers (Nelson et al., 2005). According to the National Institute for Occupational Safety and Health, NIHL is included in the ten topmost work-related nuisances affecting over eleven million employees (NIOSH, 1998).

Occupational noise-induced hearing loss is a major issue in most manufacturing industries regardless of extensive research conducted on the mechanism of injury, accessibility of ethics for conventional noise exposure levels and illustration of efficient programs for prevention of hearing loss (Seixas et al., 2005). The impact of occupational noise-induced hearing loss is damaging, ranging from social isolation and stigmatization to grave nationwide financial burden (Smith, 2004). The number of individuals affected globally by ONIHL rose from 120 million in 1995 to 250 million in 2004 (WHO, 1999; WHO, 2001).

Although NHIL has not been completely eradicated in some advanced countries, noise production from equipment in industries and manufacturing companies are occasionally computed and measured in order to access its impact on workers. It is from such findings that policies and hearing conservation strategies are developed to lessen the physical, psychological and economic impact of hazardous noise levels (Fuente & Hickson, 2011).

In developing and under-developed countries, summary statistics on occupational noise induced hearing loss do not exist (Nelson et al., 2005). In Ghana, there is paucity of data on the impact of occupational noise on employee health especially those in the industrial, manufacturing and construction sectors. It is therefore likely for workers in such units to retire with varying degrees of hearing impairment following years of continuous exposure. Many companies will also lose huge sums of monies to law suits claims especially now that workers have become enlightened on issues related to work place safety and health.

1.3 Conceptual frame work

Figure 1 shows the conceptual framework of this study.

Occupational noise levels, age, the use of certain ototoxic drugs especially in the management of some ear infections are among factors that predispose workers to hearing loss. Also tumours growing between the brain and inner ear can directly trigger hearing loss among workers.

The frequency and intensity of noise together with duration of exposure are major determinants of hearing loss among workers. Hearing loss therefore becomes extensive following continuous exposure to harmful occupational noise levels over longer time periods.

Workers' knowledge on the harmful effect of occupational noise and training on hearing conservation methods influence their decision to use hearing protection device while working in noisy environment. The absence or lack of knowledge and training thereof result in non-compliance and failure to use hearing protection devices, especially in the work environment where noise is above permissible exposure limits. This invariably leads to the occurrence of ONIHL.

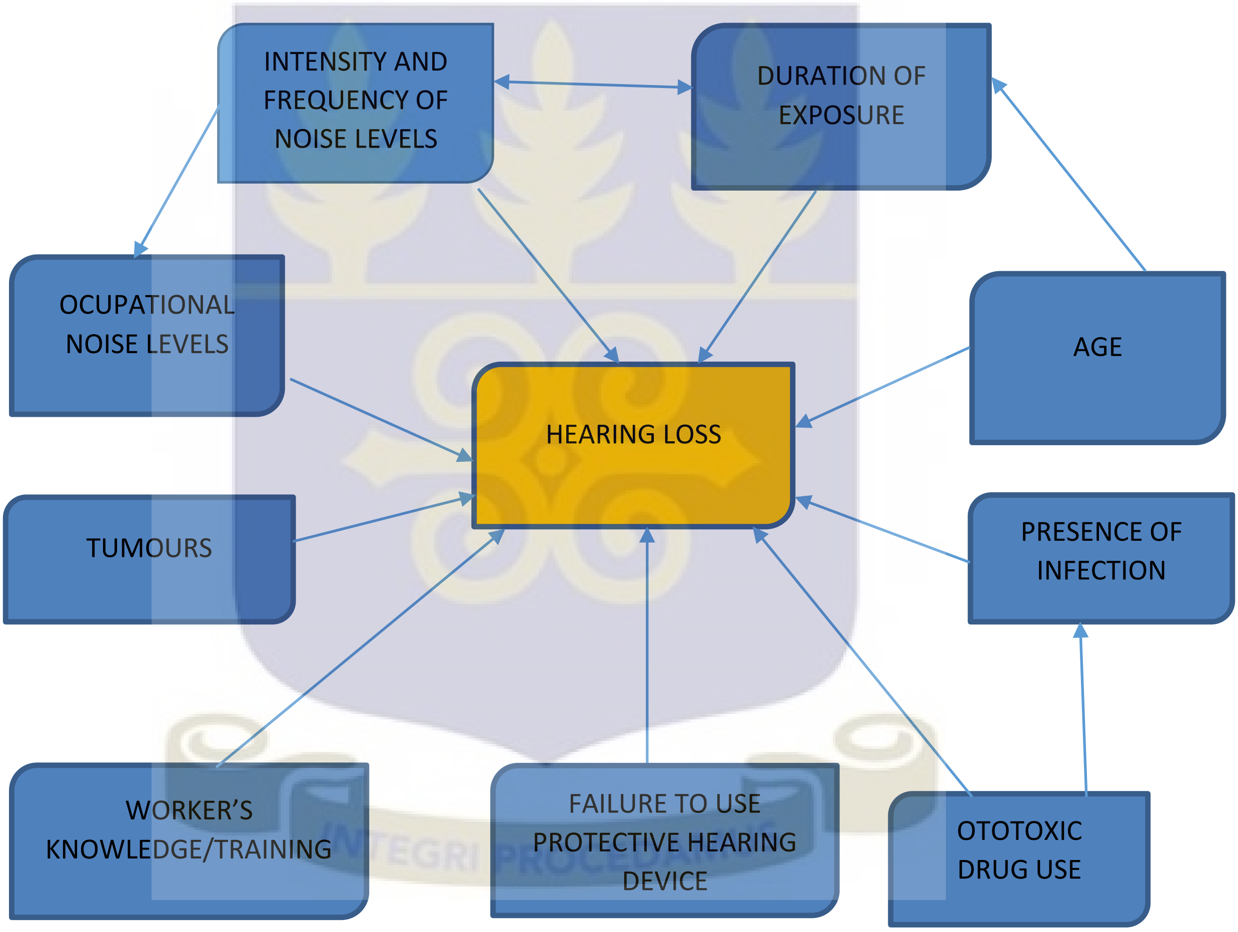

Figure 1: Conceptual frame work

1.4 Justification

Noise pollution is expanding swiftly mainly as a result of progression in industrialization and commercial activities. It has become a focal menace globally and WHO recognizes noise as a hazard which could affect both humans and the environment (Anomohanran, 2013). Occupational noise causes noise induced hearing loss (NIHL) among workers who are continuously or intermittently exposed. The seriousness of occupational noise induced hearing loss has not been fully grasped by Ghanaians although industrialization is on the ascendency. In spite of the fact that, EPA has standards and regulations to control noise levels in Ghana, the awareness and acknowledgment of NIHL as an occupational hazard is low. Overall, there is a paucity of data regarding NIHL in most developing and under-developing countries where the mean noise level is often above suggested standards in the industrialized world (Nelson et al., 2005). It is therefore important to carry out such a study to highlight dangers associated with uncontrolled occupational noise levels and to come up with recommendations to prevent NIHL so as to reduce its prevalence among workers in noise emitting industries. Information obtained from carrying out this study would again augment research data base on occupational noise pollution and its health effect on hearing among Ghanaians.

1.5 Research questions

1. Are workers in the cement manufacturing company in Tema aware of the long term health effects of noise exposure?
2. Do workers in the cement manufacturing company in Tema use hearing protection device during work?
3. What is the prevalence of hearing loss among cement factory workers in Tema?
4. What are the predictors of hearing loss among cement factory workers in Tema?

1.6 General objective

To determine the effect of occupational noise levels on hearing among cement factory workers in Tema.

1.7 Specific objectives

1. To assess knowledge on occupational noise levels and hearing loss among cement factory workers in Tema.
2. To assess the use of hearing protection device among cement factory workers in Tema.
3. To determine the prevalence of hearing loss among cement factory workers in Tema.
4. To determine the predictors of hearing loss among cement factory workers in Tema.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Noise is both an occupational and environmental hazard known to cause degeneration in hearing acuity and millions of individuals are still exposed to hazardous sound levels especially at the work place (Aguis, 2006). An instantaneous shot from a fire arm at close range may be all it takes to damage hearing permanently. Likewise, continuous exposure to repeated loud equipment or machinery used at work for extended time periods replicate the same damaging effect on hearing. The effect of noise is often misjudged because injury is gradual and lacks external physical variations. Workers are therefore often not aware of this damage to them until hearing loss occurs. NIHL is often characterized by a notch seen at 4000 Hz which progressively worsens until frequencies crucial to understanding speech is affected (Fligor, 2011) .

To effectively manage health issues related to NIHL, it is key to know two important features. First, the extent of hearing loss multiplies with duration of exposure and noise intensity, as such excessive and sustained exposures cause permanent and profound hearing loss. Second, there are variations in individuals prone to NIHL, thus not all individuals subjected to a given noise level acquire the same grade of hearing loss (OiSaeng et al., 2013). Current research has failed to establish the reason for variations in susceptibility among individuals, however certain factors like age, ototoxic medication, type II diabetes and hypertension have been linked to it (American College of Occupational and Environmental Medicine, 2012).

This chapter extensively discusses ONIHL, adverse effects of occupational noise, signs and symptoms of ONIHL, degree of hearing loss, permissible exposure limits and prevention of ONIHL.

