WORK ENVIRONMENT NOISE LEVELS AND AUDITORY STATUS OF GENERATOR USERS IN AGBOWO AND AJIBODE AREAS OF IBADAN, NIGERIA

BY

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF EPIDEMIOLOGY, MEDICAL STATISTICS AND ENVIRONMENTAL HEALTH, FACULTY OF PUBLIC HEALTH, COLLEGE OF MEDICINE IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PUBLIC HEALTH (ENVIRONMENTAL HEALTH) DEGREE

OF THE

UNIVERSITY OF IBADAN

MAY, 2012

Certification

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DEDICATION

This research work is dedicated to the Almighty Allah in whose hand is the dominion and is able to do all things. I also want to dedicate this research work to my late mother, who meant the world to me through her endless love and sacrifice for all her children. May the Almighty Allah grant her eternal peace, amin.

ACKNOWLEDGEMENTS

First and foremost, I express my gratitude to the Almighty Allah, for the unlimited guidiance and love shown to me throughout my study, the protection over my health and life in times past, present and in the future. I am eternally grateful to my loving parents, my brothers Bashiru, Ibrahim, Teslim and my sisters Hadiza, Nana, Nefi whose love, care, encouraging words and financial support enabled the timely completion of this work.

My sincere thanks goes to my supervisor Dr. Godson R.E.E. Ana, for his motivation, constructive critism, professional guidance, exposure and encouragement towards the completion of this work. Your immeasurable contribution will always be appreciated.

My special appreciation goes to the Dr. Olufunmilayo I. Fawole (Head, EMSEH Department) for her lectures, motherly advice and kind attention paid to me. I appreciate all the lectures, comments, contributions and constructive criticism of Dr. E.O. Oloruntoba, Dr. O.M. Bolaji, Dr. O.T Okareh (Environmental Health Unit) and Dr. O.E Oyewole (Department of Health Promotion and Education), Dr. L.V. Adekunle, Dr. I.O. Ajayi, Dr. O.B. Yusuf, Dr. M.D. Dairo, Dr. A.A. Fatiregun, Dr B.O Adedokun, Dr. A.S. Adebowale, Mr. J.O Akinyemi, Mr A.F. Fagbamigbe, Mr Aduroja and Mr Nathaniel (Epidemiology and Medical Statistics Unit).

I am immensely indebted to Mrs Osisanya the Audiologist in the Ear, Nose, Throat and Eye Department in the University College Hospital (UCH) for her training on pure tone audiometry.
I appreciate all my senior colleagues Benjamin Renshaw, Yemi Adetule, Chimere Ohajinwa (2005/2006), Ukhun Anthony, Okin Amina, Pastor Adeniji, Olowolade Tope, Ubochi Micheal, Osatimeyin Muyiwa (2007/2008), my colleagues Fakunle A., Temilade B., Jimoh L., Ogunwale T., Ojo O., Adebisi B., Idayat., Ukachukwu L and Adeyemi W. I appreciate all the love and words of encouragement from Zainab, John, Lamide, Tolu, Jibike, Busola, Osas, Biodun, Sayo of (2009/2010) set. To all the members of muslim students society, UCH branch, I say a big thank you for your prayers, love and support.

YESUFU Alegbema Luqman

ABSTRACT

The increasing use of electric generators in small scale businesses is predicated on the erratic and inadequate power supply in Nigeria. Electric generators produce noise at levels capable of inducing hearing impairment. Hitherto, few studies have assessed the auditory status of generator users in Nigeria. This study was designed to compare the work environment noise levels and auditory status of generator users in two areas where generators are used in Ibadan.

A comparative cross sectional study was conducted in Agbowo (high generator use) and Ajibode (low generator use) areas of Ibadan. Noise levels of work environment were measured using calibrated AEMC sound meter. Measurements were made before business activity commenced (6am-8am), at the peak of business activity (11am-1pm) and at the close of business activity (4pm-6pm) for a period of 12weeks. Generator characteristics were documented with a checklist. All 515 generator users in both communities (Agbowo: 304, Ajibode: 211) were surveyed. Information on socio-demographic characteristics and pattern of generator use were obtained with a pretested interviewer administered questionnaire. One hundred and twenty two and 84 users who reported daily generator use in Agbowo and Ajibode respectively were recruited for audiologic evaluation. Audiometric measurements were done with calibrated Maico MA27 audiometer. Hearing impairment was defined as audiologic values of >50dB in both ears while excessive noise levels in work environment was defined as > 70dB(A) in accordance with WHO standards. Data were analyzed using descriptive statistics, Chi-square test and Logistic regression.

The average noise level around the work environment in Agbowo (78.5±3.9dB(A)) significantly exceeded the WHO standard [65-70dB(A)] compared with Ajibode (59.7±4.4dB(A)). The maximum noise level obtained was during the peak activity period of 11am-1pm; Agbowo: 84.4±8.74dB(A) versus Ajibode: 69.9±4.65dB(A) ($p<0.05$). The mean generator noise levels in Agbowo and Ajibode were 100.5±7.5dB(A) and 91.2±4.86dB(A) respectively ($p<0.05$). The proportion of diesel engines in Agbowo (65.0%) exceeded those in Ajibode (10.0%). The mean age of generator users in Agbowo and Ajibode were 25.4±5.4 years and 24.8±5.8 years respectively. The average daily generator use were [Agbowo: 5.5±1.7 hours/day and Ajibode: 2.1±1.1 hours/day] respectively ($p<0.05$). The mean distance of generator to users was significantly lower in Agbowo (1.9±1.5m) than in Ajibode (5.6±4.1m). More respondents in Agbowo (60.0%) compared with those in Ajibode (19.0%) placed their generators indoors during business activity ($p<0.05$). The audiometric assessment revealed pure tone average of 59.6±11.7 dB and 44.5±14.7 dB for generator users in Agbowo and Ajibode respectively ($p<0.05$). The proportion of those with hearing impairment in Agbowo and Ajibode were 75.6% and 34.5% respectively ($p<0.05$). Hearing impairment was higher among generator users in Agbowo compared with their counterparts in Ajibode (OR: 5.9, 95%CI: 3.2-10.8).

Noise levels in Agbowo area exceeded the standard for work environment and the burden of hearing impairment is high in the two areas. The use of sound-proof generators and ear plugs are recommended to ameliorate the potential effect of generator noise on hearing.

Key Words: Generator noise levels, Hearing impairment, Generator users.
Word Count: 477

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GLOSSARY OF TERMS AND ABBREVIATIONS

AG1	Agbowo phase 1
AG2	Agbowo phase 2
AG3	Agbowo phase 3
AJ1	Ajibode phase 1
AJ2	Ajibode phase 2
AJ3	Ajibode phase 3
ANOVA	Analysis of Variance
ANSI	American National Standards Institute
BC	British Columbia
CBN	Cntral Bank of Nigeria
Db	Decibel
dB(A)	Decibel A weighting
EPRI	Electric Power Research Institute
FEPA	Federal Environmental Protection Agency
GPS	Geographical Positioning Station
HPD	Hearing protection devices
IOSH	Institute for Occupational Safety and Health
ISO	International Organnisation for Standardization
kW	Kilowatts
NCS	Nigerian Customs Service

NESREA	National Environmental Standards Regulation Enforcement Agency
NIDCD	National Institute on Deafness and Other Communicable Disorders
NIHL	Noise induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
ONIHL	Occupational noise induced hearing loss
OHSW	Occupational Health Safety and Welfare
PHCN	Power Holding Company of Nigeria
PTA	Pure tone audiometry
PTS	Permanent Threshold Shift
REM	Rapid Eye Movement
SLM	Sound Level Meter
SPSS	Statistical Package For Social Science
TTS	Temporary Threshold Shift
UCH	University College Hospital
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Noise can be define as an unwanted or undesired sound whereas environmental noise is any unwanted or harmful outdoor sound created by human activities that is detrimental to the quality of life of individuals. Noise pollution is now recognized worldwide as a major problem for the quality of life in any urban area (Piccolo *et al*, 2005). In most developed countries, standards for air pollution and noise exposures are an important part of environmental policy to improve local environmental quality; this is hardly the case in developing countries like Nigeria. As majorities are encumbered with the problem of poverty and disease while noise which effect is insidious goes unnoticed.

Excessive noise is a pervasive occupational hazard with many adverse effects, including elevated blood pressure, reduced performance, sleeping difficulties, annoyance and stress, tinnitus, noise-induced hearing loss (NIHL) and temporary threshold shift (Smith, 2004). Of these, the most serious health effect is Noise induced hearing loss resulting from irreversible damage to the delicate hearing mechanisms of the inner ear. Noise induced hearing loss typically involves the frequency range (pitch) of human voices, and thus interferes with spoken communications (Olaosun, 2009).

Occupationally-acquired noise-induced hearing loss is a sub-categorization of acquired hearing impairment whereby workplace excessive noise exposure can be rationally attributed to a quantifiably reduced hearing capacity (Australian Government National Occupational Health and Safety Commission, 2009). Occupational noise is considered to be a major cause of adult-onset hearing loss worldwide (Nelson *et al.,* 2005). Workers across the world continue to be at risk of hearing loss due to the presence of a high level of noise at their workplaces (Verbeek *et al.*, 2009).

Despite enhanced awareness of the hearing impact of excessive noise exposure (Bove, 2006; NIDCD, 2006), and the increasingly-stringent focus on occupational health, safety, and welfare (OHSW), occupational noise-induced hearing loss (ONIHL) remains a significant source of potentially-avoidable morbidity (Irwin 1997; Concha-Barrientos 2004; NIOSH, 2006).

Electricity which is one of the dividends of industrialization has become an essential requirement for most people in the developing countries. In Nigeria, most of the cities and towns are connected to the national power grid for electricity supply (Makinde *et al.*, 2008) which is used for domestic, commercial and industrial purposes among other uses. Figure 1 provides the trend of electricity consumption along with its disaggregated components. By visual inspection, electricity consumption by the residential sector has dominated other sectors since 1978, while the industrial sector's demand has witnessed continuous downward trend. The fall in the industrial sector's demand for electricity can be attributed to inadequate power supply (Ekpo, 2010) which has forced manufacturers to resort to privately generated electricity for powering their production processes.

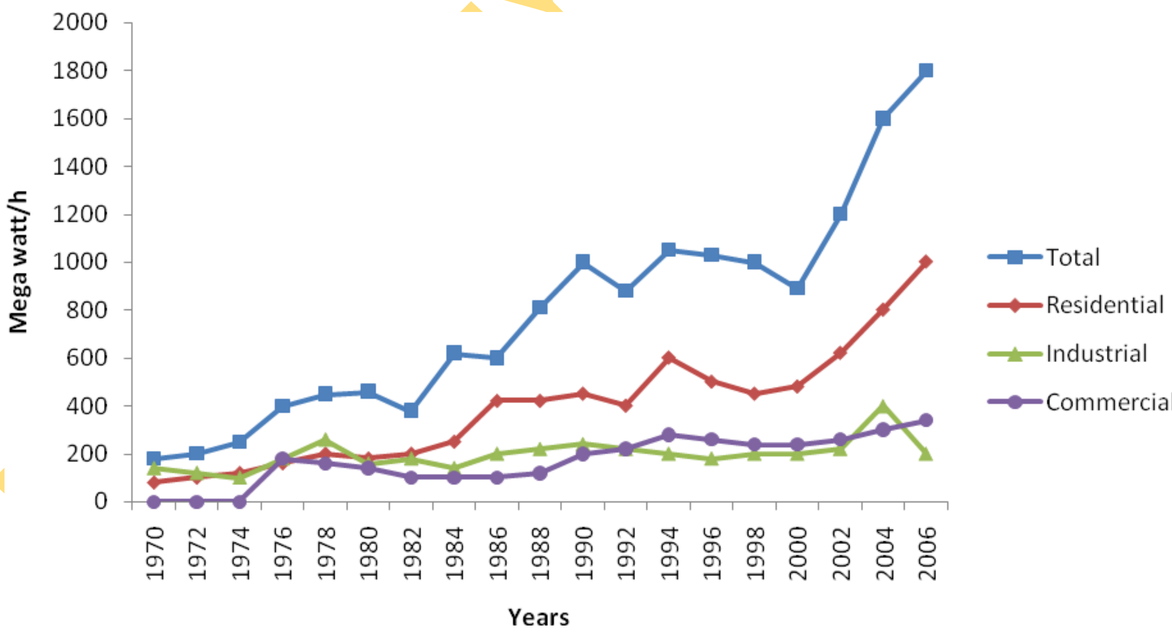


Figure 1.1: Trend of electricity consumption in Nigeria (1970-2005), CBN Statistical Bulletin (2009).

Electricity interacts with human development at different levels. It helps to facilitate economic development and poverty reduction by underpinning industrial growth and enhancing productivity. It contributes to social development by helping to fulfill the basic human needs of nutrition, warmth and lighting, in addition to education and public health (UNDP, 2005). The availability and the reliability of electricity supplies have always been a vexed issue in Nigeria (Ibitoye and Adenikinju, 2007). The electricity sector in Nigeria has been constrained by many factors among which are generation deficit, weak transmission and distribution infrastructure, poor utility performance, long period of investment and maintenance neglect in the 1980s and 1990s . The poor attention devoted to the electricity sector in the past has had a debilitating effect on Nigeria's economic development and her industrialization process.

Interestingly, Nigerian manufacturers have consistently identified poor power supply as the most important constraint to their business. Majority of them have to supplement publicly supplied electricity with very expensive self generation in the form of electric generators, which is now very common in most parts of the country. These electricity generating sets (electric generators) while in operation constitute a major source of environmental noise pollution and thus small scale businesses that would have been essentially noiseless, now produce heavy noise pollution from generators (Akande and Olonge, 2001).