2.2 Definition and mechanism of hearing

The ability to identify sound is known as hearing (Duthey, 2013). Sound is characterized by an extensive spectrum of frequencies. Frequencies at which human beings hear are known as audio or sonic while frequencies below and above are termed infrasonic and ultrasonic respectively. The frequency range at which humans hear is between 20 and 20000 Hz. The inability to perceive sound frequencies in the normal range of hearing is known as hearing impairment (Duthey, 2013). The ear is the medium by which humans hear. The auditory system is made up of the outer, middle and inner ear and an acoustic nerve known as the 8th cranial nerve. Sound produced is collected by the outer ear and transmitted to the middle ear via the ear canal and tympanic membrane. Sound energy causes vibration of the tympanic membrane. This allows vibrations to be transmitted to the inner ear via tiny bones known as ossicles. The ossicles allow precise sound wave transmission from air filled outer ear to the fluid filled inner ear. If not for this structure, sound energy would have recoiled from the ear without creating the air to fluid modification (Koop, 2015).

The inner ear is divided into two main parts namely cochlea and vestibular system. The vestibular system unlike the cochlea is responsible for balance, movement of the head and positioning in space. The cochlea which is snail shaped houses the auditory sensory receptor (delicate hair cells). The auditory sensory receptor is made up of the inner and outer hair cells. The outer hair cells amplify sound vibrations that enter the inner ear from the middle ear while the inner hair cells transform vibrations into electrical waves. The electrical signals that are produced, are sent to the brain via the 8th cranial nerve for storage and interpretation for later use (Rutka, 2011).

2.3 Types of hearing loss

There are three main types of hearing loss. They are conductive, sensorineural and mixed hearing losses.

2.3.1 Conductive hearing loss (CHL)

Conductive hearing loss occurs when hearing thresholds for bone conducted signals are enhanced much more than the air conducted signals. CHL is linked with outer and middle ear dysfunction while a normal inner ear function is maintained. A typical audiogram for CHL reveals a typical bone conduction (0-25 dB) and an atypical air conduction threshold levels which are higher than 25dB. CHL invariably affects all frequency ranges, however low (250-500 Hz) and mid-range frequencies (250Hz-2 kHz) are the most affected. For severe CHL, a significant loss of 60 dB or more is recorded. In instances where there is a total severance of the conductive function of the ear, sound waves are transported to the cochlea through skull vibration and fluid movements (Alshuaib et al., 2015).

Common causes of CHL include; ear infection, too much wax in the ear, fluid in the middle ear from cold and allergies, poor Eustachian tube function, hole in the eardrum, swimmer's ear, foreign body in the ear canal and malformation of the outer ear, ear canal and middle ear. CHL is mostly treated medically, surgically or by the use of amplification and assistive devices (American Speech-Language-Hearing Association, 2015).

2.3.2 Sensorineural hearing loss (SHL)

Sensorineural hearing loss is defined as "hearing loss caused by damage to the sensory cells of the inner ear or the vestibulocochlear nerve" (Coates, 2010). SHL is potentially the commonest form of permanent hearing loss which may present either at birth or later in life. With this type of hearing loss, the proficiency for hearing soft sound is significantly reduced and audible sounds are perceived to be muffled (American Speech-Language-

Hearing Association, 2015). Factors known to cause SHL are genetics, ototoxic drug use, aging, head trauma and extensive exposure to loud noise. SHL caused by extensive exposure to loud noise stimulates mechanical damage to the inner ear structures. It is therefore advisable to ensure that workers with exposures above the permissible threshold limit of 85 dB are appropriately equipped with protective ear devices. In some peculiar cases, the cause of SHL is unknown. For such instances, SHL is either described as idiopathic or sudden sensorineural hearing loss (Coates, 2010). SHL is mostly unresponsive to medical and surgical treatments. Completely avoiding the cause of SHL is the best practice.

2.3.3 Mixed hearing loss

Mixed hearing loss is a blend of sensorineural and conductive damage in the same ear. In most cases, it is easy to treat the conductive damage. The sensorineural damage is often tough to treat and manage (American Speech-Language-Hearing Association, 2015).

2.4 Degree of hearing loss

Degree of hearing loss refers to the gravity of the loss. Table 2.1 shows a classification system commonly used in describing the degree of loss.

Table 2.1: Grades of hearing impairment

Degree of hearing loss	Hearing loss range (dB)
Normal	-10- 15
Slight	16-25
Mild	26-40
Moderate	41-55
Moderately severe	56-70
Severe	71-90
Profound	90+

Source: Clark (1981)

2.5 Noise pollution and noise exposure

Climatic change and global warming which is linked with findings centred on carbon dioxide discharges and extreme heat are relentlessly heard on the media and in publications. Much importance is thus placed on atmospheric pollutants rather than noise. Among humans, the impact of noise on health is mostly not given much audience (Moela, 2010).

Noise occurs all the time. It has a damage dose effect on worker's health (Goines & Haglar, 2007). It is characterised by intensity (loudness), pitch (frequency) and duration of exposure which is usually appraised using a logarithmic decibel (dB) scale. Noise ranges from austere sources like a barking of a dog to multifaceted technology such as air planes and large automobiles, thus not all noise exposures are work related (Goines & Haglar, 2007). Many people are engaged in frivolous activities that produce hazardous noise levels. In the US for example, about sixty million of their population possess fire arms with inadequate hearing protection (Asamoah-Baidoo, 2011). For such a population, their susceptibility to acquiring hearing loss is high. People particularly at risk of hearing loss due to excessive work place noise levels are those working at heavy production units and the agricultural sector (Fligor, 2011). Below is a table showing sources of sounds and their perceived loudness.

Table 2.2: Sources of sound and perceived loudness

SOUND	LOUDNESS (dB)
Whisper	30-40
Quiet room	50
Conversations	60
Lawnmower	90
Stereo headphones	110-120
Rock concert	110-120
Jet	140
Gunshot	140-170

Source: Rabinowitz (2000)

2.6 Sources of noise

2.6.1 Environmental noise

Ambient or environmental noise levels are harmful open-air sounds fashioned by human activities (Goines & Haglar, 2007). These include sound radiations from transports (e.g. road traffic and air traffic) and sites from industrial activities. Environmental or ambient noise pollution has many adverse implications. Its severity and enormousness will continuously escalate mainly because of present societal trends seen in developmental and population growth. Its severity "*will also intensify in relation with the increase in the use of progressively more powerful, varied and highly mobile source of noise*" (Schell et al., 2006).

Although environmental noise is principally considered to be an urban issue, it is not a completely modern occurrence because, it has progressed over time. Its negative effect is slowly extending to the already scarce wildlife reserves in the world. Environmental noise pollution may not model the eminent destruction that comes with atomic wars, its consequences are same and lingering (Dooley, 2002).

In health, the presence of environmental noise has been computed and found to be disturbing. Quite a number of researches done further highlight the fact that, the quality of life of people is severely affected by noise. The World Health Organisation (WHO) has developed policies to implement a community noise management plan, which is aimed at decreasing the effect of noise on health (WHO, 2010). The developed guidelines peg permissible noise levels at 35-40dB during daytime and 30-40dBA at night. For permissible indoor noise levels, WHO pegs it at 35dB whereas threshold noise levels in the bedroom is set at 30dB to allow for sound and peaceful sleep (WHO, 2010).

2.6.2 Occupational noise

Occupational noise is simply defined as noise from the work place. It is a prevalent risk factor with a clear evidence base connecting it to a significant health outcome commonly known as occupational noise induced hearing loss (Concha-Barrientos et al., 2004). It is distinctive from ambient or environmental noise in that, it is by characterisation associated with the work place. It requires the combined effort of the employer and employee to adequately reduce the impact workplace noise has on hearing abilities (Concha-Barrientos et al., 2004). The outcome of excessive occupational noise level is permanent and its gravity increases with continuous exposure (Concha-Barrientos et al., 2004). It is therefore important to evaluate the load of disease related with occupational noise in order to influence policies and concentrate more research in line with reducing workplace noise levels (WHO, 2001).

2.7 Pathophysiology of ONIHL

In order for the ears to recognize sounds, a shearing force ought to be exerted on the stereocilia of the hair cells which coat the basilar membrane of the cochlea (Rabinowitz, 2000). A force of such magnitude, causes cellular metabolic overload, cell damage and cell death. ONIHL subsequently causes “wear and tear” to these sensitive inner ear structures. A simultaneous interaction with ototoxic substances such as heavy metals and solvents multiplies the damaging effect of noise (Rabinowitz, 2000). Progression of ONIHL reduces only when exposure to hazardous noise level is removed. There are variations among individual susceptibility towards ONIHL, however reasons for such variations remain unknown (Rabinowitz, 2000).

2.8 Effects of occupational noise levels

Exposure to noise has two main effects; auditory and non-auditory (Gaganija et al., 2011). The auditory effects are mainly ONIHL and tinnitus (ringing in the ear). The non-auditory effects are displayed below.

Table 2.3: Non-auditory effects of occupational noise

Physical effects	Increased cardiovascular risk Fatigue and sleeplessness Impaired communication Increased accidents and injury risks.
Psychological and social effects	Annoyance Depression Memory loss Reduced quality of life Social isolation and stigmatization Lowered moral and self-esteem.
Economic effects	Increased absenteeism Reduced productivity and performance Employment and income disruption

Source: Gaganija et al (2011)

2.9 Occupational noise induced hearing loss (ONIHL)

ONIHL is a condition that deteriorates with time due to continuous exposure to hazardous workplace noise levels (Kirchner et al., 2012). With occupational noise-induced hearing loss, the very first contact or exposure to excessive noise levels is seen in an increase in hearing threshold (shift in hearing threshold) which is measured using an audiometer. The increase is seen as alterations in hearing thresholds of an average of 10dB or more at 2000, 3000, and 4000Hz in either ear (NIOSH, 1998).

ONIHL develops in two phases. The first phase being a Temporary Threshold Shift (TTS) is characterized by slight hearing loss following an exposure to noise removed after a rest period. With this phase, a major complaint of workers is a "ringing sensation" in the ears after work periods. Recovery time in this phase is usually within 16-24 hours and it has been documented that injury is not to the sensory cells (Šušković, 2012).

The second phase which is known as Permanent Threshold Shift (PTS) occurs only after continuous and frequent exposure to noise levels that cause TTS. When a worker moves from TTS to PTS, the damage at this level is permanent because the sensory cells have been compromised (Šušković, 2012).

2.9.1 Characteristics of occupational noise induced hearing loss

The American College of Occupational and Environmental Medicine (2002) outlines the following characteristics of ONIHL.

- ONIHL is sensorineural
- It is almost always symmetric and bilateral
- Mostly the first indication of hearing loss due to noise exposure is a "notching" of audiogram at high frequencies of 3000, 4000 and 6000 Hz with recovery set at 8000Hz. The specific site of the notch is dependent on noise frequency and the length of the ear canal. As a result, in early ONIHL occurrence, the mean hearing threshold at lower frequencies of 500, 1000 and 2000 Hz are better than the mean hearing threshold at 3000, 4000 and 6000. The hearing levels at 8000 Hz is mostly better than the deepest part of the notch.
- The degree of ONIHL is maximum after 10-15 years of continuous or intermittent exposure.
- Continuous exposure of noise daily for several years is more dangerous than intermittent noise exposures which allows the ears to have some amount of rest period.

- The risk of acquiring ONIHL is low when exposed to noise levels below 85 dB, however it rises extensively when exposure is above this level.

2.9.2 Signs and symptoms of occupational noise induced hearing loss

Occupational Noise Induced Hearing Loss (ONIHL) is a definitive example of sensorineural hearing loss. It lacks obvious signs and symptoms such as bleeding and pain as such the onset of early signs and symptoms are mostly unnoticed (NIDCD Fact Sheet, 2014).

Signs and symptoms suggestive of ONIHL include; transient tinnitus (ringing or buzzing in the ear), temporary threshold shift, ear discomfort after exposure, difficulty hearing in noise, hypersensitivity, loss of sensitivity and high frequency hearing loss. Often workers with this condition struggle to comprehend conversations, especially in instances where conditions are deemed to be unfavourable. An example of this was seen among 60% of operating engineers working in a construction industry who complained of difficulty in understanding speech with background noise (OiSaeng et al., 2013).

ONIHL also may quieten high frequency sounds thereby making it cumbersome for workers to distinguish among speech consonant sounds especially in surroundings with varying background noise levels. A worker who frequently increases the volume on the television and radio set or one who struggles to hear conversations over the telephone is at risk of developing ONIHL.

2.10 The influence of ageing on noise induced hearing loss

Hearing loss associated with ageing has a complex aetiology involving both intrinsic and extrinsic factors. Several reports on the effect noise has on presbycusis (hearing loss due to ageing) have been hypothesized over the century. It is still very difficult to recognize one factor responsible for causing presbycusis (Rosenhall, 2003). The effect of noise is vague, therefore the association between noise-induced hearing loss and age-related hearing loss is complex, difficult to ascertain and poorly understood. One major setback with age-related hearing loss is the fact that it is has several causes (Rosenhall, 2003).

A conventional additive method used in determining NIHL in the aged presumes that presbycusis adds to noise-induced permanent threshold shift (NIPTS). This additive method has been adopted by ISO 1999 and it has been used by previous literatures (Welleschick & Raber, 1978). This formula suggested by ISO 1999 operates on the allusion that, total hearing loss, is a summation of age-related hearing loss and noise-induced permanent threshold shift (NIPTS) minus a compression factor used when threshold shifts surpass 20-25 dB. This addictive rule has conversely been questioned and opposed by several literatures (Bies & Hansen, 1990; Macrae, 1991; Mills et al., 1996). A less than additive method implies that the deterioration associated with presbycusis is decreased within the noise frequencies in noise- damaged ears, as such injury due to noise is unlikely to occur in the aged ear with presbycusis. Mills et al. (1998) tested the validity of the additive model by exposing desert rats at a young age to extreme noise levels. These rats were examined at old age and it was determined that the additive method overrated the interaction between noise and ageing. Henry (1982a, b) also in an animal study among older mice without presbycusis reported that, the mice had a slight vulnerability to noise stimulation than younger adult mice. Mills et al. (1998) again experimented on different mice and observed that ageing with or without hearing loss enhanced sensitivity to NIHL. Factors such as gender and genetic characteristics were known to equally contribute to NIHL (Rosenhall, 2003).

2.11 Daily permissible exposure limits for noise

Permissible exposure limits at work place are set in order that, the overall noise exposure does not go above exposure standards. The table below shows permissible exposure time limits for workers.

Table 2.4: Permissible exposure limits

Continuous dB	Permissible exposure time
115	Less than 30 seconds
112	Less than 1 minute
109	Less than 2 minutes
106	Less than 4 minutes
103	7.5 minutes
100	15 minutes
97	30 minutes
94	1 hour
91	2 hours
88	4 hours
85	8 hours

Source: Occupational Public Health Programme (2009)

2.12 Diagnosis of occupational noise induced hearing loss

Diagnosing ONIHL is often complicated. It is further complicated by the presence of some confounding factors such as aging, diseases and drug use which also trigger hearing loss. Making a concise diagnosis of ONIHL therefore is dependent on accurate occupational history of the worker and pure tone measurements using an audiometer (Occupational Safety & Health Service, 1994).

2.13 Tympanometry

Tympanometry simply refers to the electronic and acoustic measurement techniques used in assessing middle ear status. When combined with otoscopy, it is highly effective in ruling out outer and middle ear pathologies (Allison, 2016). There are three major types of tympanograms; Type A, B and C.

Type A: This type is usually shaped like a tepee. It signifies a normal middle ear which is free of fluids and any other pathological abnormalities which would avert the admittance of sounds from the middle ear into the cochlea. It is again characterised by a peak pressure which falls between +50 and -150 millimetres and peak compliance which falls between 0.2 and 1.8 mm (Duffey, 2007; Allison, 2016)

Type B: Tympanograms are a flat line. This type is coherent with middle ear abnormalities, where fluids and infections are accumulated behind the ear drum. This type is common in instances where there is a hole in the ear drum. A larger ear drum is usually indicative of a perforated ear drum (Duffey, 2007).

Type C: This type is also shaped like a tepee, however, it is skewed negatively when plotted on a graph. It shows negative pressures in the middle ear space which is usually specific to sinus and allergic congestion. This type is characterised by a normal peak compliance, however, the peak pressure is often greater than -150 mm (Duffey, 2007; Allison, 2016).

2.14 ONIHL in other occupational setting other than the cement manufacturing plant

Numerous research studies have shown that extreme workplace noise levels affect hearing abilities of workers. In a study conducted among workers in a textile factory, Shakhatreh et al (2000) found elevated levels of hearing loss among workers with continuous exposures. In their study, the prevalence of hearing loss at different noise levels in the textile factory was compared to hearing loss acquired as a result of length of service in the textile factory. Seventy workers exposed to various workplace noise levels were compared with seventy individuals without any exposure to occupational noise levels. From their study, it was found that, hearing loss was higher among the exposed group.

Thirty percent and eight percent of the exposed and unexposed population had hearing loss respectively. It was also found that hearing loss increased significantly among workers who worked in areas in the factory where the noise level was 95 dB. Their study showed an increase in hearing loss (39%) among workers who had worked for 25 years or more in the textile factory. Duration of exposure and work place noise levels exceeding 85 dB were the main determinants of hearing loss.

Similarly, in a cross-sectional survey conducted in a textile factory in Lagos, Osibogun et al (2000) recorded elevated hearing threshold levels among workers exposed to noise above permissible levels. In their study, 204 workers were randomly recruited from the various units of the textile factory and put into three categories. The criteria adopted for grouping the workers was based on noise levels produced at the various units. Those exposed to 90 dB were classified as the exposed group, workers exposed to 85-90 dB were classified as those with less exposure while those exposed to noise levels at 85 dB were classified as the non-exposed group.

A comparative analysis of hearing thresholds among all three groups using pure tone audiometry revealed higher threshold levels among the noise exposed group with significant threshold shift detected at the 4000 Hz frequency. The authors also noticed a positive correlation between increased hearing thresholds and duration of exposure.