Occupational Noise induced hearing loss (ONIHL) is one of the hazards posed by working with electric generators and since the effect of noise on hearing is a gradual health outcome, small scale business operators may not notice any change in their hearing abilities until a large threshold shift has occurred (Akande and Ologe, 2001). This reflects the insidous effect of noise on hearing ability (Smith, 1998). This study focuses on documenting the work environment noise level within two commercial settings where generators are used selected from the high and low generator use areas in Ibadan and the evaluation of auditory status of generator users..

1.2 Problem statement

Noise is the major avoidable cause of permanent hearing impairment worldwide (WHO, 1997). Adult-onset hearing loss has been described as the “fifteenth most serious health problem” in the world, with profound effects ranging from social isolation and stigmatization of individuals to serious national economic burdens (Smith, 2004). Estimates of the number of people affected worldwide by hearing loss increased from 120 million in 1995 (WHO, 1999; WHO, 2001) to 250 million worldwide in 2004 (Smith, 2004). Much of this impairment may be caused by exposure to noise on the job. In the United States of America (USA), for example, more than 30 million workers are exposed to hazardous noise (NIOSH, 1998). In Germany, 4−5 million people (12−15% of the workforce) are exposed to noise levels defined as hazardous by WHO (WHO, 2001).

Impaired hearing from loud noise exposure could lead to poorer quality of life due to reduced social and cognitive function (Schmuzigger, 2006). Individuals with hearing loss may experience isolation and even depression due to inability to converse normally with others (Daniel, 2007). People with noise induced hearing loss (NIHL) can also experience hypersensitivity to sound, tinnitus, and balance dysfunction (Kilburn, 1992). Data for developing countries as regards noise level are scarce, and available evidence suggests that average noise levels are well above the occupational level recommended in many developed nations (Suter, 2000; WHO/FIOH, 2001). Developing countries, including Nigeria, lack effective legislation against noise. Where these exist, they are often poorly enforced and implemented (WHO, 1997).

1.3 Rationale for the study

Electric generators produce noise capable of inducing hearing impairment. Onset of hearing impairment is slow and insidous thus most people are unaware of its development until a large threshold shift has occured. The paucity of information on effect of electric generator on auditory health has further compounded the problem as majority of those who use it for commercial activity are unaware of the risk posed by exposure to the noise from generators. This makes it a great concern to public health as workers suffering from NIHL are not only denied the ability to converse normally with others, but also are endangered in the work environment, as their ability to perceive an audible warning is seriously compromised (Ringen, 1994). Studies on occupational noise exposure have been done mostly in developed countries. Studies on the effect of occupational noise among Africans are few. Osibogun *et al.,* (2000) found noise-induced hearing loss among textile workers in Lagos, Nigeria, who were exposed to environmental noise of more than 90dB.

In addition, a recent study by Omokhodion *et al.,* (2008) revealed excessive noise levels which ranged from 85-105dBA in workshops operating machines such as saw mills, carpentry tools, printing presses and grain mills in an urban community in Nigeria. Both studies did not report auditory conditions of workers. In Nigeria, reports of work done in some industries in our environment show excessive exposure to noise, sometimes in excess of 95dBA, with the eventual high prevalence (50–80%) of sensorineural hearing loss (Oleru *et al.,* 1990). Among grinding machine operators mean noise levels recorded was 105.8 ± 9.3 dBA, with 62.5% of them having hearing impairment (Bisong *et al.,* 2004). Omokhodion et al., (2008) also reported excessive noise levels ranging from 85-105 dBA among machine operators in Ibadan, Nigeria.

There are also no studies on chronic exposure to noise from electric generator, which is one of the occupational peculiarities of Africans, particularly Nigerians who use it for commercial activities as well as home use. An assessment of noise levels produced from electric generators as well as the evaluation of the hearing status of generator users may assist governments in formulating legislation governing noise levels at areas where generators are used. This is particularly important considering the fact that policy and practical measures can be used to reduce exposure to occupational noise (WHO/FIOH, 2001). Noise readings and audiologic evaluations would be compared with WHO guideline limits and the information gathered in this research would also create awareness amongst the generality of generator users on noise levels that can pose harm to them and personal protective measures that could be adopted.

1.4 Research questions

1. What are the characteristics of the electric generators identified in Agbowo and Ajibode?
2. What are the work environment noise levels produced in Agbowo and Ajibode commercial area?
3. What are the noise risk areas in Agbowo and Ajibode commercial area?
4. What are the occupational characteristics and pattern of generator use among generator users in Agbowo and Ajibode commercial area?
5. What are the respondents level of knowledge as regards health hazards associated with electric generator use?
6. What are the perceptions of the respondents as regards the risk associated with generator noise?
7. What is the proportion of respondents having hearing loss due to noise exposure

1.5 Objectives

1.5.1 Broad objective

The main objective of this study is to determine the work environment noise levels and auditory status of electric generator users in Agbowo and Ajibode commercial areas of Ibadan.

1.5.2 Specific objectives

The specific objectives of this study are to:

1. Characterize the types of electric generators in the selected study areas.
2. Determine the work environment noise levels in the selected study areas.
3. Develop a risk map for noise in Agbowo and Ajibode commercial areas.
4. Document the Occupational characteristics and Pattern of generator use among generator users in the selected study areas.
5. Assess the respondents level of knowledge on health hazards associated with the use of electric generator.
6. Document respondents perception of risk associated with noise from electric generator
7. Determine the proportion of respondents having hearing loss due to noise exposure.

1.6 Research hypothesis

H1 There is no significant relationship between the hours at work and respondents hearing status.

H2 There is no significant relationship between the educational status and knowledge of health hazards associated with generator noise.

H3 There is no significant relationship between commercial area and knowledge of Health hazards associated with generator noise

H4 There is no significant relationship between commercial area and Perception of risk associated with noise from electric generator

H5 There is no significant relationship between the work location and respondents hearing status.

1.7 Limitation of the study

Most owners of targeted businesses were reluctant to release their employees for audiologic evaluation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Concept of Noise

Noise is derived from the Latin term nausea. It is an inescapable part of everyday life and can be defined by various ways, but essentially it can be described as “wrong sound, in the wrong place at the wrong time” (Thompson, 1994). The concepts of sound and noise have no physical difference although they are distinct when observed by a human listener (Berglund and Lindvall, 1995). A major distinction between sound and noise is that sound is regarded as noise when it becomes a source of inconvenience to another individual. Noise is a number of tonal components disagreeable to man and more or less intolerable to him because of the discomfort, fatigue, disturbances and, in some cases, pain it cause.

2.2 Sources of Noise

Noise originates from human activities, especially during urbanization and the development of transport and industry. Though, the urban population is much more affected by such pollution, however, small town/villages along side roads or industries are also victim of this problem. Noise is becoming an increasingly omnipresent, yet unnoticed form of pollution even in developed countries. According to Brigitte and Lindvall (1995), road traffic, construction equipment, manufacturing processes, and lawn mowers are some of the major sources of these unwanted sounds that are routinely broadcasted into the air. Road traffic is by far the largest of these, and accounts for about 78 per cent of noise annoyance worldwide.

2.2.1 Traffic Noise

Increase in vehicular traffic is a source of noise pollution around the globe especially in most urban cities around the world. The situation is getting seriously alarming with increase in traffic density on city roads (Ozkurt and Camci, 2009). Traffic related noise pollution accounts for nearly two-third of the total noise pollution in an urban area and traffic noise on existing urban road-ways lowers the quality of life and property values for persons residing in the vicinity of these urban corridors (WHO, 2001). Motor vehicles equipped with horns and bells for emergency situations and warning signals can generate noise levels above 50 dB(A) which can be considered to be extremely annoying to nearby residents. Noise annoyance can result when noise levels are between 50-55 dB(A) for outdoor environments. (WHO, 2001).

2.2.2 Construction Noise

Construction activities generate high noise levels which can exceed 95 dB (A) for large earth moving equipments utilized for site development and preparation, while the noise levels measured around power tools used for smaller tasks range from 95-105 dB (A) (Sinclair *et al*, 1995). Construction equipments such as cranes, cement mixers, welding, hammering, boring, and other work processes provide a variety of sound levels and often poorly silenced and maintained. A study carried out by Greenspan *et al.,* (1995) revealed average noise levels from 12 construction equipments as 97.5 dB (A), with range from 87-107 dB (A). Another study involving earth-moving equipment operators at 16 construction sites found noise exposure levels of 90-120 dB(A), with higher levels associated with scraper-loaders and tractor-dozers (Hattis, 1998). These activities generate heavy noise pollution are capable of inducing hearing impairment as building operations are sometimes carried out without considering the environmental noise consequence.

2.2.3 Industrial Noise

In industrial areas, the noise usually stems from a wide variety of sources, many of which are complex in nature. In industrialized countries it has been estimated that 15-20 % or more of the working population is affected by sound pressure levels of 75-85 dB (A). Workers exposed to these sound levels are likely to experience sleep disturbance, cardiovascular dysfunction, speech interference and mental health distortion, including hearing impairment and balance disorder (Satterfield, 2001). Hearing impairment in the industry can also be caused by a variety of industrial agents such as mercury, toluene, xylene, lead, carbon disulphide and carbon monoxide (Wilson *et al.,* 1992).

2.2.4 Domestic Noise

Household equipments such as vacuum cleaners, mixers and some kitchen appliances are noisemakers of the house. Though they do not cause too much problem, the effect of noise they emit on human health cannot be neglected. Furthermore, noise can be generated from neighbourhood noise consisting of neighbouring apartments and noise within one's own apartment. Noise from neighbors is often one of the main causes of noise complaints (Berglund and Lindvall, 1995).

2.2.5 Electricity Generating Plants

Electric energy occupies the top grade in energy hierarchy as it finds innumerable uses in homes, industry, agriculture, and defense and of course in some nations, transportation. Nigeria's electricity power situation is very poor because of erratic power supply. As a result there is an upsurge in the use of electricity generating plant with its attendant noise pollution on the environment and human health (Akande and Olonge, 2001). Most workplaces and homes use generating plants 24 hours in alternative to power supply. The noise from generated plants in Nigeria coupled with its accompanying smoke emission to the sky which has greatly contributed to the breaking of the ozone layer in the sky.

2.2.6 Noise from Religious Worship Institutions

Nigeria is a multi religious society and is therefore prone to religious activities. These activities manifest in congregational worship in various forms. These congregational worships are held in Mosques, Churches and other nonconventional areas like residential and workplaces, in the daytime and even throughout the night (Makinde *et al.*, 2008). Noise of significant levels is generated from these congregational worships with the use of heavy public address systems and intensity of the voices of the worshippers oozing from inside.

2.3 Concept of Occupational Noise

Occupational noise can be described as noise from workplace environment. It is different from environmental noise which is classified as noise in all other settings, whether communal, residential or domestic (Traffic, playgrounds, sports and music). Mechanized industries are responsible for increased noise levels at occupational settings which pose serious health problems. More and more people are affected by noise exposure than any other environmental stressor. However, because its associated health effects are not as life-threatening as those for air, water and hazardous waste, noise has been on the bottom of most environmental priority lists (Cowan, 1994). People respond differently to noise and the level at which noise will start to cause damage is not known . However, the amount of damage caused by noise depends on the total amount of energy received over time (McBride et al., 2001). Implying that the louder the noise the lesser time it takes to cause damage to the ear. However, this limit did not guarantee the safety for the auditory system of workers. Figure 2 illustrates the different exposure times for different sound levels, all equivalent to exposures of 85 dB(A) for eight hours. A 3 dB(A) increase in noise level will produce twice the energy output and cause the same damage in half the time.

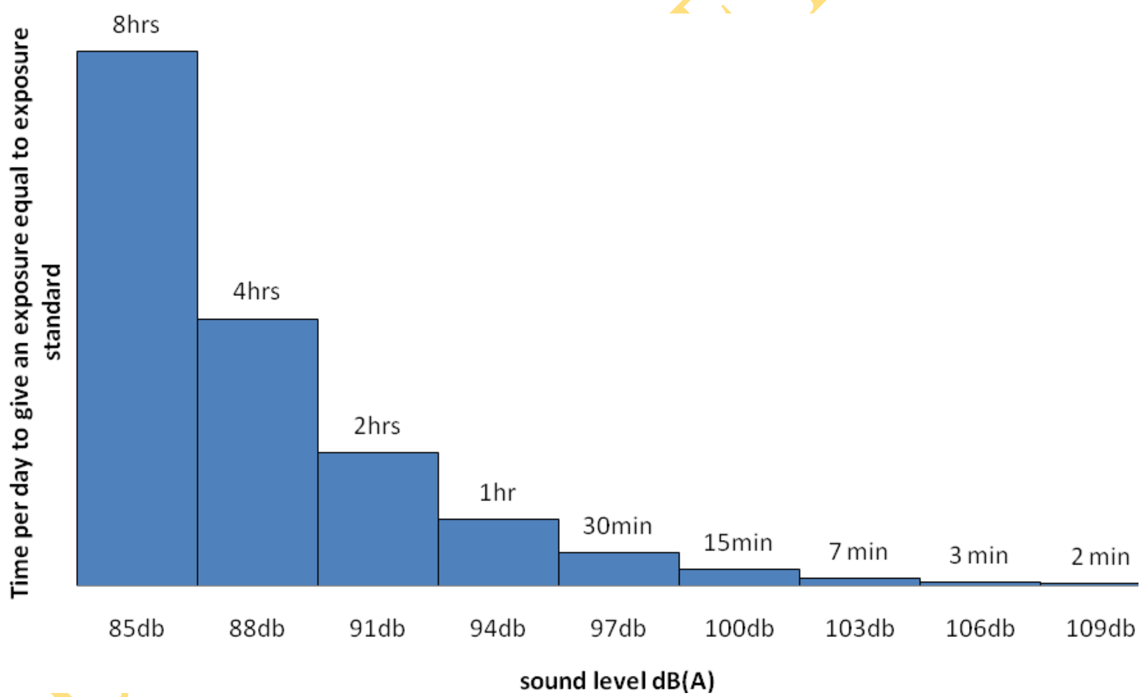


Figure 2.1: Exposure times for different sound levels, all equivalent to exposures of 85 dB(A) for eight hours. NIOSH, 1998 (Increase in Noise levels increases risk of hearing loss)