In Ghana, Boateng and Amedofu in 2004 discovered that industrial noise pollution adversely affected hearing abilities of workers. The authors conducted a noise survey at the following work areas; printing presses, corn mills and saw mills after which audiometric assessments of 818 workers recruited for the study were done. A questionnaire was used to gather scientific and demographic data from participants. From the total population aged 20-50+ years, 463, 193 and 163 belonged to sawmills, corn mills and printing presses respectively. It was found that, the locally manufactured mills were responsible for the excessive noise produced at work. The study showed that noise levels at the corn mills and saw mills exceeded 90 decibels. The authors observed that 23%, 20% and 7.9% of workers in the corn mills, saw mills and printing press exhibited signs of NIHL. More than 20% of individuals who had been exposed to noise levels above 85 decibels in the corn and saw mills had classical NIHL at 4 KHz compared to 10% of printers. The fraction of workers with NIHL occurring at 4 KHz increased as a function of duration of exposure. They also observed that, a significant association existed between noise exposure levels, duration of exposure and development of NIHL in corn mill and saw mill workers.

Based on the above literature, higher workplace noise exposure levels coupled with duration of exposure were among factors contributing ONIHL.

2.15 ONIHL due to exposure to noise levels at cement manufacturing companies

In Tanzania, noise from machines used at cement manufacturing companies was found to be one of the main occupational hazard for individuals working in the industrial sectors. Mndeme and Mkoma in 2012 conducted a study titled “assessment of work zone noise levels at a cement factory in Tanga, Tanzania”. Their study sought to measure noise levels at the various units and to assess the attitudes of workers towards noise health hazards.

Responses from individuals on noise pollution, demographic information, nature of work, working hours, years of experience and use of protective devices were evaluated using structured questionnaires. Noise survey of both the production and non-production sections were assessed using a digital sound level meter. Offices and restaurants found at the company served as control sites. The highest noise level computed at the power plant was 104.3 decibels.

This exceeded standards set by WHO and the Tanzanian Bureau of Standards. Workers who also worked at the mills, compressor room and silos were exposed to noise levels well above 85 decibels. Workers at the packing plant, canteen, workshop and garage units had less exposure since the average noise levels were below 85 decibels. It was documented that, about 70% of the sampled population used HPD during work. Fifteen percent of the workers however lacked definitive understanding on the effective use of HPDs.

Individual responses also indicated that, 47.5% of the workers were exposed to noise for more than five years whereas 82.5 % indicated that, there could be health effect as a result of exposure to workplace noise levels. From their study, 20.5%, 53.8% and 17.9% complained of headaches, hearing problems during conversations and irritability respectively. They concluded by stating that, regular monitoring of the worker's use of HPDs was key in protecting workers from the psychological and physiological impact of noise.

Ali et al (2012) also conducted a similar study in a cement manufacturing plant in Nigeria. The aim of the study was to determine the prevalence and predictors of sensorineural noise induced hearing loss (SNIHL). One hundred and forty three participants were randomly selected and catalogued into exposed (76) and non-exposed (67) groups based on noise exposure levels at the work place. Each participant went through otological examination and pure tone audiometric testing following an interviewer administered semi-structured questionnaire.

A noise survey of the various unit was conducted using a sound level meter. Based on findings from the study, the authors found that, the prevalence of SNHL was high among workers in the cement plant. The study revealed that, the highest and lowest average noise levels participants were exposed to were at the cement mill (104 dB) and administrative block (44 dB) respectively. The study again revealed that, the use of HPDs were relatively low among the noise exposed group. Only 24.5% used HPDs regularly while 35.5% did not. When queried about the reason behind the irregular use of HPDs, 14.5%, 11.8% and 6.6% respectively maintained that, HPDs were unavailable, uncomfortable and unnecessary. Again 2.6% responded that, they were unaware of HPDs. Their study showed that, 61.8% and 46.3% of exposed and unexposed individuals had worked for more than 10 years.

The authors found that, threshold shifts at 4 KHz was maximum. They highlighted the need for periodic hearing assessment, especially among workers exposed to noise levels above 85 decibels. Table 2.5 displays the results of the noise survey at the cement factory.

Table 2.5: Noise levels in a cement plant in Nigeria

Sections	No. Participants (%)	Noise range (dB-A)	Average noise
Central administration block (controls)	67 (46.9)	35-45	44
Mechanical workshop	11 (7.7)	76-80	78
Packing plant	10 (7.0)	78-86	84
Heavy motor repair department	5 (3)	86-91	88
Quarry	12 (8.4)	86-95	89
Cement mill	12 (8.4)	98-105	104
Kiln	8 (5.6)	88-92	91

Source: Ali et al (2012)

In Ghana, a study conducted at GHACEM in Tema assessed the prevalence of ONIHL, measured the noise levels produced at the various units of the industry and compared the prevalence of hearing impairment among workers with different lengths of exposure. In 1995, Yabani in a cross-sectional study revealed that, 42% of randomly selected individuals from GHACEM had definite NIHL, 15% showed signs of NIHL, 38% had good hearing while 5% had excellent hearing. The study showed that, the production unit of the GHACEM Company accounted for most of the hazardous noise levels produced, with levels ranging from 80 to 108 decibels. Workers at the milling unit accounted for majority of hearing loss recorded.

Eleven workers (35%) who have had continuous exposure for 5 years had NIHL while three workers (23%) with exposure periods between 6 to 10 years had NIHL. For exposure periods of 11- 15 years, 28% had NIHL while 62.9% of individuals with exposure periods of 16 years or more presented with NIHL.

Findings from his study showed that, the prevalence of NIHL increased significantly with increase in length of exposure. The table below displays results of the noise survey conducted at the various work stations at GHACEM.

Table 2.6: Noise survey of machines at different work stations at GHACEM

DEPARTMENTS	NOISE LEVELS (dB)
MILLING DEPARTMENT	
Feed mill Table 1	95
Feed mill Table 2	100- 103
Mill Floor 1	105- 108
Mill Floor 2	99- 100
Compressor Hall 1	89- 90
Compressor Hall 2	90- 92
Compressor Hall 3	95- 100
Gear Box Hall Mill 1	100-105
Gear Box Hall Mill 2	95- 98
Gear Box Hall Mill 3	100-102
PACKING DEPARTMENT	
First Rotor Packer	83-87
Second Rotor Packer	77- 80
Loading Area	86
ENGINEERING DEPARTMENT	
Workshop	83- 84
ADMINISTRATION	
General office	72- 78
Laboratory	75- 78
Canteen	67- 78

Source: Yabani (1995)

2.16 Prevention of ONIHL: hearing conservation programme

ONIHL is a permanent and irreversible condition with no current remedy mainly because damaged hair cells lack the ability to regenerate. The condition is however avoidable and early recognition of ONIHL through frequent audiometric testing is key in averting further hearing loss (American College of Occupational and Environmental Medicine, 2012). There are varied preventive mechanisms that are effective in preventing ONIHL. The desired method usually chosen is largely dependent on the source of loud noise produced at work and the motivation of the employer or worker.

Judging by the impact of ONIHL on worker's quality of life, the Occupational Safety and Health Administration (OSHA) recognises that, an effective hearing conservation programme is key to the protection of workers, who are frequently exposed to noise levels above 85dB. In view of this, OSHA encourages all employers to adopt a comprehensive hearing conservation programme for workers at risk of ONIHL (OiSaeng et al., 2013). A comprehensive hearing conservation programme by OSHA has five main features namely;

2.16.1 Periodic noise exposure monitoring

Routine measurement of noise at the workplace is integral for detecting workers who have been overly exposed and for choosing suitable hearing devices. Noise exposure monitoring should be performed once there is the risk of exposing workers to noise levels above 85 dB for an eight hour work cycle. Periodic noise monitoring should also be conducted anytime there is a change in work methods, tools and controls at the work place (Occupational Public Health Programme, 2009).

2.16.2 Engineering and administrative controls

Engineering controls are employed to reduce and inhibit the diffusion of noise through the use or substitution of engineered machinery (Occupational Public Health Programme, 2009). An example of engineering control is changing to a lower decibel equipment. Administrative controls on the other hand integrate changes in the work processes by alternating workers through the shift systems. Ideally in a hearing conservation programme, engineering and administrative controls are the best forms of practice, however, engineering controls are expensive and often unfeasible to achieve. OSHA therefore prescribes the use of personal protective hearing devices for hearing protection in instances where engineering controls can't be used (OiSaeng et al., 2013; NIDC Fact Sheet, 2007).

2.16.3 Periodic audiometric evaluation and follow ups

Frequent and yearly audiometric testing and screening of all workers, particularly those at risk of acquiring ONIHL due to continuous exposure to hazardous noise levels is important. Best practice directs that, as part of pre-employment proceedings, workers are to be subjected to audiometric testing to acquire baseline readings. These baseline readings together with subsequent readings are important in calculating threshold shifts which are vital for diagnosing hearing loss. If a worker shows major threshold shift following an audiometric testing, and when the loss in the higher frequencies is equal or more than 10 dB in both ears, the worker ought to be informed and urgent measures to protect the worker from experiencing more damaging effect ought to be implemented (Rosenstock, 1998).