Table 2.1: Equivalent time-intensity levels referred to the action levels according to the NIOSH (1998) Directive

Action Level	L_{Aequ}, 8h	**Equivalent levels for time indicated (trade-off 3dB)**
First Action Level (minimum) provide protection	80 dB(A)	83 dB(A)-4hr13; 86 dB(A)-2hr; 89 dB(A)-1hr; 92 dB(A)-30min14; 95 dB(A)15min; 98 dB(A)-8min; 101 dB(A)-4min; 104 dB(A)-2min; 107 dB(A)-1min
Sound Action Level Mandatory protection	85 dB(A)	88 dB(A)-4hr; 91 dB(A)-2hr; 94 dB(A)-1hr; 97 dB(A)-30min; 100 dB(A)-15min; 105 dB(A)-5min; 111 dB(A)-1min
Maximum Exposure limit	87 dB(A)	90 dB(A)-4hr; 93 dB(A)-2hr; 96 dB(A)-1hr; 99 dB(A)-30min; 102 dB(A)-15min; 107 dB(A)-5min; 113 dB(A)-1min

Table 2.2 Noise exposure limits for Nigeria (FEPA, 1991)

Duration per day, hour	**Permissible Exposure Limit dB(A)**
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

2.4 Noise Characteristics

Sound becomes noise when it has an undesirable physiological or psychological effect on people. Nevertheless, it is important to understand the physical characteristics of sound since these characteristics determine the various ways we have of measuring and describing sound. The main physical characteristics are: sound pressure level, sound frequency, type of sound, and variation in time. Typical sound pressure levels range from about 20 dB LAeq in a very quiet rural area to between 50 and 70 dB LAeq in towns during the day time, to 90 dB LAeq or more in noisy factories and discotheques to well over 120 dB LAmax near to a jet aircraft at take-off (Berglund and Lindvall, 1995). An audio-frequency is associated with the perception of the pitch of a tonal sound.

Sound frequency is measured by the number of repeated cycles of the sound wave in one second (c/s or Hz) and the audible frequency range is 20-20,000 Hz. Sound pressure level weighted with A-, B-, and C-filters in sound level meters is intended to take into account part of the differential frequency sensitivity. The sound pressure has the unit Pascal (Pa), while sound pressure level has the unit dB (WHO, 2001). The sound pressure level usually vary with time. The type of sound describes the particular features of a sound which makes it possible for a listener to identify it. The ability to identify the source is very important in determining community annoyance (WHO, 2001). The speed of sound (c), the frequency (f), and the wavelength (λ) are related by the equation

$$\lambda = c/f \quad (1)$$ (Berglund and Lindvall, 1995).

2.5 Noise Level Measurement and Summation

A sound level meter is a scientific instrument used to measure environmental noise levels within about plus or minus 1 dBA (Canadian Hearing Society, 2006). The intensity of sound is measured using the decibel scale, which is a logarithmic scale in which the zero calibration represents the threshold of hearing at each frequency for healthy normal young people. Sounds that are audible to the human ear fall in the frequency range of about 20-20,000 Hz, and the highest sensitivity is between 500 and 4,000 Hz (WHO 1997). Normal hearing is accepted as a threshold of 20 dB or better at each of the frequencies measured. Sound levels in decibels are calculated in logarithmic basis (Olaosun, 2009). An increase in 10dB represents a ten-fold increase in acoustic energy, while an increase of 20dB results from 100 times the energy. A-weighted sound level or dBA is used to characterize sound. The A-weighting curve is used to weight sound pressure levels as a function of frequency, approximately in accordance with the frequency response characteristics of the human auditory system. Generally, energy equivalent sound/noise descriptor called Leq is commonly used to describe average environmental sound level over an hour.

Table 2.3 Adding and subtracting noise levels

Difference between the two sound levels	Quantity to be added to or subtracted from the higher level
0	3
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1
7	0.8
8	0.6
9	0.5
10 or more	0

2.6 Noise Induced Hearing Loss

2.6.1 Occupational Noise and Hearing Loss- Magnitude of the problem

Occupational noise is considered to be a major cause of adult-onset hearing loss worldwide (Nelson, 2005). Workers across the world are at risk of hearing loss due to the presence of a high level of noise at their workplaces (Verbeek *et al.*, 2009). In USA, more than 30 million workers (almost 1 in 10) are exposed to unsafe noise levels on the job (Scott *et al.*, 2004). In Europe, about 35 million people are exposed to detrimental noise levels (> 85 dB-A) in industrial plants (Sulkowski *et al.*, 2004). In the Canadian province of British Columbia (BC), one fourth of all workers are exposed to high level of noise capable of causing hearing loss (WorkSafeBC, 2009). Summary statistics on noise exposure are not available for most industrializing and non-industrialized countries; however, high occupational noise exposure levels have been reported and available evidence suggests that average noise levels are well above the occupational level (Suter, 2000; WHO/FIOH, 2001). A recent study in Nigeria reported high levels of occupational noise (>90dB) among traders and 100% of workers exposed for a period of 14 years developed hearing impairment (Ighoroje *et al.*, 2004 and Bisong *et al.*, 2004).

2.6.2 Development of Noise Induced Hearing loss

Noise induced hearing loss develops almost insidiously over a period of 10-20 years (Sulkowski *et al.*, 2004). By the time it is noticeable, it may have reached a well advanced stage of disability (McBride *et al.*, 2001). NIHL typically involves the frequency range (pitch) of human voices, and thus verbal communication is affected (Nelson *et al.*, 2005). When a person is exposed to a high level of noise, temporary hearing loss (temporary threshold shift-TTS) may occur (Meyer *et al.*, 2002). With the complete cessation of noise exposure, the auditory threshold returns to normal within a few hours. But if the noise exposure continues for long periods and/or periods of recovery are reduced, permanent hearing loss or permanent threshold shift (PTS) occurs.

It becomes noticeable when the person faces difficulty in carrying out verbal communication in regular activities. PTS is irreversible (Meyer *et al.*, 2002).The first signs of hearing loss can be detected in the audiogram, which is usually a dip or notch in the audiogram maximal at 4 kHz (McBride *et al.*, 2001). The notch broadens with increasing exposure, and may eventually become indistinguishable from the changes of aging (presbycusis) when the hearing shows a gradual deterioration at the high frequencies (McBride *et al.*, 2001).

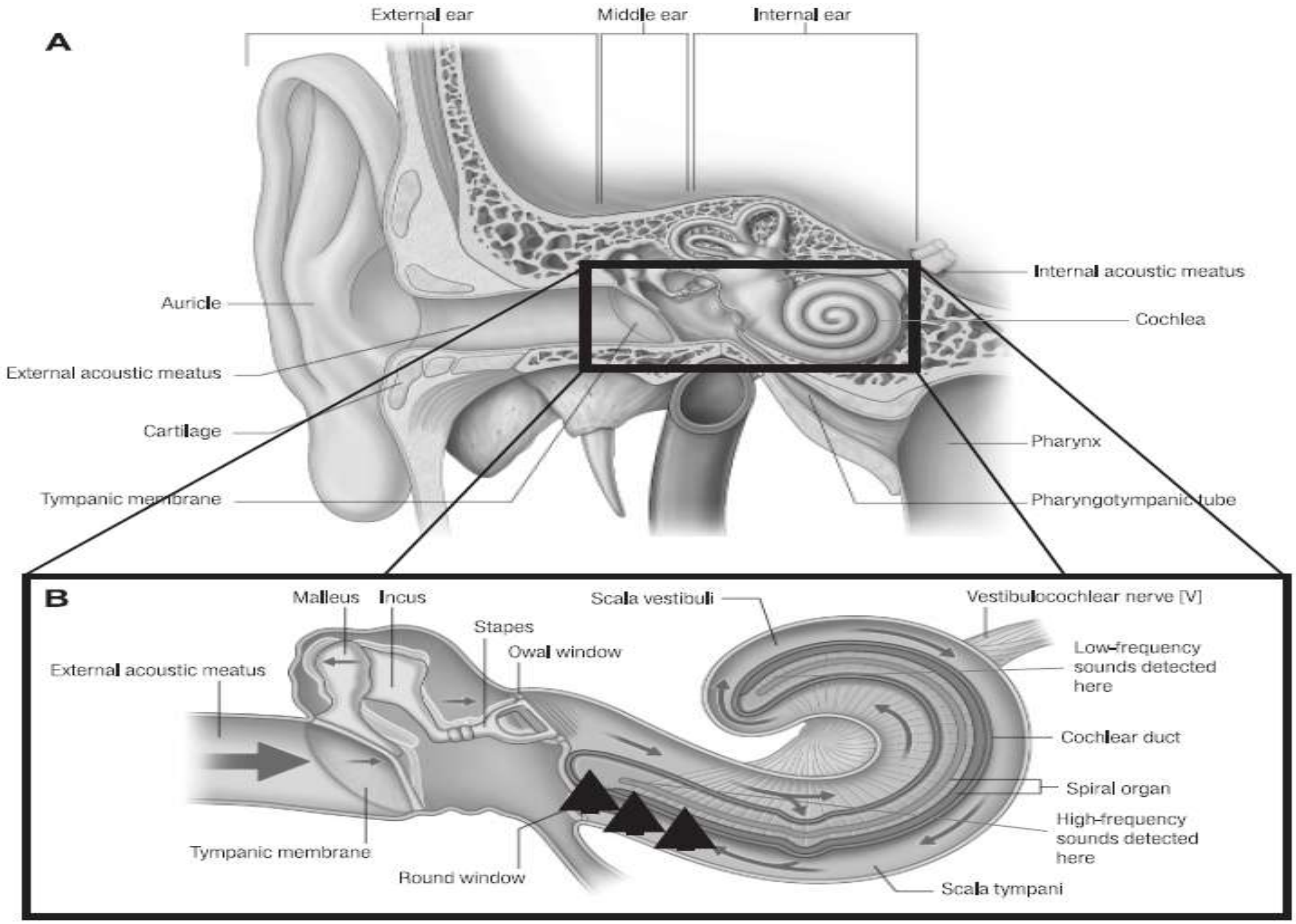


Figure 2.2: (A) The Human ear. (B) Showing regions of the cochlear most frequently damaged by prolonged excessive noise exposure and associated with Occupational Noise Induced Hearing Loss (large arrowheads). Adapted from (Drake *et al.*, 2006)

2.6.3 The Impact of Hearing Loss on Well-being

NIHL can have a significant negative impact on the quality of life (Hetu *et al.,* 2003). Hearing loss not only interferes with an individual's working life but can also restrict social activities and create problems in his/her personal life (Hetu *et al.,* 2003). It may be a risk in an industrial work setting because of the inability to detect a warning signal or the localization of sound sources. In many cases, sufferers may try to conceal their hearing impairment for fear of being stigmatized by co-workers who, due to a lack of awareness about occupational hearing loss, may mistakenly assume the problem to be associated with the natural aging process or a biological defect (Hetu *et al.,* 2003). Hearing loss may be greeted with jokes by some co-workers. The affected person may try to withdraw himself from social gatherings (Smith *et al.,* 1997). Hearing loss may result in misunderstanding, reduced ability to interact freely with significant others and may be an obstacle in obtaining intimacy (Smith *et al.,* 1997).

2.7 Hearing Protective Devices (HPDs) and noise induced hearing loss

A study by Amedofu *et al* on hearing impairment among workers in a surface gold mining company in Ghana (1998), revealed that noise induced hearing loss is absolutely preventable through the consistent and proper use of ear protection. Besides avoiding excessive noise, wearing hearing protection such as ear-plugs and earmuffs constitute an important preventive measure. The effectiveness of hearing protective devices in preventing noise induced hearing loss is greatly dependent on the correct use and wearing of the equipment (Sulkowiski et al., 2004). Hearing protective devices (HPDs) can work as a short-term solution to prevent NIHL if their use is carefully planned, evaluated, supervised, and consistent (NIOSH, 1998; Arezes and Miguel, 2002)

2.8 Age and noise induced hearing loss

Most industries employ workers of varying ages. The need to benefit from skilled labour has made it necessary for several companies to retain the services of workers who are in their middle ages and in some cases nearing retirement age. The risk of noise induced hearing loss in these older workers has been seen to be higher as compared to the younger workers. Age related hearing loss, also called presbyacusis, has a gradual onset and normally presents as a bilateral high frequency loss (8 000 hertz). In a study on the epidemiology of noise induced hearing loss in Poland, the majority of cases observed were those workers aged 50-59 years old and exposed to noise over 20 years (Sulkowiski et al., 2004).

2.9 The Non Auditory Effects of Noise

2.9.1 Speech Interference

Speech interference is basically a masking process in which simultaneous, interfering noise renders speech incapable of being understood (Lazarus, 1998). Environmental noise may also mask many other acoustical signals important for daily life, such as door bells, telephone signals, alarm clocks, fire alarms and other warning signals, and music (Hass-Slavin *et al.*, 2005). As the sound pressure level of an interfering noise increases, people automatically raise their voice to overcome the masking effect upon speech (increase of vocal effort). This imposes an additional strain on the speaker (Berglund & Lindvall, 1995).