2.16.4 Employee / management education and training

As part of health and safety promotion at the workplace, employers are mandated to periodically educate and train their employees annually on the effects and prevention of noise. For workers exposed to work place noise levels at or above 85 dB, education and training should be frequent. Training sessions that are organised should tackle, (1) the physical and psychological effect of noise and hearing loss; (2) HPD selection, use, fitting and care; (3) audiometric testing and (4) the roles and responsibilities of both the employer and employee in NIHL prevention (NIOSH, 1998). It is necessary that, a comprehensive record of all medical surveillance of workers, noise surveys and training programmes are kept for future evaluation and improvement of hearing conservation programme (Occupational Public Health Programme, 2009).

2.16.5 Personal hearing protection

Appropriate selection of hearing devices can be instrumental in preventing ONIHL. Hearing protective devices (HPD) are mandated by law to be branded with a Noise Reducing Rating (NRR) centred on function acquired under ideal laboratory conditions. Examples of HPDs are earplugs and ear muffs. Earplugs are smaller compared to ear muffs. When these are fixed properly, noise intensity is minimised by 15-30 dB (Fligor, 2011). For supplementary effect, wearing both devices simultaneously reduce noise effect by an additional 5dB. Workers do not get maximum protection from using HPDs because, they are either not fitted properly or there is total lack of compliance to wearing it. It is important therefore, for workers to know that the best HPD is not the one with the maximum NRR but rather, the one that is constantly worn during work hours. It is therefore mandatory for all employers to provide training on how HPDs should be properly fitted. This allows for its effective use among workers (Fligor, 2011; NIOSH, 1998).

2.17 Conclusion

The use of heavy machinery and enclosed working environment contribute to excessive noise produced at the cement factory. This makes workers susceptible to NIHL. Other dynamics include; gaps in knowledge of noise dose/source relationships, the unavailability of effective noise controls and the need for worker education (Rabinowitz, 2000). Rarely are workers involved in control regimes aimed at reducing exposures at the work place. This is especially predominant in most developing countries where the import of NIHL has not been fully grasped. Worker's involvement in such matters is critical in the implementation of exposure reduction schemes.

Industries in the advanced countries have made modifications which primarily include the introduction of an occupational hearing conservation programme. This programme is made up of administrative and engineering controls aimed at reducing noise exposure, training or education of employees in the use of protective hearing device and regular audiometric testing for workers exposed to noise above the permissible exposure levels. Obsolete and noisy machinery have been substituted and acoustic engineering controls have been employed to further eliminate harmful noise. All efforts are therefore geared towards protecting workers from acquiring NIHL.

The use of personal protective equipment on the hierarchy of controls is often the last option to be considered. However, in developing and under-developed countries, personal protective equipment is firstly employed to protect workers from extreme noise exposures. This is because elimination, substitution and engineering controls are extremely expensive to practice. It has been found that, workers do not comply with the use of personal protective equipment because of lack or little sensitization on the effect of NIHL. Employers should therefore be concerned about the health and safety of their employees.

Future research should focus on obtaining statistics of workers affected by occupational noise levels. Again evaluating the disease burden of ONIHL will ensure that, stringent measures are put in place to protect the hearing of workers.

CHAPTER THREE

METHODOLOGY

3.1 Study area

The study was conducted at the Ghana cement manufacturing company at Tema. Tema is a municipality located on the Gulf of Guinea and the Atlantic coast of Ghana. It is situated 25 kilometres East of the capital city; Accra. Tema is the 11th most densely populated community in Ghana with approximately 161,612 people. The Greenwich Meridian passes directly through the city.

GHACEM is the leading cement producing company in Ghana. It has severed the people of Ghana in diverse ways since its inception in 1976. It has two main grinding yards situated in the two harbour cities of Ghana; Takoradi and Tema. GHACEM manufactures three principal products: GHACEM super rapid, GHACEM Portland and Sulphate resistant cement. The cement producing company has over the years generated 30 million tons of cement in excess and has continuously offered employment for the people of Ghana.

GHACEM in Tema has a production unit which is subdivided into milling, maintenance and packing units. It was in these units that workers were frequently exposed to noise, thus for the purpose of this study, the production unit was used.

3.2 Study population

Participants at the production unit were contract workers who worked in shifts. Three shift systems were employed to rotate the workers. The morning, afternoon and evening shift periods started from 6am-2pm, 2pm- 10pm and 10pm- 6am respectively. Workers at the production unit were engaged in mixing and dispensing of cement products, loading and packing of cement products onto vehicles, repairing of equipment used in production and cleaning of the plant. Aside being exposed to hazardous workplace noise levels, workers at the production unit were susceptible to respiratory, skin and eye conditions as a result of continuous exposure to toxic dust, fumes and gases. Workers who were in the packing unit were susceptible to musculoskeletal injuries such as neck, shoulder and back pain. These injuries were as a result of the awkward postures and repetitive motions assumed during work process.

3.3 Study sample

The study sample was made up of 132 men working at the production unit of GHACEM. Ninety-eight of the participants were from the packing unit while thirty-four were from the milling unit.

3.4 Study design

A descriptive analytical cross-sectional study design was conducted among cement factory workers in Tema. In this study, demographic and scientific data of the workers were collected using a questionnaire while audiometric testing was employed to assess hearing acuity of the workers. The background noise level in the assessment room at GHACEM was determined using a sound level meter.

3.5 Sample size calculation

Sample size was determined using the method of Cochran (1963). In determining the sample size, three factors were considered; the level of confidence, sampling error and the degree of variability with respect to the attributes being measured. For this study, a 95% level of confidence together with a sampling error of 9.8% and a 50% degree of variability were used. Based on the above, the sample size was calculated using the formula:

$$n = \frac{{z_{\alpha/2}}^2 pq}{\varepsilon^2}$$

Where; n = the sample size.

$Z_{\alpha/2}$ = the critical value.

p = the degree of variability (estimated proportion of cement factory workers with hearing loss).

ε = the level of precision or sampling error

$q = 1 - p$

Thus $\alpha = 0.05$, $p = 0.5$, $q = 1 - 0.5 = 0.5$, $\varepsilon = 9.8\%$ and $Z_{0.025} = 1.96$

$$n = \frac{1.96^2 \times 0.5 \times 0.5}{0.098^2} = 100$$ Cement factory workers

Therefore, a sample size of approximately 100 workers would be representative enough with 95 percent level of significance, 9.8 percent sampling error and a maximum measure of variability of 50 percent.

Assumptions made during the calculation;

- The level of precision or sampling error was 9.8 percent
- The confidence level was 95 percent
- The degree of variability or proportion of cement factory workers with hearing loss was estimated to be 50 percent approximately since it was unknown.

3.6 Sampling technique

Prior to the start of data collection, a meeting with the management of GHACEM was scheduled, where all the processes involved in conducting the study were thoroughly explained. A copy of the proposal submitted for ethical clearance was made available to management for further perusal. A letter from management was sent to supervisors and foremen at the production unit explaining the details of the study and asking them to release the workers on specified days of data collection. The foremen and supervisors informed the workers about the study, thus only willing participants showed up to be recruited. In order that, work processes were not disrupted during data collection, the convenience method of sampling was the most appropriate. Participants who showed up for the study were thoroughly briefed on the benefits and procedures involved and their consent was sought before enrolling them fully.

3.7 Study variables

The independent and dependent variables were occupational noise levels and hearing loss respectively. Other variables of interest considered during the study were; HPD use, age, worker's knowledge, working hours and duration of exposure time/ length of service.

3.8 Eligibility

Participants who had been exposed to noise for a year or more and those who consented either by signing or thumb printing on the consent form were considered to be eligible for participation, however workers who have had head injuries, ear infections and surgeries, tumours, familial record of hearing defects and those on ototoxic medication were excluded from the study.

3.9 Data collection equipment and materials

Hearing assessment and noise survey of the assessment room were conducted by a certified audiologist from the Korle-Bu Teaching hospital. Testing of participants was done before the start of work. This allowed the ears to recover from any fatigue or temporary threshold shift that may have occurred. Participant's scientific and demographic information were collated by trained research assistants. All equipment were calibrated to meet the standard set by the American National Standards Institute (ANSI).

3.9.1 Questionnaire

A modified questionnaire made up of four main sections was used in collecting personal and scientific data from the participants. Section A collected demographic information, Section B collected general medical and hearing history, Section C measured HPD use and Section D assessed the knowledge of workers on the effect of occupational noise levels. The questionnaire employed the use of both closed and open ended questions. Questionnaire was administered under close supervision to prevent the workers from influencing each other's results. For workers who couldn't read and write, research assistants helped in filling the questionnaire. A participant was only allowed to start this process of the experiment after he had been thoroughly briefed and had consented either by signing or thumb printing on the consent form given.

3.9.2 Otoscope

A Welch Allyn 25020 clinical otoscope was used to directly view the ear canal and the tympanic membrane for the presence or absence of cerumen and other foreign bodies among the workers before further audiometric and vestibular testing were done.

3.9.3 Sound level meter

A Wensen WS 1361 type 2 digital sound level meter was used to assess background noise levels of the assessment room.

3.9.4 Welch Allyn TM 262 Auto Tymp device

This was used for audiometric and tympanometric testing of study participants.

3.10 Data collection procedure

3.10.1 Noise survey of assessment room

The background noise level of the assessment room was measured and found to be 35dB. This served as a quiet environment for assessment. Background noise levels in the assessment room was monitored and checked twice in a day. This was done to ensure that the measured background noise level remained constant throughout the experiment.