2.9.2 Sleep Disturbance

Uninterrupted sleep is known to be a prerequisite for good physiological and mental functioning of healthy persons (Griefahn et al. 1996, 1998); sleep disturbance, on the other hand, is considered to be a major environmental noise effect. The primary sleep disturbance effects are: difficulty in falling asleep (increased sleep latency time); awakenings; and alterations of sleep stages or depth, especially a reduction in the proportion of REM-sleep (REM = rapid eye movement) (Berglund & Lindvall, 1995)

2.9.3 Cardiovascular and Physiological effects

Environmental and occupational noise can act as a stressor (Passchier-Vermeer 1993; Berglund and Lindvall, 1995). Acute noise exposures activate the autonomic and hormonal systems, leading to temporary changes such as increased blood pressure, increased heart rate and vaso-constriction. Many studies in occupational settings have indicated that workers exposed to high levels of industrial noise for 5–30 years have increased blood pressure and hypertension as compared to workers in control areas (Passchier-Vermeer, 1993).

2.9.4 Effect of Noise on Performance

It has been documented by (Evans and Lepore 1993; Evans 1998; Hygge *et al*., 1998; Haines *et al.,* 1998) in both in workers and children exposed to occupational noise, that noise adversely affects cognitive task performance. Accidents may also be an indicator of performance deficits. The few field studies on the effects of noise on performance and safety showed that noise may produce some task impairment and increase the number of errors in work, but the effects depend on the type of noise and the task being performed (Smith, 1990). Among the cognitive effects, reading, attention, problem solving and memory are most strongly affected by noise.

2.9.5 Effect of Noise on Mental health

Latent mental illness is thought be exacerbated and intensified by noise pollution and not believed to be a cause of mental illness (Goines and Hagler, 2007). In one study, children who were exposed to noise levels above 55 dB had decreased attention, difficulty with social adaptation, and increased oppositional behavior to others compared to children not exposed to these noise levels (Ritovska *et al.,* 2004). Noise pollution via community noise also causes annoyance and disturbance among those with depression and anxiety and may make their symptoms worse (Berglund and lindvall, 1995).

2.10 Electric Generator- The Nigerian Problem

Nigeria has been described as one of the major leaders in electric generator imports in Africa. This is probably due to the failed attempts to find lasting solution to the power sector (Ibitoye and Adenikinju, 2007) which from all indications, has virtually collapsed in spite of all the money already pumped into it. This has encouraged the proliferation of electric generators as alternative power sources. A whopping sum of about $103.1 million was spent importing generators between January and June 2010 (Ibitoye and Adenikinju, 2007). According to statistics released by the Nigerian Customs Service (NCS) in an issue published in THE NIGERIAN COMPASS (TNC) in 2010, Nigeria assumed the unenviable position for the past five years since 2007, as the leading importer of generators in Africa. Nigeria has also been spending $8 billion annually running generators. During the period under review, countries in Africa such as Angola, Egypt, Algeria and Libya, which follow in the lead, respectively, came near almost half of Nigeria's import levels. It is worrisome that due to the unsatisfactory performance of the power sector, virtually every household, as well as a considerable number of corporate bodies and manufacturers now rely heavily on generators to ensure smooth operations.

2.11 Electric Generator Characteristics

Portable engine driven electric generators are used to supply electricity in shops, offices and homes when there is a break in power supply (Akande and Olonge, 2001). The Electric Power Research Institute (EPRI) breaks down portable generators into the following components which are mounted onto a metal chassis (EPRI, 1999), they are:

- Internal combustion engine,
- AC alternator,
- Starting and regulating controls,
- Electric power outlets,
- Safety devices such as ground fault circuit interrupters and circuit breakers
- starter

In these generators, the alternator and engine are mounted on a frame through rubber mounts as shown in Figure 2.3. Such generators are normally placed outside shops/ offices and generate high noise levels causing annoyance to people in the neighbourhood. These power generating sets may be of diesel or petrol engines. Diesel engine generator sets are widely used as main electric power supplying equipment in many industrial plants and facilities in official/ residential buildings, especially in the situation of abrupt electric outage. In this case, the components of the diesel engine generator set, such as radiator fan and engine exhaust (Bhattacharya et al., 1992) would appear as main noise sources in the plants or buildings. Most conventional diesel engine generator sets have simple covers only to protect the components and guide the flow of cooling air, and would generate very high level of noise. In Nigeria, rising and unstable cost of diesel fuel has encouraged the use of petrol powered electric generators (Oparaku, 2003) especially in residential areas.

Generators may be categorized by power output. According to Consumer Reports, small generators produce 3.0 to 4.0 kilowatts (kW); mid-sized units, 4.5 to 7.0 kW, and large units around 10kW (Consumer Reports, 2003). Both commercial users and consumers purchase generators. While markets in the United States are not clearly differentiated, consumers overwhelmingly purchase light duty lower cost models that run on gasoline (Frost and Sullivan, 2003). In Nigeria, Akande and olonge in (2001) revealed that gasoline (Petrol) powered generators are commonly found in the homes and commercial settings due to the cost of petrol as compared to diesel, whose cost has risen steadily over the past five years (Ibitoye and Adenikinju, 2007).

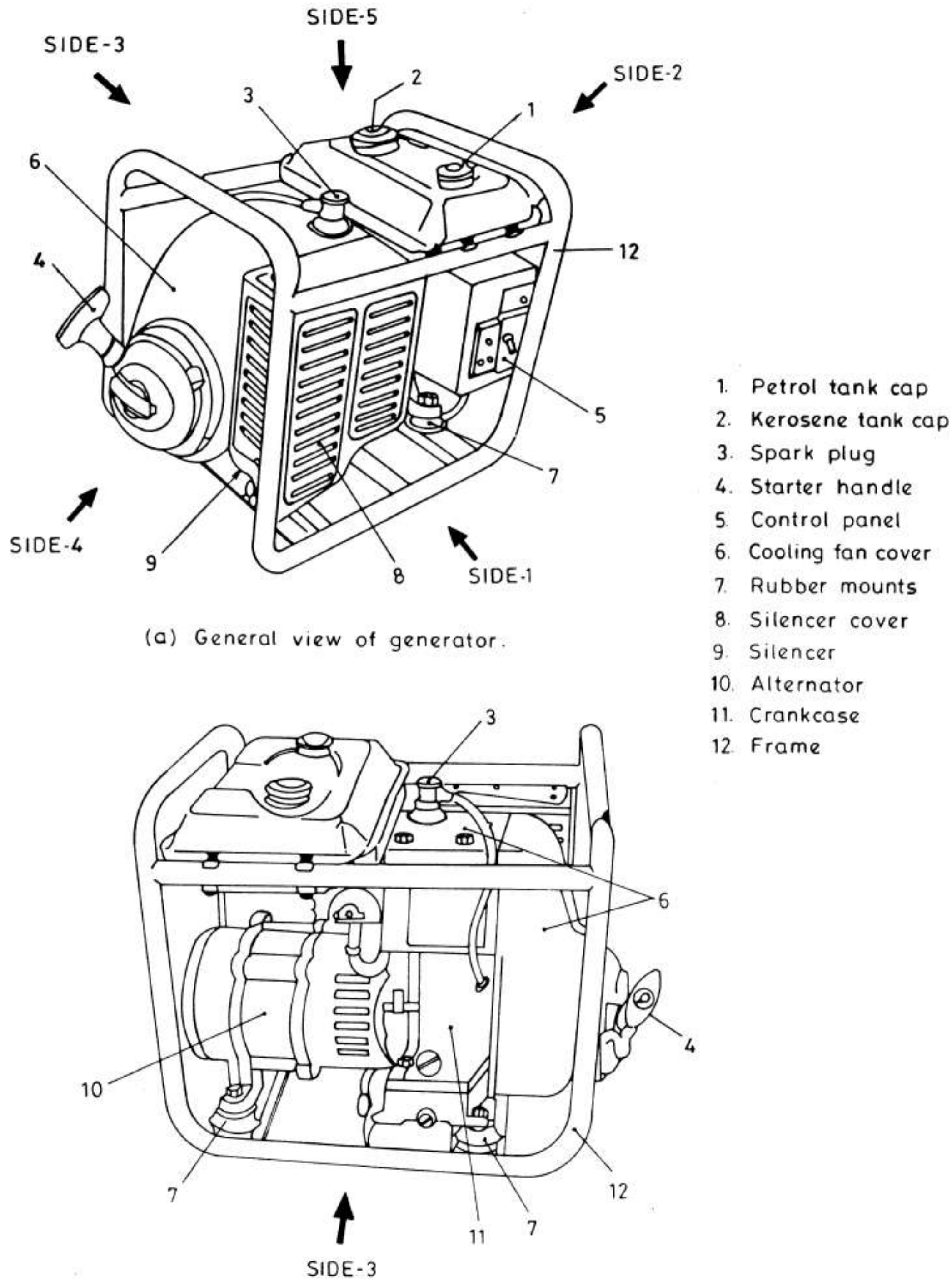
2.11.1 Noise Control from Electric Generators

Although several studies have been conducted towards the reduction of generator noise (Tandon *et al.*, 1998; Cesta and Pedro, 2000; Cesta and Pedro 2001; Parvathi *et al.*, 2003), it was majorly control of noise at the source, while other engineered noise control measures such as control along the propagation pathway and at the receiver of sound have not been explored. The following control techniques were described by Kirk, (1998).

- **At Source**: Isolation of noisy machinery by acoustic enclosures and vibration isolators. Engineering acoustic enclosure design consists of structurally controlling all noise paths at the source. Tandon *et al.*, 1998 discovered that the major noise source in any generator came from the cooling fan cover, silencer shell, silencer cover and the engine crankcase.

- **In The Pathway**: Using acoustic partitions or barriers to block the transmission of noise from source to receiver; applying sound absorbing materials on walls, floors and ceilings of rooms; using baffles on the ceiling. Cuesta *et. al.*, (2000) and (2001) on active control and also optimization of the active control system (steel wall panels) for exhaust noise control from an enclosed generator have been conducted

- **At The Receiver**: Providing an acoustic enclosure for workers when it not feasible to isolate the noisy machine (generator) (WorkSafe, 2009). The use of Hearing protection devices (HPDs) have been advocated if all engineering and administrative controls have failed to control noise.



(b) Generator view looking from alternator side.

Figure 2.3: Parts of a Portable Electric Generator

2.12 Importance of Knowledge and Perception

2.12.1 Knowledge of risk

A lack of knowledge is identified as one of the barriers to change (Grol and Wensing, 2004). Knowledge about occupational hazards (such as noise from electric generator) is suggested to be a predictor of preventive behaviour at work (Cheung, 2004). Consequently, the provision of knowledge of risk to workers through educational intervention was found to be effective in reducing the incidence of a workplace hazard (Porru *et al.*, 1993). Furthermore, an intervention study carried out by (Ferrite and Santana, 2005), demonstrated that knowledge of risk regarding cardiovascular disease was associated with change in risk behavior, which in turn resulted in physiologic changes in risk for cardiovascular disease.

The ideal scenario is optimum worker involvement in any hazard control program. Workers who are knowledgeable about noise hazards are more likely going to change their behaviour regarding hearing protection. Employee actions, in almost all situations, can significantly reduce exposures. The goal should be to make the workers as knowledgeable as practicable (Kahan and Ross, 1994)

2.12.2 Perception of risk

Although knowledge is a necessary factor, it is not a sufficient reason to change individual or collective behaviour. Motivation to change is dictated by a combination of factors (Green and Kreuter, 1991). Effective behavioural change is facilitated by greater knowledge, experience, and personal risk perception (Gregson *et al.*, 1998). Risk perception is the subjective assessment of the probability of a specified type of accident happening and how concerned we are with the consequences (Sjöberg, 2004). Risk perception plays a significant role as a predictor of workers' protective behaviour, such as, use of hearing protection devices (Arezes and Miguel, 2005). Perceived severity and perceived vulnerability and benefits are likely to motivate individuals to take preventive action (Lee *et al.,* 2005).

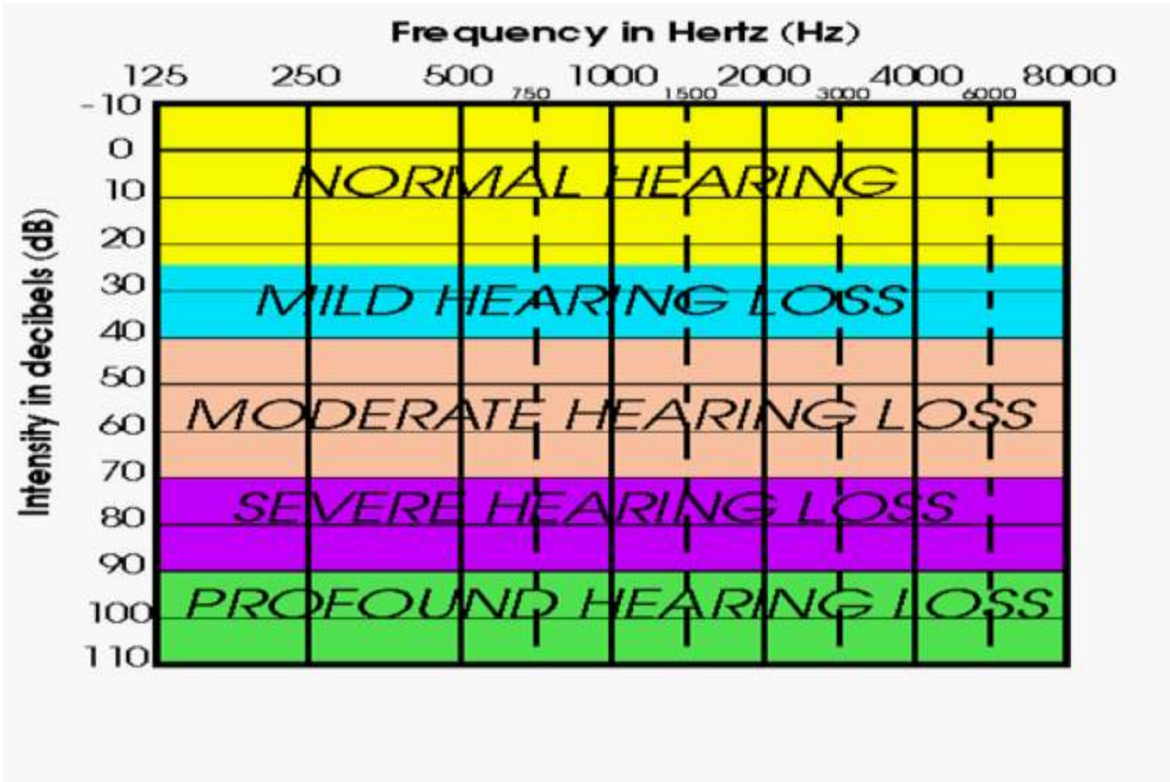
2.13 Hearing loss and Detection

2.13.1 Principles of Audiometry

Hearing is one of the major senses and like vision is important for distant warning and communication. It can be used to alert, to communicate pleasure and fear. It is a conscious appreciation of vibration perceived as sound. The function of the ear is to convert physical vibration into an encoded nervous impulse (Keren *et al.*, 2002). The ears are paired organs, one on each side of the head with the sense organ itself, which is technically known as the cochlea, deeply buried within the temporal bones. Part of the ear is concerned with conducting sound to the cochlea; the cochlea is concerned with transducing vibration. The transduction is performed by delicate hair cells which, when stimulated, initiate a nervous impulse. The sound conducting mechanism of the ear is divided into two parts, an outer and the middle ear, an outer part which catches sound and the middle ear which is an impedance matching device. Keren *et al.*, (2002) defined hearing loss as the inability to perceive and discriminate everyday sounds, including warning signals, speech, and music. Hearing impairments are commonly defined by the severity of the loss across the frequency range: mild (21–40 dB), moderate (41–60 dB), severe (61–90 dB), and profound (>90 dB) (WHO, 1993 and 2001)

2.13.2 Audiometric Test

Pure-tone threshold audiometry is the measurement of an individual's hearing sensitivity for calibrated pure tones. The audiometric test consists of pure tone air conduction threshold testing of each ear at 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. At each frequency, the threshold recorded for the ear is the audiometer's lowest signal output level at which the individual responds (Burk and Wiley, 2004). It is essential that audiometric equipment be calibrated, be functioning properly, and be used in an acceptable test environment to assure accurate test results. The test environment shall meet at all times the specifications detailed in Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms (American National Standards Institute, 2003) The softest sound you are able to hear at each pitch is recorded on the audiogram. The softest sound you are able to hear is called your threshold. Thresholds of 0-25 dB are considered normal (for adults). The audiogram below demonstrates the different degrees of hearing loss.



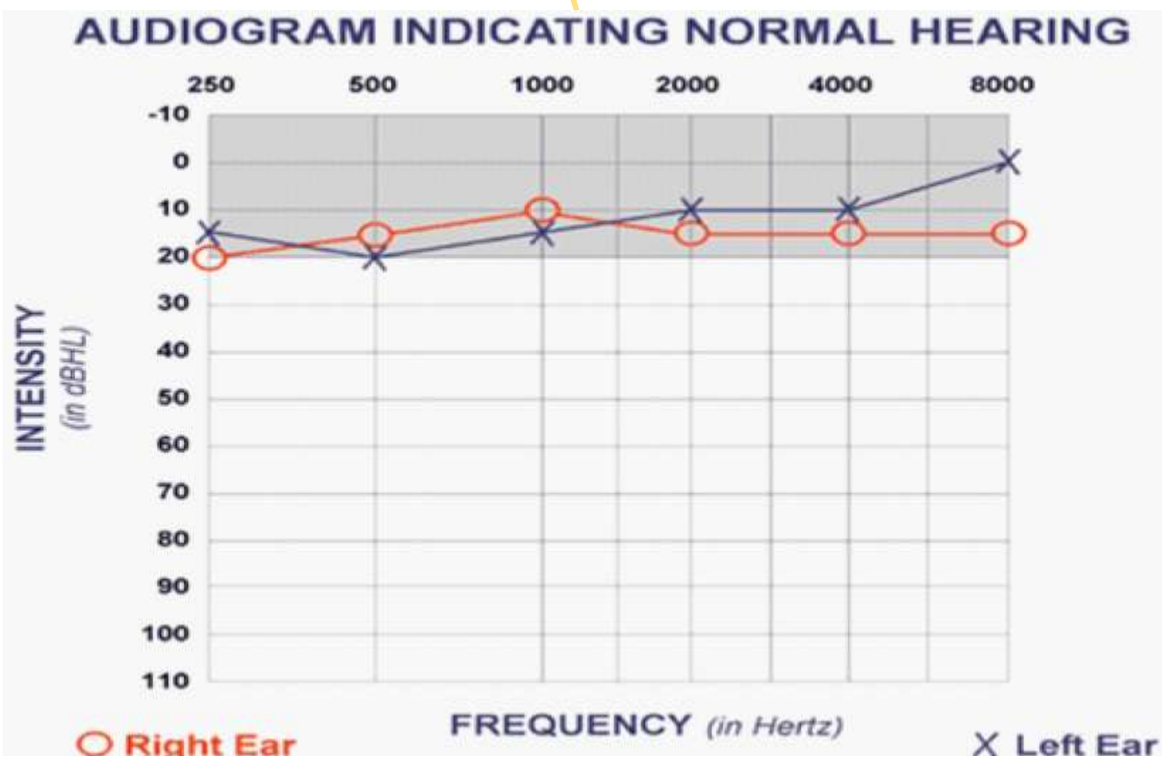


Figure 2.4: Audiogram indicating Normal and Impaired hearing threshold (Go Hear Technology, 2006)

2.13.3 Detection of Noise induced hearing loss

The average person is born with approximately 16,000 hair cells. With the limited clinical ability to detect the beginning stages of NIHL, 30 to 50% of individual's hair cells may have already been damaged before any significant decrease in hearing is detected (Daniel, 2007). The initial damage involves the part of the ear corresponding near 4 kHz which functions as the receptor for high frequency sounds (Kavanagh, 1992). However, continuous noise exposure over time may lead to damage in the part of the ear responsible for both low and high frequency sounds in the range of 2 to 5 kHz, making it difficult to engage in normal conversations. The steep decrease in hearing sensitivity or the presence of a "noise notch" on the audiogram near 4 kHz may indicate hearing loss due to noise.

2.14 Guideline limit for Noise and Hearing impairment

Noise is usually associated with annoyance (Berglund & Lindvall 1995), criteria levels are based on community surveys of people's tolerance to noise. Different types of land uses also exhibit different sensitivities to noise. The World Health Organisation guideline provides values arranged according to specific environments and critical health effects in different community setting. The WHO guideline values consider all identified adverse health effects for the specific environment. An adverse effect of noise refers to any temporary or long-term impairment of physical, psychological or social functioning that is associated with noise exposure (Berglund & Lindvall 1995). Specific noise limits have been set for each health effect, using the lowest noise level that produces an adverse health effect (i.e. the critical health effect).

Although the guideline values refer to sound levels impacting the most exposed receiver at the listed environments, they are applicable to the general population. Other time bases are recommended for schools, preschools and playgrounds, depending on activity. The World Health Organisation recommended the following classification on the basis of the pure tone audiogram taking the average of the thresholds of hearing for frequencies of 500, 1000, 2000 and 4000 Hz. Table 2.5 shows the grading of hearing impairment.

Table 2.4: Guideline values for community noise in specific environments (WHO, 1993)

Specific environment	Critical health effect(s)	LAeq [dBA]	Time base [hours]	L_{Amax} Fast [dB]
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors	Speech intelligibility & moderate annoyance, daytime & evening Sleep disturbance, night-time	35 30		 45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	During class	-
Pre-school bedrooms, indoor	Sleep disturbance	30	Sleeping-time	45
School, playground outdoor	Annoyance (external source)	55	During play	 -
Hospital, ward rooms, indoors	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial shopping and traffic areas, indoors and outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music and other sounds through headphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults) Hearing impairment (children)	- -		140 #2 120
Outdoors in parkland and conservations areas	Disruption of tranquility	#3		

#1: As low as possible.
#2: Peak sound pressure (not LAF, max) measured 100 mm from the ear.
#3: Existing quiet outdoor areas should be preserved and the ratio of intruding noise to naturalbackground sound should be kept low.
#4: Under headphones, adapted to free-field values.

Table 2.5: Grading of Hearing Impairment (WHO, 1993)

Grade of Impairment	Corresponding audiometric ISO value	Performance	Recommendations
0 – No Impairment	25 dB or better (better ear)	No or very slight hearing problems. Able to hear whispers	
1 – Slight (Mild) Impairment	26-40 dB (better ear)	Able to hear and repeat words spoken in normal voice at 1m	Counseling. Hearing aids may be needed.
2 – Moderate Impairment	41-60 dB (better ear)	Able to hear and repeat words spoken in raised voice at 1m	Hearing aids usually recommended.
3 – Severe Impairment	61-80 dB (better ear)	Able to hear some words when shouted into the better ear	Hearing aids needed. If no hearing aids available, lip-reading and signing should be taught
4 – Profound Impairment including deafness	81 dB or greater (better ear)	Unable to hear and understand even a shouted voice	Hearing aids may help understand words. Additional rehabilitation needed. Lip-reading & signing

Grades 2, 3 and 4 are classified as disabling hearing impairment. The audiometric ISO values are averages of 500, 1000, 2000 and 4000Hz

2.15 Summary of Literature review

The unsatisfactory performance of the power sector has triggered the drastic importation of electric generators as alternative sources of electricity. These generators when in use are often characterized by heavy noise pollution. Individuals exposed to these noise levels are capable of developing noise induced hearing loss. NIHL often occurs temporarily in early stages. People may experience a reduction in hearing or less sensitivity to sounds, a phenomenon known as the temporary threshold shift (TTS). After adequate time in a quiet environment, away from the noisy source, people can recover their hearing sensitivity. However, those who are constantly exposed to excessive noise will develop a permanent threshold shift (PTS) or hearing loss.

Hearing loss caused by work-related noise exposure is referred to as occupational noise-induced hearing loss (ONIHL). This phenomenon is widespread in contemporary society and generator users are not isolated from it. The victims of occupational noise induced hearing loss are predominantly adults male and female. There is a dearth of information from literature relating to hearing loss among generator users in Africa, especially with specific reference to Nigeria. Few available data on occupational induced hearing loss are derived from other occupational settings, mainly in developed countries such as America and the United Kingdom. Many of the studies are not generalizable due to limitation in scope and occupational setting, reliance on quantitative data and inability to fully capture the experience of a victim before the onset of hearing loss.

Worldwide, 16% of disabling hearing loss in adults is attributed to occupational noise, ranging from 7% to 21% in various sub regions. The louder the noise the less time it takes to cause disabling hearing loss. Certain risk factors such as age, sex, family income and education which predispose one to hearing loss contribute to the occurrence of occupational induced hearing loss worldwide. Due to the insidious nature of hearing loss, exposed individuals are generally unaware until a large threshold shift has occurred. Some of the perspectives on generator noise attenuation include source reduction, along the pathway and at the receiver. Personal preventive approach which includes use of hearing protection devices (HPDs) such ear plugs and ear muffs. Other preventive methods include regular audiologic evaluation which should be done before, during and after employment. The Nigerian Federal Environmental Protection Agency (FEPA) now under the auspices of National Environmental Standards and Regulation Enforcement Agency (NESREA) has acceptable noise exposure standards for workplace over an eight hour period. However, they are often poorly enforced and implemented, despite having the right to inspect facilities and premises, arrest and prosecute people contravening any laws on environmental standards. The effect of this agency is yet to be fully felt in the field. Various issues on the concept relating to occupational noise induced hearing loss were reviewed and the product of the review was used to guide the study.

Some of the key concepts or variables derived from the literature include the following: generator noise measurement, work environment noise level assessment and audiologic evaluation.

CHAPTER THREE

METHODOLOGY

This section presents issues on the study design, study area and study population, sampling technique, instruments for data collection process and data analysis

3.1 Study design

A cross sectional survey involving onsite observations, noise level measurements, questionnaire administration and human exposure assessment (audiometry).

3.2 Study area

The study was conducted in Agbowo and Ajibode commercial areas of Ibadan. Ibadan which is the capital of Oyo state is an indigenous African city and covers a land area of 12 kilometers radius with mapo hall as the centre. According to 2006 census figure Ibadan which has a population of about 2.6 million is mainly Yoruba speaking; and is made up of 11 local government areas. The population of central Ibadan, including five LGAs, is 1,338, 659 according to census results for 2006. It is located at an altitude ranging from 152-213m with isolated ridges and peaks rising to 247m (Sridhar and Ojediran,1983).

Agbowo area of Ibadan encourages small scale businesses due to the close proximity to the University of Ibadan. It is medium density residential area, located in Ibadan North local government and has a population of about 52,134 (Tomori, 2006). Agbowo has a lot of buildings which total up to 1414 (Tomori, 2006) most of which are used for both commercial and residential purposes. Agbowo occupies an inner city location with its advantage of proximity to the premier University, the University of Ibadan. Ajibode is low density area, located in Akinyele local government, with population size of about 15,577 and 1414 buildings (Tomori, 2006). It is mostly a residential area with very few commercial settings. It is also at close proximity to the University of Ibadan. The particular area of interest was the commercial area of Agbowo and Ajibode where there is high dependence on electric generators.