3.10.2 Pre-screening activities

Daily equipment check: To ensure that the equipment was functioning properly, biological checks, functional inspection and performance checks were done daily before hearing assessment begun.

Participant's seating: Participants were seated comfortably. The recruited study participants were seated such that, they were unable to observe hand movements of the audiologist.

Explanation of proceedings: All proceedings were thoroughly described to the participants by the audiologist. Participants were assured that the procedure was painless. Mild discomforts felt as upward, downward and sideways tugging of the ear during the insertion of either the probe of the tympanometer or speculum of the otoscope were explained. Testing lasted for ten minutes, as such, there was little interruption to the daily work processes.

Instructions: Instructions given were clear, simple and precise. Language that was easily understood by all the participants was used. Participants were asked to remove all materials such as spectacles which could disturb test results. Participants were required to sit quietly and maintain their posture until testing was over. The recruited study participants were required to raise their hand whenever a tone was heard. To ensure that the entire ear circumference had been covered by the headset, participants were asked not to change the position of the headset once it was fitted.

3.10.3 Physical ear examination

Ear examination: An otoscopy was performed to physically rule out middle ear pathologies, impacted wax and ear perforations. The otoscope provided the audiologist with a clear view of the middle ear. A tympanometer was used to measure the mobility and pressure within the middle ear. A stimulus tone of 226 Hz was introduced into the middle ear canal and the resulting graph was plotted on the tympanogram. Type A tympanograms consistent with normal middle ear pressure and compliance were defined by an ear canal volume of 0.2-2.0 ml, peak pressure between -150 and +100 daPa and peak compliance of 0.2-2.0ml. The audiologist by way of precaution progressed gently and slowly during these processes in order to prevent irritating or injuring the ear canal. Any characteristics of redness, swelling, lesions, discharge, scarring and perforations were recorded and referred for further management.

3.10.4 Determination of pure tone threshold

An ascending technique recommended for manual pure-tone threshold audiometry was used to determine the hearing thresholds of the participants. Pure tone stimuli introduced between 1 to 2 seconds were varied. The level of the first presentation was better than the expected threshold thus, the level of successive presentations were determined by the preceding response. Failure to respond to a signal resulted in a 5 dB increase in steps until a response was recorded. The intensity was then decreased by 10 dB and the process repeated for higher steps. Testing begun with 1000 Hz, followed by 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz and 8000 Hz. A retesting was done at 1000 Hz before testing at 500 Hz and 250 Hz were conducted. This process was repeated for the other ear.

3.10.5 Pure tone audiometry

Each ear was evaluated using an audiometer set at 8 different frequencies (250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz). The audiometric test results obtained were evaluated using the classification of hearing loss developed by Clark (1981). A pulsed tone was used and an audiogram was considered normal when the hearing thresholds of the participants were less than 25 dB in either ear.

3.11 Quality control

To certify that data collected were valid;

- Research assistants were trained to ensure accuracy in the collection of data.
- Study procedure was explained to participant prior to filling of questionnaire.
- Completed questionnaire was cross checked.
- Strict supervision of data collection was done.
- Proper categorization and coding of data was performed.

3.12 Pre-testing of questionnaire

Fifty of the questionnaires were pretested among cement factory workers at Dangote cement factory. The study population that was used had similar traits as workers from GHACEM. This was done to ensure that, the chosen data collection tools were devoid of biases, typographical and grammatical errors.

3.13 Data processing and analysis

Responses from participants were coded, edited and entered into Excel word after which it was transported into SPSS version 20.0 for analysis. Descriptive statistics were used to describe the demographics of participants. Appropriate measures of centrality and dispersion were calculated and summarised in a tabular form. The prevalence of hearing loss and participant's knowledge on the effect of noise levels were reported as percentages. Test of association between hearing loss and duration of work was performed using chi- square. Multinomial logistic regression was used to determine the predictors of hearing loss. A p –value less than 0.05 was considered to be significant.

3.14 Ethical consideration

Ethical clearance was sought from the Ghana Health Service Ethics Review Committee before the study begun. In addition to this, introductory letters obtained from the School of Public Health were sent to management of GHACEM to seek permission before the study begun.

Participation was entirely voluntary and willingness to participate was confirmed by either signing or thumb printing in the space provided on the consent form. Adequate information about the study was given to participants and confidentiality of all information provided was assured. Workers who were screened and found to have ear pathologies and anomalies were referred.

CHAPTER FOUR

RESULTS

4.1 Introduction

The results of the research study are presented in this Chapter. Details of the results include demographics, participant's use of Hearing Protection Devices (HPDs), their knowledge on the relationship between noise and health, distribution of pure-tone and impedance audiometry results and tests of associations and relationships.

4.2 Demographic characteristics of participants working at GHACEM

The age, religion, education and marital status of study participants are presented in table 4.1. All the study participants were males. The mean age of the participants was 33.9 ±10.21 years. Participants aged 18-29 years formed 36.4% while participants aged 50-59 years formed 10.6% of the study sample. It was observed that, 78 (59.1%) of the workers had Senior High School academic qualification while 40 (30.3%), 6 (4.5%) and 8 (6.1 %) had Junior High School, diploma and technical qualification respectively. Seventy (53%) participants were married while 62 (47%) were single. Most of the study participants were Christians (92.4%). Majority of the recruited participants were from the packing unit (74.2%).

Table 4.1: Demographic characteristic of study participants at GHACEM

Variables		Number	Percent	Mean ± SD
Age	18-29	48	36.4	
	30-39	46	34.8	
	40-49	24	18.2	33.9 ± 10.21
	50-59	14	10.6	
Total		132	100	
Education	J.H.S	40	30.3	
	S.H.S	78	59.1	
	Diploma	6	4.5	
	Technical	8	6.1	
Total		132	100	
Marital Status	Single	62	47	
	Married	70	53	
Total		132	100	
Religion		122	92.4	
Christian				
	Islam	10	7.6	
Total		132	100	
Department	Packing	98	74.2	
	Milling	34	25.8	
Total		132	100	

4.3 Participant's use of hearing protection devices (HPDS) at GHACEM

Table 4.2 showed that, majority of the study participants (56.1%) used HPDs at work. However, it was recorded that, HPD was irregularly used by the workers with 15.2% and 51.5% reporting of "always" and "infrequent" use respectively. Results from the study also showed that, participants did not always use HPDs because, it was uncomfortable (8.2%), they never thought about using HPDs (19.6%), HPDs were unnecessary (14.4%), they had limited knowledge in the use of HPDs (39.2%) and 18.6% were of the view that, they were not working in noisy environment.

Table 4.2: Worker's use of hearing protection device (HPD) at GHACEM

	Response (%)				
Item	Yes		No		
HPD use during work	56.1		43.9		
	Always	Frequently	Sometimes	Infrequently	
Frequency of HPD use	15.2	3.0	30.3	51.5	
	It is uncomfortable	Never thought about it	It's unnecessary	Limited knowledge	Do not work in noise
Justification for irregular use of HPDs	8.2	19.6	14.4	39.2	18.6

4.4 Knowledge on the relationship between noise and health among participants working at GHACEM

Majority of the study participants (86.4%) reported that, workplace noise levels affected health, while the remaining 13.6% showed that workplace noise levels did not affect health. Perceived noise levels at the workplace was average (47.0%) in terms of loudness. All the study participants showed that, workplace noise levels caused hearing loss. Also, 95.5%, 93.9% and 97 % of the recruited participants reported that, workplace noise levels caused headaches, bad temper and loss of concentration respectively.

Table 4.3: Worker's knowledge on noise effects at GHACEM

Item	Response (%)		
	Yes		No
Workplace noise levels on health effect	86.4		13.6
Perception about workplace noise levels	Very high	High	Average
	16.7	36.4	47.0
Effects of workplace noise levels	True		False
Hearing loss	100		-
Headaches	95.5		4.5
Bad temper	93.9		6.1
Loss of concentration	97		3.0

4.5 Tympanometry

As shown in Table 4.4, all the subjects presented with Type A tympanograms in 132 pairs of ears.

Table 4.4: Distribution of tympanograms among study participants at GHACEM

Category of Tympanogram	Number or ears	Percent,%
Type A	264	100.0
Type B	0	0.0
Type C	0	0.0
Type A_S	0	0.0
Type A_D	0	0.0
Total	264	100.0

4.6 Prevalence of hearing loss among study participants working at GHACEM

From table 4.5, the prevalence of hearing loss at 0.5, 1 and 2 KHz for right and left ears were 7.6% and 7.6% respectively while the prevalence of hearing loss at 3, 4 and 6 KHz for right and left ears were 21.2% and 22.7% respectively.

Table 4.5: Prevalence of pure-tone averages for right and left ears

Hearing Status	Right ear		Left ear	
	PTA_{512} (%)	PTA_{346} (%)	PTA_{512} (%)	PTA_{346} (%)
Normal hearing	92.4	78.8	92.4	77.3
Hearing loss	7.6	21.2	7.6	22.7
Total	100	100	100	100
Mean ± SD	14.9 ±10.2	19.4 ± 9.4	13.6 ± 6.7	19.8 ± 10.4

From table 4.6, the prevalence of hearing loss at 3, 4 and 6 KHz for participants from the packing department was the lowest (20.4% for right and left ears) compared to the prevalence of hearing loss (right=23.5%, left=29.4%) for participants from the milling departments.