3.3 Study population

The study participants included all generator users, adults (18 years and above), and working within the selected commercial areas. These business operators who gave their informed consent were allowed to participate in the study. Agbowo and Ajibode were selected based on the results of a preliminary survey conducted to observe the following features:

- Number of electric generators per shop in Agbowo and Ajibode
- Frequency of electric generator use (daily)
- Intensity of commercial activities
- Daily power supply outage (Hours/day for steady electricity)

3.3.1 Agbowo Generator Users

Generator users within Agbowo, who met the eligibility criteria were averaged at three hundred and four (304). They were individuals who possess and rely an electric generator as alternative power source. Agbowo has high level of commercial activity, most of which require steady electric power supply. (see Plate 3.2 for details)

3.3.2 Ajibode Generator Users.

The number of generator users in Ajibode eligible to that participated in the study was two hundred and eleven (211). They were individuals who possess and rely an electric generator as alternative power source (seee Plate 3.1 for details). Ajibode business location is selected for this study because it fits the following criteria:

- Relatively steady electric power supply from PHCN.
- Low commercial activity area

3.4 Sample size determination

A recent study in badan, Nigeria showed that the prevalence of hearing loss among mechanist (resaw, grinding and automobile workers) who were exposed to noise was 26.5%, while that of the control was 2.4% (Enweasor, 2008). The minimum sample size of the study shall be obtained using the formulae:

$$N = \frac{[\, Z_{1-\alpha/2} \sqrt{P_0(1-P_0)} + Z_{1-\beta} \sqrt{P_1(1-P_1)}\,]^2}{(d)^2}$$

where:

$Z_{(1-\alpha/2)} = 1.96$ $\alpha = 5\%$

$Z_{(1-\beta/2)} = 1.28$ $\beta = 90\%$

P_1 = Prevalence of hearing loss in noisy area= 26.5%= 0.265

P_2 = Prevalence of hearing loss in quiet area= 2.4% = 0.024

d = Absolute deviation = 7% = 0.07

N = Sample size

$$N = \frac{[1.96\sqrt{0.265(1-0.265)} + 1.28\sqrt{0.024(1-0.024)}]^2}{(0.07)^2}$$

$$N = \frac{[86.50 + 19.59]^2}{49} = \frac{[106.09]^2}{49} = 229.69 = 230$$

10% of 230, would be added to take care of attrition (no response)

Therefore, N= 230 + 23 = 253

Since the study is a comparative cross sectional design, the sample size would be doubled in order to account for the comparative group and for better precision in the study.

Therfore N= **506**

3.4.1 Classification of Commercial area

Agbowo and Ajibode commercial areas were classified into three locations each to enable easy environmental monitoring process and ensure more validity and reliability of study findings: they are classified under the following headings:

Table 3.1 Classification for Commercial area

Category	**Description of Commercial environment**
AG1 and AJ1	Enclosed commercial environment (EC)
AG2 and AJ2	Roadside commercial environment, close to traffic areas (RSS)
AG3 and AJ3	Single street shops (SSS) or Dispersed Location

3.5 Sampling procedure

The sampling procedure was divided into four phases. Each phase is described as follows:

- *Phase 1*: **Onsite Observation and Generator Characterization**; The environmental noise sources were identified in each categorized location. Traffic density was also estimated based on number of automobiles every 15minutes during the sampling time frame. Number of shops in each categorized location was obtained and 60% of them were picked systematically for generators characterization. See table 3.2 for details.

- *Phase 2*: **Noise Monitoring and Risk Map development**; Noise levels were obtained on Monday, Wednesday and Saturday in each categorized location over a period of 12 weeks. Mean noise levels within sampling time frame of 6-8am, 11am-1pm, and 4-6pm were obtained to identify peak periods for noise. A GPS facility was used to obtain cordinates of noise measurement points to identify high, medium and low risk areas on a google earth software.

- *Phase 3*: **Survey**; Administration of questionnaire to all consenting generator users in Agbowo and Ajibode commercial areas. This was a total of 515 generator users.

Agbowo	211
Ajibode	304
Total	515

- *Phase 4*: **Audiologic evaluation** (to determine hearing status); Generator users who reported daily generator use constituted 40% of the total population in the 2nd Phase (511) were recruited into this phase. See table 3.3 for details

Table 3.2 Proportional distribution of the shops by strata for phase 1

Agbowo	Number of shops	Proportional Allocation (60%)	Sampled shops	Systematic Selection
Location (AG1)	52	$\frac{60 * 105}{100} = 63$	(52*63)/105= **31**	52/31=2
Location (AG2)	31		(31*63)/105=**19**	31/19=2
Location (AG3)	22		(22*63)/105=**13**	22/13=2
Total	**105**		**63**	
Ajibode	**Number of shops**	**Proportional Allocation (60%)**	**Sampled shops**	**Systematic Selection**
Location (AJ1)	27	$\frac{60 * 71}{100} = 47$	(27*47)/71=**16**	27/16=2
Location (AJ2)	31		(31*47)/71=**18**	31/18=2
Location (AJ3)	22		(22*47)/71=**13**	22/13=2
Total	**71**		**47**	

Table 3.3 Proportional distribution of the target population by strata for phase 3

Agbowo	Total Number of Participants	Participants for audiometry (those who reported daily generator use)
Location (AG1)	116	47
Location (AG2)	105	42
Location (AG3)	83	33
Total	**304**	**122**
Ajibode	**Total Number of Participants**	**Participants for audiometry (those who reported daily generator use)**
Location (AJ1)	73	29
Location (AJ2)	67	27
Location (AJ3)	71	28
Total	**211**	**84**

3.5.2 **Eligibility for participation** (Inclusion/ Exclusion)

The major criteria for the selection of the study participants were as follows:

Phase 1:

1 Utilization of electric generator.

2 The shop must be located within the selected commercial area.

3 Voluntary participation in electric generator noise assessment.

Phase 2:

1. Utilization of electric generator
2. Participant must be a full time worker (8-10hours daily) and (6-7days weekly).
3. Participant must have been on the job for no less than six (6)months.
4. Voluntary participation in the survey.

Phase 3:

1. Daily generator use.
2. Absence of previous hearing problem extracted from questionnaire (in phase 1)
3. Participant must not be on ototoxic drugs e.g gentamicin, streptomycin, chloramphenicol (McCombe *et al*, 1992; McCombe *et al*, 1994)
4. Voluntary participation in an audiometery assessment

The rationale behind the eligibility criteria is to reduce the possible influence of confounders and effect modifiers in the study.

Plate 3.1: Cross section of Ajibode Commercial Area

Plate 3.2: Croos section of Agbow Commercial Area

3.6 Identification of Sampling Coordinates and Development of Risk Map

The GPS was obtained from the Department of Epidemiology, Medical Statistics and Environmental Health, College of Medicine University of Ibadan. The GPS is hand-held, battery-powered factory calibrated gamin GPS was used to determine the geographic coordinates of the locations selected in Agbowo (AG1-AG3) and Ajibode (AJ1-AJ3) for noise level assessment. The GPS can provide information 24 hours a day on location, velocity and time in any weather condition anywhere in the world. (see Plate 3.3 for details). The coordinates of the locations which appeared on the display screen of the GPS after signal is acquired from the satellite in space were recorded and then inserted into a Google Earth Software package to develop the risk map. The risk map was interpreted based on the mean noise level measured for each of the classified commercial locations in Agbowo (AG1, AG2 and AG3) and Ajibode (AJ1, AJ2 and AJ3).

High Risk	80 – 90 dB(A)
Medium Risk	70 – 80 dB(A)
Low Risk	60 – 70 dB(A)

Plate 3.3: GPS Facility

3.7 Noise Monitoring

A high quality data logger sound level meter manufactured in the United States of America by AEMC Instruments, with shockproof holster (CA 832) was obtained from the Environmental Health Unit, Department of Epidemiology, Medical Statistics and Environmental Health, Faculty of Public Health, University of Ibadan. It was used to obtain the noise levels in decibels (dBA) generated by electric generators in the two commercial locations (Agbowo and Ajibode). The light weight sound level meter is designed ergonomically for easy hands-on-operation. It measures sound according to the sensitivity of human ear with fast and slow responses using both A and C weighting curves. The electrical signal from the transducer is fed to the pre-amplifier of the sound level meter and, if needed, a weighted filter over a specified range of frequencies. Further amplification prepares the signal either for output to other instruments such as a tape recorder or for rectification and direct reading on the meter. The rectifier gives the RMS value of the signal. The RMS signal is then exponentially averaged using a time constant of 0.1 s ("FAST") or 1 s ("SLOW") and the result is displayed digitally or on an analog meter. See plate 3.4 for more details

3.7.1 Work Environment Noise Level Monitoring

3.7.1.1 Background noise level measurements.

The environmental sound quality produced by the generator source was recorded using the quest sound level meter (SLM) type 2 model 2700. When the measurements were made, the microphone was placed in such a way that it was not in the acoustic shadow of any obstacle in appreciable field of reflected waves. Measurements obtained was compared with the International norms (WHO recommended sound levels) . Three complete sets of sound level measurements were taken:

1. One complete set of measurement before the start of commercial activity (6-8am)
2. One complete set of measurement at the peak of commercial activity (11am - 1pm).
3. One complete set of measurement at the close of commercial activity (4-6pm).

3.7.1.2 Frequency of measurement

The ambient noise levels were determined at two periods of the day after the background levels were obtained at : 6am-8am, 11am-1pm and 3pm-6pm for logistics. The purpose of this periodic determination of noise levels was to identify peak periods for noise levels produced by the power generators in these operational areas. Noise readings were obtained at 10 minute Intervals. The outdoor noise level measurement was carried out for three days weekly for a period of three months for both groups. The process involved:

1. Classification of business area into three districts (AG1-3 and AJ1-3)
2. Five noise measurement points (MP1 to 2MP5) were established in each classified commercial (ASTM, 2008) and noise levels at each point obtained. This was then used to obtain the mean noise level for each classified location (AG1-3 and AJ1-3)
3. Measurement of work environment noise levels at points (MP1 to MP5) were done at three periods of the day for Monday, Wednesday and Saturday. A total of twenty seven (45) noise readings were obtained per day in classified commercial area for a period of three months.
4. The whole process was repeated in Ajibode commercial area.

3.7.2 Noise Level at Worker Position

A sound meter was positioned at 10 and 30cm from the worker's ear to obtain the actual noise level filtering into the ear. The sound level meter was set at slow and measurements were done in A-weighting scale. This was obtained while generator was in operation. Participants selected for audiometry monitoring who also reported daily generator use were featured in this aspect of the survey.

3.7.3 Generator Noise Level Measurement

The noise level produced from generators were measured using a sound level meter placed at about 1.2m-1.5m above the ground surface and 1m distance (Bhattacharya, 1992). Measurements were done in such a way as not to be in the acoustic shadow of any obstacle in the appreciable field of reflected waves. Sound level from generator was obtained while the generator was put on. The sound level meter was set to slow and measurements were done in A-weighting decibel mode. See plate 3.2 for details.

Plate 3.4 Sound level meter

3.8 Determination of Generator Distance

The measuring stick was used to determine the distance of the generators from the position of the worker and also the dimension of the shops studied. The measurment obtained was in meters. After every measurement the scale was returned to zero (0) before another measurement was obtained. See plate 3.3 for details

Plate 3.5 Generator to worker distance measurement

3.10 Survey

3.10.1 Questionnaire

The questionnaire was administered to the total number of generator users in both Agbowo (304) and Ajibode (211). A semi structured questionnaire was used to collect quantitative data on occupational noise from selected respondents. The design of the questionnaire was done through extensive literature review. It was grouped under six sections labeled A-E (see appendix II). Section A contained the sociodemographic characteristics of respondents. Information on respondent's pattern of generator use was documented in section B. The knowledge on health hazards associated with generator noise was assessed in section C. The respondents' perception to risk associated with exposure to generator noise was documented in D. Section E addressed respondents' health auditory condition prior to the study.

3.10.2 Validity and reliability of the questionnaire

After development of questionnaire, it was pre-tested among business operators in Ajose building in UCH, Ibadan. Several amendments were made to the questionnaire after which they were pre-tested in a pilot study among participants with similar characteristics among business operators in the student union building in University of Ibadan, Ibadan. In the pretest, the questionnaire was administered to 10% of the sample size of the study population (i.e. 40 respondents). The Cronbach's Alpha method was used to determine the reliability of the questionnaire. An Alpha coefficient of 0.5 and above is indicative of the reliability of the questionnaire. The closer the value of the alpha coefficient is to 1 the more reliable the questionnaire. The Alpha coefficient obtained from the analysis of the pre-test was 0.75, an indication that the questionnaire was reliable.

***Knowledge Information Section*:** The knowledge information section comprised of 17 questions and they were scored thus:

Total knowledge scale: 17

Maximum score: 1 and Minimum score: 0

Good Knowledge: $\geq 50^{th}$ percentile (9-17)

Poor Knowledge: $< 50^{th}$ percentile (0-8)

Perception Information Section: The perception information section comprised of 8 questions and they were scored thus:

Total perception scale: 8

Maximum score: 1 and Minimum score: 0

Positive perception: ≥ 50th percentile (5-8)

Negative perception: < 50th percentile (0-4)

3.10.3 Onsite Observations

An environmental exposure assessment form was designed and developed, and was used for the study. It was divided into two sections. Section A captured basic measurements pertaining to the generator characteristics (Type, Age, Model, environmental noise produced from generator when in operation and number of generators (according to the ASTM (2008) protocol which is given by:

- High : ≥25 generators and Low: <25 generators
- Noise sources within a 5m radius of each other would be categorized as (High), while the presence of these noise source at greater than 5m would be categorized as (Low).

Furthermore, onsite observation of noise attenuation technique: "placement", "generator enclosure" and "distance of generator to worker" would be documented based on:

Placement	Indoor or Outdoor
Generator enclosure	Enclosed or Not Enclosed
Distance of generator to worker	<5m or Greater than 5m

- Generator condition was also observed and was rated as either poor or good based on the following criteria:

Condition	**Characteristics**
Poor	Leaking exhaust, exposed engine surfaces,noise from other surfaces and oil leakages.
Good	Opposite of above

3.10.4 Traffic Density

The number and type of automobiles was obtained manually by counting the number of vehicles within an interval of 15min for one hour in Agbowo and Ajibode commercial areas. This was done for within each sampling time frame (6-8am, 11am-1pm, and 3-6pm). The number of automobiles for a 15min time period is then multiplied by 4 to obtain the traffic density for one hour for a particular sampling time frame (Abam, 2001). This is then compared with the standard set by (Ozkurt and Camci, 2009). The traffic density is calculated as the number of vehicles or automobiles over the time as shown below:

$$Density_i = \frac{V_i}{T}$$

$Density_i$: Traffic density of vehicles type i

V_i: Number of vehicle type i that passed the road in time period T

T: Time period

The classification of traffic density was given by:

Category	Cars/minute	Cars/hour
High Traffic	>40	>1600
MediumTraffic	10 - 39	400 - 1600
Low Traffic	<10	<400

Source: Ozkurt and Camci, 2009

3.11 Audiometric Test

The audiometry was conducted using a high quality MAICO SCREENING AUDIOMETER MA27 manufactured by Maico Instrument, USA . It was properly calibrated fulfilling the international organization for standardization (ISO- 389) criteria for audiometric testing (ISO 389, 1991). The audiometer is made up of an ear phone , a frequency analyzer and a sound sensor. (see Plate 3.6 for details). Audiologic measurements were recorded in blue and red biro. The blue pen was for the right ear, while the red pen was for the left ear. An audiometric assessment form was used for each participant.

A pure tone audiometry (air conduction threshold) for both ears was carried out on 40% of the participants (as described in table 3.2) and at different sound frequencies in ascending order as follows: 0.5kHz, 1, 2, 3, 4, 6, and8 kHz and then in descending order to 0.5kHz following the Institute for Occupational Safety and Health (IOSH) requirements. Frequency spectrum calibration in decibel was done to fulfill the International Organization for Standardization (ISO 8253-1) for audiometric testing environment (ISO, 1991). Approximately 206 consenting participants participated in audiometric test.

3.11.1 Procedure for Audiologic Evaluation

The audiometer consists of four parts namely; oscillator (used to change the frequency of sounds heard), an audio amplifier, an attenuator (used to control volume loudness), and a pair of headphones. The amplitude of a tone is slowly increased until the person hears the sound. Afterwards the sound is reduced by 10dB and then increased by 5dB. This is done continously until the person is able to identify the lowest sound he/she can perceive (threshold limit). The person is asked to give a sign such as raising the hand once the sound is heard. (see Plate 3.7 for details). Pitch is changed using the oscillator.The result of a hearing test is plotted on a audiogram form and the graph at a glance gives the hearing status of a person. The graph gives a profile of the person's threshold of hearing. It compares the profile to a line representing normal hearing in order to detect hearing loss.

Plate 3.6 Maico Audiometer

Plate 3.7: Audiologic evaluation of a respondent

3.12 Statistical Analysis and Data Management

The questionnaires were checked for completeness and serial numbererd to ensure easy identification and recall. The data was sorted, edited and coded manually. The questionnaire was imputed into a file structure while the analysis was carried out using the Statistical package for social science (SPSS) software version 15. The quantitative data were analyzed using descriptive statistics, chi-square test, Pearson correlation and logistic regression. The results are presented using tables, pie charts and bar graphs.

T-test was used to compare mean noise levels between Agbowo and Ajibode business area and the WHO recommended standard. ANOVA was used to determine the statistical difference between noise levels across the businee districts and across the time of measurement. A noise map was developed from noise survey using coordinates from the GPS with Geographical Information System software of goggle. Noise levels were summarized usind descriptive statistics (proportions, means, standard deviation, bar graphs, and frequency tables). Percentile was used to summarize the knowledge and perception of respondents.

An audiogram was used to record audiometric result. Graph was ploted using red and blue which represented the right and left ear respectively. Audiogram sheets were attached to the questionnaire of respondents. Pure tone average of respondents was computed using the average of sound level of three specific frequencies viz: 0.5 KHz, 1 kHz and 2 kHz. Pure tone average of respondents was ranked into impaired and normal hearing using the following scale:

- Impaired hearing = pure tone average >25dB
- Normal hearing = pure tone average <25dB

Audiometric results were analyzed using descriptive statistics and inferential statistics. The results are presented in tables, line graphs and bar graphs. Hearing status was also correlated with respondents “age”, “years at work” and “Noise at workers position”.

Finally, Inferential statistics such as (Chi-square (X^2) was used to test for association between qualitative variables such as knowledge, perception and hearing status. While Simple logistic regression was used to control for any confounding effect related to ;age, sex, duration at work and business location (Agbowo and Ajibode). The odds of developing hearing loss at Agbowo was obtained from the logistic regression, after controlling for confounders.

3.10 Ethical Considerations

The ethical principles guiding the use of human participants in research were taken into consideration in the design and conduct of the study. Ethical approval was provided by Joint University of Ibadan and University College Hospital (UI/UCH) Ethics Review Committee (see appendix V) for the letter of approval). Permission was obtained from the chairman of the Agbowo and Ajibode business centres association.

Participation in the study was made voluntary and informed consent was obtained from each participant involved in the study (See appendix IV). Each participant was provided with information about the focus of the study, objectives of the study, study methodology, inconveniences that might be experienced and the potential benefits of the study to society. Participants involved in audiologic evaluation were guided through the process and were given the option to pull out of the evaluation process at any time, without any repercussion. No identifier such as name of participants was required and all information provided was kept confidential.

CHAPTER FOUR

RESULTS

This chapter presents the general information about the commercial locations (GPS location and shop characteristics) as well as results of the Generator characteristics (type, model, noise levels and age), questionnaire survey (socio-demographic characteristics, occupational characteristics, pattern of generator use, knowledge of hazards associated with generator use, perception of risk associated with exposure to generator noise, health effects experienced by persons exposed to generator noise . The audiometric (pure tone: air conduction) results of participants is also presented**.**

4.1 General Description of the Commercial Environment

The two commercial environment (Agbowo and Ajibode) where the study was carried out were located in high and low commercial activity areas of Ibadan. Agbowo area is characterized by high commercial activity due its closeness to an academic instituition. It is also located close to peculiar sources of noise which the business people are exposed to. In addition, due to the erratic power supply and the high demand for electricity, most of them have opted for electric generator as alternative source of power. These machines emitt high amounts of sound and are used mainly at close proximities to the users. Although Ajibode is close to the University of Ibadan, is was characterized by low commercial activity. It is also located close to peculiar noise sources like traffic, music outlets and electric generators. There is low utilization of electric generators due to the relatively steady supply of electricity.

The general information obtained from Agbowo and Ajibode commercial areas indicate that all the respondents selected from the shops in each area were mixed (males and females). Agbowo recorded the highest population of generator users. The average window and door size of the shops was recorded for both commercial areas. Agbowo and Ajibode were located close to other environmental noise sources. These sources were identified using an observational checklist. See Table 4.1, 4.2 and figure 4.4 and 4.5 for details

Table 4.1: General information about the shops in Agbowo and Ajibode

Commercial Location	Agbowo	Ajibode
Number of shops	105	71
Generator Users	304	211
Shop owners	Mixed	Mixed
Major noise source	Traffic, Electric generators Music recording houses	Traffic

***Mixed: Male and Female**

Table 4.2: Mean Area and dimensions of shops studied

Business districts	Windows (m) Mean(LxB)	Door (m) Mean(LxB)	Shop (m) Mean(LxB)	Distance of shop to traffic (Mean ± SD)
Agbowo	1.26×1.07	1.83×1.31	3.43×2.92	13.29±5.33
Ajibode	1.12×0.77	1.94×1.22	2.86×2.52	3.42±2.42

4.2 Characteristics of Electric Generators

4.2.1 Trade Name of Electric Generators

A total of 110 electric generators were sampled from 110 respondents, which comprised 50 in Ajibode and 60 in Agbowo. Tiger electric generators was the most common brand used by respondents in Agbowo (20%) and Ajibode (32%). This was followed by Elepaq generator (Agbowo: 18.3% and Ajibode: 20%), Sumec generator (Agbowo: 15% and Ajibode: 18%) Yamaha (Agbowo: 16.7% and Ajibode: 5%). Sifang diesel generators were more in number in Agbowo (21.7%) than Ajibode (4.0%). See Figure 4.1 and 4.2 for details

4.2.2 Electric Generator power category

The generators were categorized according to the three major sizes. Out of the 63 generators sampled in Agbowo; 9(14.3%) were small, 40(63.5%) were medium sized and 14(22.2%) were large. In Ajibode; 36(76.6%) were small, 9(19.1%) were medium sized and 2(4.3%) were large. See Figure 4.3 for details

4.2.3 Noise Level from Electric Generators

Ambient noise levels of electric generator and when in operation were measured. A total of 110 electric generators were sampled while in operation and this comprised 63 generators in Agbowo and 47 generators in Ajibode. Measurements were done in decibel (dBA). The mean noise level produced by generators in Agbowo and Ajibode were 100.5 ± 7.5 dB(A) and 91.2 ± 4.8 dB(A) respectively. Diesel generators were more in Agbowo (60%) as compared to Ajibode (10.0%) and contributed to the overall noise burden in Agbowo (106.3 ± 6.92 dB(A)) as compared to petrol generators (94.1 ± 6.3 dB(A)) See table 4.3a and 4.3b for details.