Table 4.6: Prevalence of hearing loss at the packing and milling departments at GHACEM

		Hearing Status			
		Right ear (%)		Left ear (%)	
Department	Levels	PTA_{512}	PTA_{346}	PTA_{512}	PTA_{346}
Packing	Normal hearing	95.9	79.6	93.9	79.6
	Hearing loss	4.1	20.4	6.1	20.4
Milling	Normal hearing	82.4	76.5	88.2	70.6
	Hearing loss	17.6	23.5	11.8	29.4

4.7 Test of associations among study variables

Table 4.7 showed a non-significant association between hearing status and work duration at PTA_{512} and PTA_{346} [χ^2 (3, *n*= 132) = 0.90 and 5.34; $p > 0.05$] for right ears.

Table 4.7: Association between work duration and hearing status for right ears

Pure-Tone Average (PTA)	Hearing Status	Work Duration (hours) 5	6	7	8	χ^2	df	p-value
PTA_{512}	Normal hearing	6	14	14	88	0.90	3	0.83
	Hearing loss	0	2	2	6			
	Total	6	16	16	94			
PTA_{346}	Normal hearing	6	12	8	78	5.34	3	0.15
	Hearing loss	0	4	8	16			
	Total	6	16	16	94			

Significant at 0.05

Table 4.8 also showed a non-significant association between hearing status and work duration at PTA_{512} and PTA_{346} [χ^2 (3, *n*= 132) = 3.87 and 1.55; $p > 0.05$] for left ears.

Table 4.8: Association between work duration and hearing status for left ears

Pure-Tone Average (PTA)	Hearing Status	Work Duration (hours) 5	6	7	8	χ^2	df	p-value
PTA_{512}	Normal hearing	4	14	16	88	3.87	3	0.28
	Hearing loss	2	2	0	6			
	Total	6	16	16	94			
PTA_{346}	Normal hearing	4	12	10	76	1.55	3	0.67
	Hearing loss	2	4	6	18			
	Total	6	16	16	94			

Significant at 0.05

From table 4.9 multiple regression analysis was used to test if age, length of service, departments and knowledge significantly predicted hearing loss at PTA_{512} for right ears. The results of the regression indicated that the 4 predictors explained 6% of the variability [$R^2 = .06$, $F_{(4, 127)} = .97$, $p > 0.05$] in hearing loss, which was not significant. None of the tested variables significantly predicted hearing loss at PTA_{512} for right ears.

Table 4.9: Multiple regression showing predictors of hearing loss for right ears at PTA_{512}

		PTA_{512}			
Predictors	R^2	Beta	B	T	p-value
Constant	.06		8.53	1.15	.26
Age		.09	.93	.58	.56
Length of service		-.00	-.00	-.01	.99
Department		.21	4.88	1.66	.10
Knowledge		-.03	-.24	-.26	.80

*Significant at 0.05

Multiple regression analysis was used to test if age, length of service, departments and knowledge significantly predicted hearing loss. From table 4.10, the results of the regression indicated that the 4 predictors significantly explained 24% of the variability [$R^2 = .24$, $F_{(4, 127)} = 4.81$, $p < 0.05$] in hearing loss. It was found that age ($\beta = .47$, $p < 0.05$) as an independent variable significantly predicted hearing loss at PTA_{346} for right ears.

Table 4.10: Multiple regression showing predictors of hearing loss for right ears at PTA_{346}

		PTA_{346}			
Predictors	R^2	Beta	B	T	p-value
Constant	.24		14.05	2.27	.03
*Age		.47	4.46	3.39	.00
Length of service		-.02	-.03	-.13	.90
Department		.04	.79	.32	.75
Knowledge		-.10	-.68	-.88	.39

*Significant at 0.05

From table 4.11, multiple regression analysis was used to test if age, length of service, departments and knowledge significantly predicted hearing loss at PTA_{512} for left ears. The results of the regression indicated that the 4 predictors explained 36% of the variability [$R^2 = .36$, $F_{(4, 127)} = 2.52$, $p > 0.05$] in hearing loss, which was not significant. None of the tested variables significantly predicted hearing loss at PTA_{512} for left ears.

Table 4.11: Multiple regression showing predictors of hearing loss for left ears at PTA_{512}

		PTA_{512}			
Predictors	R^2	Beta	B	T	p-value
Constant	.36		11.86	2.51	.02
Age		.27	1.84	1.82	.07
Length of service		.04	.05	.28	.78
Department		.09	1.44	.77	.45
Knowledge		-.13	-.62	-1.03	.31

*Significant at 0.05

Multiple regression analysis was used to test if age, length of service, departments and knowledge significantly predicted hearing loss. From table 4.12. The results of the regression indicated that the 4 predictors significantly explained 32% of the variability [$R^2 = .32$, $F_{(4, 127)} = 7.25$, $p < 0.05$] in hearing loss. It was found that age ($\beta = .47$, $p < 0.05$) as an independent variable significantly predicted hearing loss at PTA_{346} for left ears.

Table 4.12: Multiple regression showing predictors of hearing loss for left ears at PTA_{346}

		PTA_{346}			
Predictors	R^2	Beta	B	T	p-value
Constant	.32		16.00	2.47	.02
*Age		.47	4.90	3.54	.00
Length of service		.13	.26	.10	.32
Department		-.05	-1.21	-.47	.64
Knowledge		-.12	-.88	-1.07	.29

*Significant at 0.05

CHAPTER FIVE

DISCUSSION

Excessive workplace noise has been explained by various researches as a known hazard affecting hearing acuity of workers. Research studies mostly done, surveyed noise levels produced at the workplace, determined the degree and prevalence of hearing loss and assessed relationships existing between duration of exposure and hearing loss. This study conducted at GHACEM also set out to determine the effect occupational noise levels had on hearing acuity among sampled individuals using pure tone audiometry, otoscopy, tympanometry and questionnaire.

The results from the study showed that, all the workers employed at the production unit were males. The most prevalent age group was 18-29 (36.4%) years. This may be due to the need for younger individuals who met the physical work demands at GHACEM. Majority of the participants were literates with at least a senior high school qualification (59.1%).

Assessing the use of hearing protection at GHACEM was key towards understanding and amending inadequacies in noise exposure reduction efforts in the company. The study revealed that HPD use was high, with 56.1% reporting of its use at work. Specifically, 15.2% and 51.2% of the study participants reported "always" and "infrequent" use of HPDs respectively. Limited knowledge in HPD use (39.2%) was the most prevalent reason given by GHACEM workers for the infrequent use of HPDs. These results were comparable to findings of Ali et al (2012) who discovered that, 24.5 % and 35.5% of individuals, exposed to noise in a Nigerian cement factory, reported regular and irregular use of HPDs respectively. The reasons given for irregular use of HPDs in their study were; unavailability (14.5%), discomfort (11.8%), HPDs not necessary (6.6%) and limited knowledge (2.6%). However, Mndema & Mkoma (2012) reported that, about 15% of workers in a cement factory in Tanzania, did not always use HPDs because they lacked understanding in the effective use of HPDs. NIOSH (1998) documented that, in order to increase the likelihood that HPDs would be used effectively, employers were mandated to provide training on how to appropriately choose, fit and use HPDs.

This study found that, workers at GHACEM exhibited an in-depth knowledge on the effect of noise on health. All participants examined disclosed that, workplace noise levels caused hearing loss. Responses from study participants also indicated that, work place noise levels caused headaches (95.5%), bad temper (95.5%) and loss of concentration (97%). The high prevalence of the aforementioned responses could be as a results of the workers experiencing such effects (headaches, bad temper and loss of concentration) of workplace noise levels. This was consistent with findings made by Mndema & Mkoma (2012) who revealed that, 20.5%, 53.8% and 17.9% of workers respectively reported of experiencing headaches, hearing problems and irritability as a result of exposure to work place noise.

All study participants at GHACEM, were subjected to middle ear assessment with the tympanometer. The results from the study indicated that, all the ears tested presented with Type A tympanograms. This was an indication of normal middle ear pressure and tympanic membrane mobility in all the ears tested.

The prevalence of hearing loss at PTA_{512} (0.5, 1 and 2 KHz) was found to be 7.6% for right and left ears and 21.2% (right ears) and 22.7% (left ears) at PTA_{346}. This meant that, most of the participants presented with a high frequency hearing loss. The American College of Occupational and Environmental Medicine (2002) stated that, the first indication of occupational hearing loss was a "notching" of audiogram at high frequencies of 3000, 4000 and 6000 Hz. In a study conducted among workers in a textile factory, Shakhatreh et al (2000) found elevated levels of hearing loss among individuals with continuous exposures. The audiograms of 70 workers exposed to various workplace noise levels were compared with the audiograms of 70 individuals without any exposure to occupational noise. Thirty percent and eight percent of the exposed and unexposed population had hearing loss respectively. The study also showed an increase in hearing loss (39%) among workers who had worked for 25 years or more in the textile factory.

Similarly, in a cross-sectional survey conducted in a textile factory in Lagos, Osibogun et al (2000) recorded a significant hearing loss among workers exposed to noise. The results from the study revealed significant threshold shifts at 4000 Hz among the noise exposed group. The study also reported a positive correlation between increased hearing threshold levels and duration of exposure.

In Ghana, Boateng and Amedofu in 2004 determined the effects of industrial noise pollution on the hearing acuity of workers. A hearing loss prevalence of 23%, 20% and 7.9% among workers at the corn mills, saw mills and printing press were recorded respectively. The study showed that noise levels at the corn mills and saw mills exceeded 90 decibels.

Workers at the milling unit presented with a higher prevalence of hearing loss at PTA_{512} and PTA_{346} than workers at the packing unit. Differences in noise exposure may have accounted for the difference in the prevalence of hearing loss among workers at the aforementioned departments. This finding was in agreement with a study by Yabani (1995) which showed a significantly higher prevalence of hearing loss among workers at the milling unit.

There was no significant association between work duration and hearing status for both ears at PTAs 512 and 346. This may be explained by the reason that, most of the study participants were new employees who had not spent more than 5 years on the job. Similarly, Yabani (1995) demonstrated that, workers who spent at least 5 years at a cement factory exhibited symptoms of NIHL.

There was also no significant relationship between the selected predictors (age, length of service, department and knowledge) and hearing loss for right and left ears at PTA_{512}. However, age was a significant predictor of hearing status at PTA_{346} for right and left ears. The relationship between age and hearing status was positive. This meant that, older study participants presented with more severe hearing loss than the younger participants. Several studies have demonstrated the synergistic effect of noise on presbycusis (hearing loss due to ageing). However, the association between noise-induced hearing loss and age-related hearing loss are still unclear and difficult to ascertain. This is because age-related hearing loss has several causes (Rosenhall, 2003).

An additive method mostly used in determining NIHL in the aged suggests that, presbycusis adds to noise-induced permanent threshold shift. However, this has been contested by several literatures (Bies & Hansen, 1990; Macrae, 1991; Mills et al., 1996). Mills et al. (1998) tested the validity of the additive model by exposing desert rats at a young age to extreme noise levels. These rats were examined at old age and it was found that the additive method overrated the interaction between noise and ageing. Henry (1982a, b) also in a mice study reported that, older mice were susceptible to noise stimulation than younger adult mice. Other factors such as gender and genetic characteristics were attributed to the occurrence of NIHL (Rosenhall, 2003).

CHAPTER SIX

CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

6.1 Conclusion

This study sought to determine the effect of occupational noise levels on hearing among cement factory workers in Tema. Specifically, worker's knowledge on the effects of noise, use of hearing protection device at work, prevalence of hearing loss among the workers and associations between exposure time and hearing status were determined. The study revealed that, majority of the recruited participants demonstrated a high level of knowledge about noise and its effect on health. A greater number of the study participants used HPDs at the workplace. The prevalence of hearing loss at the milling unit was greater than the prevalence of hearing loss at the packing unit at PTAs (512) and (346). There was no significant association between work duration (hours) and hearing loss for PTA (512) and PTA (346), however, age was found to predict hearing loss for both ears at PTA_{346}.

6.2 Recommendations

Based on the findings of this study, the following recommendations were made.

1. Appropriate hearing protection devices that are comfortable and fit snugly should be provided for workers at GHACEM.
2. Individuals working in units where noise levels exceed 100 dB should wear double hearing protection to sufficiently decrease noise exposure levels.
3. Employers should offer periodic training on appropriate use of HPDs to increase worker's efficient use of HPDs.
4. Intense monitoring of worker's use of HPDs during work should be performed and appropriate penalties for offenders should be enforced.

5. Periodic hearing assessment for workers particularly those exposed to noise levels above 85dB should be done.
6. Pre-employment hearing assessment should be performed for all contract workers at the production unit.

6.3 Limitations of the study

A definitive diagnosis of noise-induced hearing loss is often performed by a comparison between baseline audiograms and subsequent audiograms. The unavailability of baseline audiograms in the current study did not allow for a comparative analysis.

Secondly the cross-sectional study design employed did not allow for causal and effect relationships to be established.

Thirdly, the convenience sampling technique used in recruiting the study participants, may not have been representative enough of the entire population.

Lastly, the lack of consent to carry out a noise survey at GHACEM, did not allow for an extensive evaluation of the overall noise levels that workers at the production unit were exposed to.

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APPENDICES

Appendix 1: Participant's consent address

Participant's consent address

I am Judith Arthur from the School of Public Health, University of Ghana pursuing a Master's programme in Occupational Hygiene. As part of the course programme and requirement for graduating, I am conducting a research titled **"The effect of occupational noise levels on hearing among cement factory workers in Tema"**. The rationale behind this project is to assess the effect of occupational noise levels on hearing acuity.

The risk to you by participating is minimal. The discomforts associated with this study are, time needed to fill out the questionnaire and the mild discomforts that may be experienced during sharing of personal information but be assured that confidentiality and anonymity will be used.

Data collection will be done in a day. You will be exposed to various sound frequencies that are very harmless. The purpose of this exposure is to only assess your hearing acuity. Participation is therefore completely voluntary and you are free to opt out if you wish not to continue with this study. There will be no form of monetary compensation but for taking time off to participate in the study, you might be refreshed with water or soft drinks.

For any enquiries and explanation on the project, you are free to email me via (judithabaarthur@gmail.com) or call on 020-875-322. You may also call Dr Judith Stephens, my supervisor on 024-428-5224 or Madam Hannah Frimpong, the GHS-ERC administrator on 0243235225/ 0507041223. By completing and submitting this survey, you are giving your consent.

Thank you

Appendix 2: Consent form

Consent form

I………………………….. have been thoroughly briefed and understand the entire methodology and significance of the on-going research which is being conducted by Judith Arthur (MSc Occupational Hygiene)

On my own accord, I hereby consent to be part of the study based on my understanding of what the study entails.

I am doing this on condition that under no circumstances will any reference be made to my actual identity to other persons outside this study as promised by the researcher

Respondent's signature/thumb print……………… Date………………

Researcher's signature…………………… Date………………

Appendix 3: Questionnaire

Questionnaire.

THE EFFECT OF OCCUPATIONAL NOISE LEVELS ON HEARING AMONG CEMENT FACTORY WORKERS IN TEMA.

SECTION A: DEMOGRAPHIC DATA

1. Gender: Male / Female

2. Age: ....

3. Department: □ Milling unit □ Packing unit □Maintenance unit

Others, specify……………………………………

4. Years of service: ……………

5. Educational level: □JSS □SHS □Diploma □Technical □Degree □Masters □PHD

   Others, specify: ………………………

6. Marital status: □Single □ Married □Widowed □Separated

7. Religion: □Christianity □ Islam □Traditionalist

   Others, specify……………………..

SECTION B: GENERAL MEDICAL AND HEARING HISTORY

8. Do you have any earaches or ear infection? □Yes □ No

9. Have you had any ear surgery? □Yes □ No

If yes, which ear? □ Right □ Left □ Both

Month and year of surgery:……………………………………

10. Have you had any head injury? □ Yes □ No

If yes, explain (please note if there was a skull fracture with fluid exudate from the ear)

……………………………………………………………………………………………

11. Do you experience ringing in your ears? □Yes □No

If yes, how often? □Daily □ Weekly □ Occasionally

Which ear? □ Right □ Left □ Both

12. Do you have balance problems? □ Yes □ No

If yes, have you experienced any of these symptom?

a) Faintness □ Yes □ No
b) Spinning □ Yes □ No
c) Unsteadiness □ Yes □ No

If yes have you been treated for this? □ Yes □ No

13. Have you taken Aspirin within the last 24 hours? □ Yes □ No

14. Have you had any antibiotic treatment? □ Yes □ No

If yes did you receive treatment within the last 6 months? □Yes □ No

15. How would you rate your hearing? Please tick appropriate box

	GOOD	FAIR	POOR
RIGHT EAR			
LEFT EAR			

SECTION C: USE OF PROTECTIVE HEARING DEVICE

16. Do you use protective hearing device when working? □ Yes □ No

17. If yes, how often do you wear it? □ Always □ Frequently □ Sometimes □ Infrequently

18. If not always, what is the reason? □ It is uncomfortable □ Never thought about it □ Its unnecessary □ Limited knowledge □ Do not spend much time working in noisy environment

Other ………………………………..

19. How many hours are you working per day?...................................

SECTION D: KNOWLEDGE ON EFFECTS OF NOISE LEVELS

20. Can workplace noise levels affect health? □ Yes □ No

21. What can you say about noise levels at your work place? □ Very high □ High □ Average

22. For each, state whether the following is true or false.

Workplace noise levels cause;

a) Hearing loss ………
b) Headaches ……….
c) Bad temper ……….
d) Loss of concentration ……..

Appendix 4: Audiometric Evaluation Form

Audiometric evaluation form

Participant's Initials:

Age:

Gender:

Department:

Duration of Work:

Otoscopy:

AUDIOMETRIC RESULTS

	250Hz	**500Hz**	**1K Hz**	**2K Hz**	**3K Hz**	**4K Hz**	**6K Hz**	**8K Hz**
R - AC								
L – AC								
R – BC								
L - BC								

TYMPANOMETRY	RIGHT	LEFT
ECV (0.2 – 2.0)		
PEAK COMPLIANCE (0.2 -1.6)		
PEAK PRESSURE (-100 - +100 daPa)		
PTA	RIGHT	LEFT