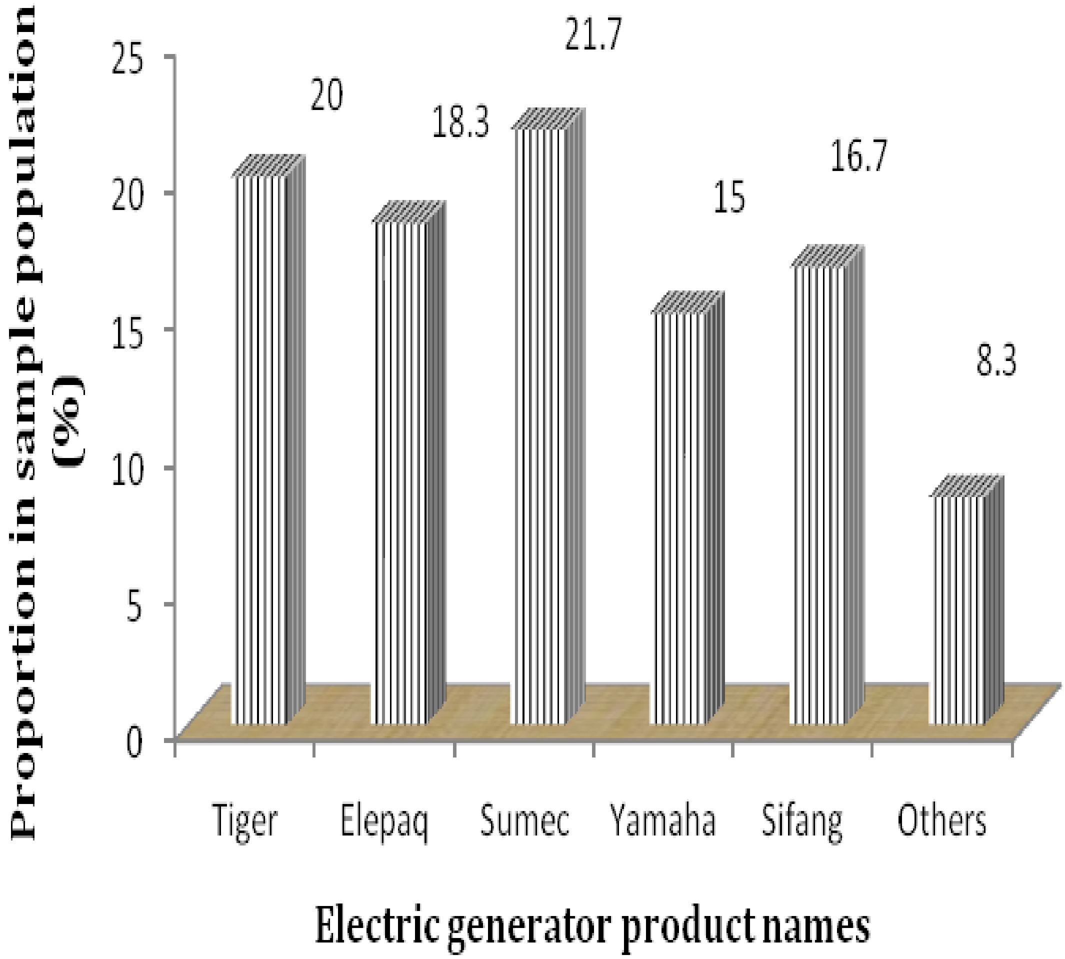


Figure 4.1 Major Brands of Electric Generators used by Respondents in Agbowo

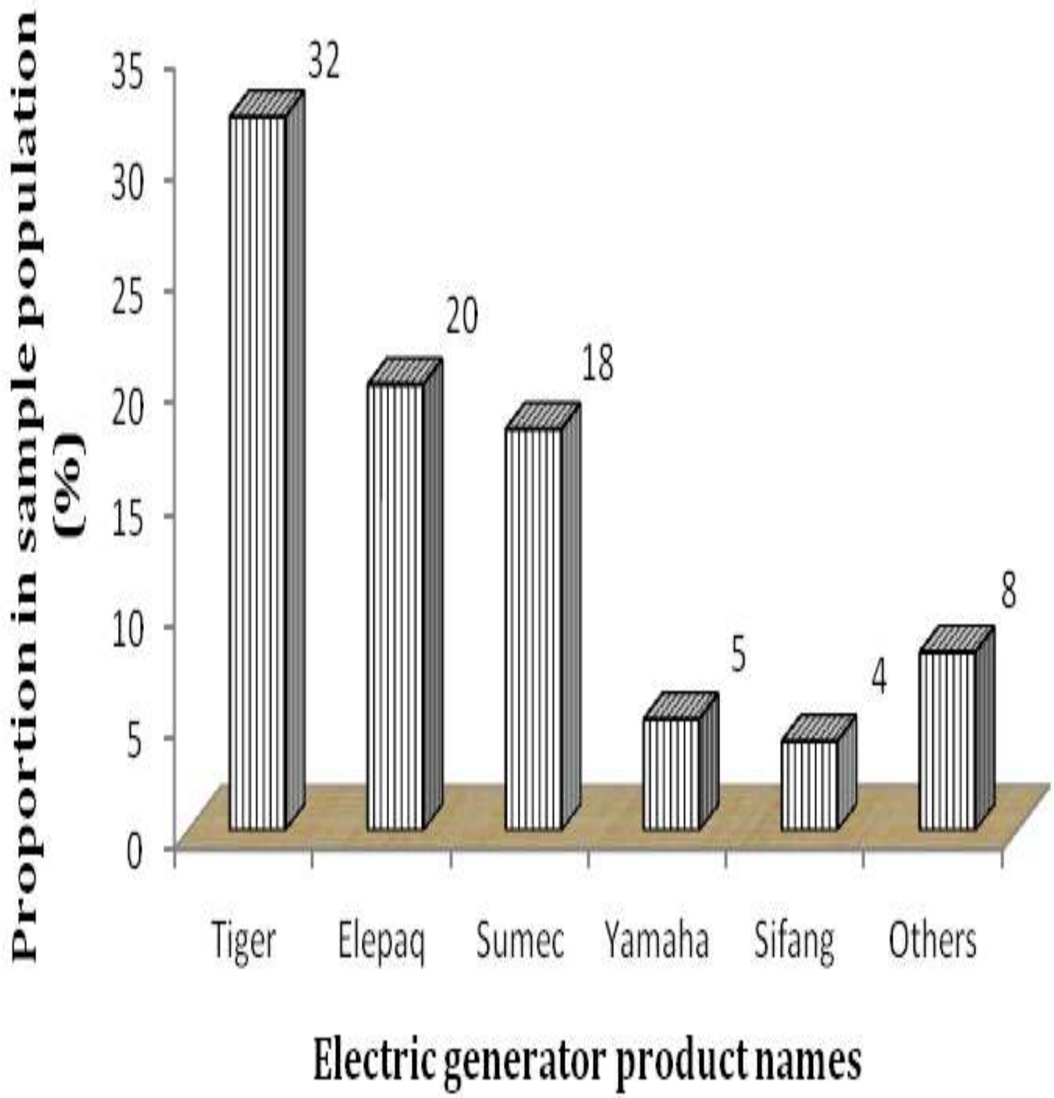


Figure 4.2 Major Types of Electric Generators used by Respondents in Ajibode

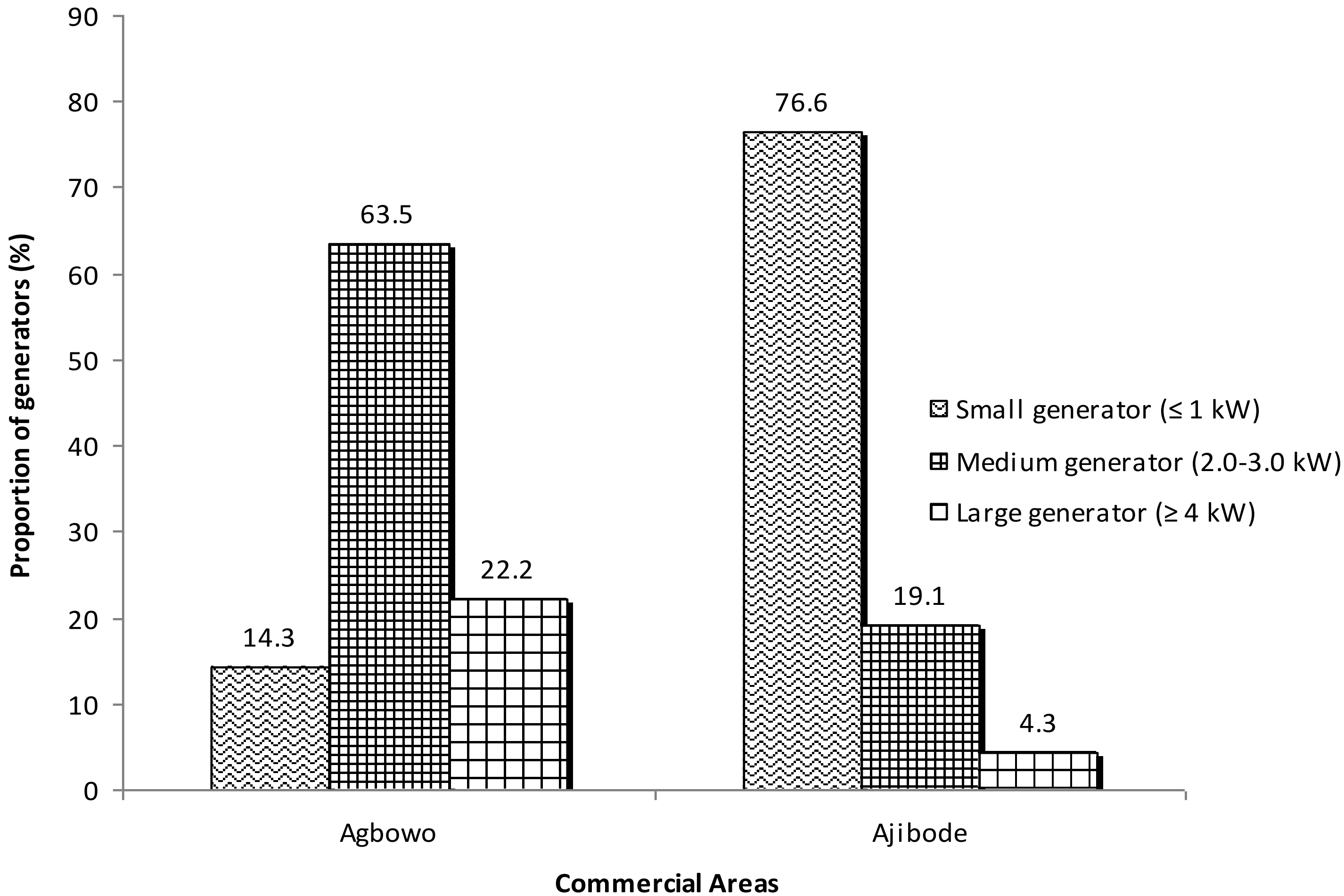


Figure 4.3 Electric Generator engine type used in Ajibode and Agbowo

Table 4.3a Background Noise Levels when Electric Generator is in off mode.

Business Location	Cases	Noise levels (dBA)			
		Mean	Standard Deviation	Minimum	Maximum
Agbowo	60	68.9	5.9	56.7	98.7
Ajibode	50	58.5	4.2	50.0	69.8

Table 4.3b Background Noise Levels when Electric Generators are in operation

Business Location	Cases	Noise levels (dBA)			
		Mean	Standard Deviation	Minimum	Maximum
Agbowo	60	100.5	7.5	86.90	121.00
Ajibode	50	91.2	4.9	84.50	107.2

4.3 Onsite Observations

4.3.1 Generator Condition and Noise Attenuation practices

There was a significant difference in the conditions of generators in Agbowo and Ajibode ($p<0.05$). Generators in Agbowo 45(76.3%) that were categorized as poor conditioned were significantly higher than poor conditioned generators in Ajibode 14(23.7%) (See Plate 4.1 for details). There was a statistically significant difference in the noise attenation technique observed in Agbowo and Ajibode ($p<0.05$). Generator attenuation technique was observed using a checklist. In Ajibode over half 12(60.0%) of the respondents enclosed their electric generator as compared to Agbowo 8(40.0%) (See Plate 4.2 for details).

Majority of the respondents in Ajibode 26(63.4%) place their electric generator at greater than 5m from their place of work as compared to Agbowo 15(36.6%). Few respondents in Ajibode 9(18.4%) as compared to Agbowo 40(81.6%) place their electric generators at less than 5m from workplace. None of the respondents was observed using proper hearing aid.

4.3.2 Environmental Noise Sources in Classified Locations

In Ajibode, all three classified locations (AJ1-3) recorded low number of generators as compared to Agbowo where AG1 and AG2 recorded the presence of greater than 25 generators. Other noise sources such as music recording houses, automobile and motorcycles and religious centres showed variation in their numbers across the classified locations in Agbowo and Ajibode commercial areas. See Table 4.4 and 4.5 for details.

Table 4.4a: Onsite Observations

Onsite Observations	Ajibode (%)	Agbowo (%)	Total (%)	p-value
Generator Noise Attenuation				
Enclosed	12(60.0)	8(40.0)	20 (100)	0.000 ($p<0.05$)
Distance < 5m	9(18.4)	40(81.6)	49(100)	
Distance <5m	26(63.4)	15(36.6)	41(100)	
Generator Condition				
Poor	14 (23.7)	45(76.3)	59(100)	0.000 ($p<0.05$)
Good	33(64.7)	18(35.3)	51(100)	

Table 4.4b: Characteristics of Environmental Noise sources

		Agbowo	Ajibode
Noise Source	Number of Generators	+++	++
	Number of Music recording houses	++	++
	Traffic Volume	++	+
	Number of Religious centres	+	+
Generator Enclosure	Not Enclosed	+++	++
	Enclosed	+	+
Generator Engine Type	Petrol	++	+++
	Diesel	+++	++
Hearing aid use		-	-
Generator age	<6months	+	++
	>6months	+++	+

+++: Highly present, ++: Moderatly present, +: Present, -: Absent

Plate 4.1: Poor conditions of Electric Generators

Plate 4.2: Exposed engine generators

Table 4.5 Major Sources of Environmental Noise in Classified locations in Agbowo and Ajibode

Commercial Area	Location	Number of electric generators	Sources of Noise		
			Car	**Music Recording Houses**	**Motorcycles**
Agbowo	**AG1**	≥ 25	Low	High	Low
	AG2	≥ 25	High	None	High
	AG3	< 25	Low	Low	Low
Ajibode	**AJ1**	< 25	None	Low	None
	AJ2	< 25	Low	None	High
	AJ3	< 25	Low	High	Low

KEY:

Generator [High Generator Number: ≥ 25, Low Generator Number: < 25] (ASTM, 2008)

Noise Sources (Cars, Music Recording Houses and Motorcycles); High: >5m radius, Low: ≤5m (ASTM, 2008)

4.4 Geographical Cordinates showing sampling Locations and risk areas

Each Commercial area (Agbowo and Ajibode) was classified into three (3) locations. Onsite noise level measurement were determined at three periods of the day (6am-8am, 11am-1pm and 3-6pm) for measurement points (MP1, MP2, MP3, MP4, and MP5) in each of the classified commercial locations (AG1-3 and AJ1-3). The global Positioning system(GPS) facility was used to determine all the coordinates of the measurements points (MPs) (See Appendix XI and XII). The noise levels of MPs and the coordinates were used to develop a risk map showing high, medium and low risk areas based on noise levels obtained. See Appendix IX, X and Plate 4.3 and 4.4 for details.

4.5 Noise Levels at Agbowo

The mean noise level in Agbowo was 78.5 ± 3.9 dB(A). (See Figure 4.4 for details). The mean noise level between the various time periods (6-8am, 11-1pm and 3-6pm) were 68.9dBA, 84.4dBA and 75.9dBA respectively and were significantly different ($p<0.05$). All the noise levels measured within the 3 periods for all the sampling points in Agbowo had a mean noise level of 78.5dB which exceeded the World Health Organization (WHO) guideline limit of 70dB for commercial environments (indoor and outdoor). The highest noise level being observed at 11am – 1pm. Maximum and minimum noise levels were observed for the various time periods: (6am-8am: 56.7dBA-98.7dBA); (11am-1pm: 68.5dBA-101.4dBA) and (3pm-6pm: 61.6dBA-93.7dBA) respectively, with all the maximum values above the WHO guideline limit for commercial environment . See Table 4.8 for details

4.6 Noise Levels at Ajibode

The mean noise level in Ajibode was 59.7 ± 4.4 dB(A). (See Figure 4.4 for details)The mean noise level between the various time periods (6-8am, 11-1pm and 3-6pm) were 58.5dBA, 69.9dBA and 67.6dBA respectively and were significantly different ($p<0.05$). All the noise levels measured within the 3 periods for all the sampling points in Agbowo had a mean noise level of 59.7dB which did not exceed the World Health Organization (WHO) guideline limit of 70dB for commercial environments (indoor and outdoor). The highest mean noise level

(69.9dBA) was measured at 11am – 1pm. Maximum and minimum noise levels were obtained for the various time periods: (6am-8am: 50.0dBA-69.8dBA); (11am-1pm: 59.5dBA-86.0dBA) and (3pm-6pm: 50.1dBA-82.1dBA) respectively, with all the maximum values above the WHO guideline limit for commercial environment, except for 6-8am . see Table 4.7 for details. Multiple comparison of mean noise levels showed that there was a significant difference between locations, with Agbowo having a higher noise level of 84.4dB as compared to 69.9dB in Ajibode obtained at 11-1pm. This time period was identified as the peak period when all generators are in operation. See Table 4.8 for details

4.7 Noise levels at Worker position

The noise levels that the workers were exposed to were measured at the three time frames (6-8am, 11-1pm and 3-6pm) . The mean noise level were otained and compared with WHO guideline limit. The workers at Agbowo were exposed to mean noise level of 81.0dBA which exceeded the WHO guideline limit of 70dBA. The maximum and minimum values ranged from 63.6 dB(A) to 99.2 dB(A). In Ajibode, workers were exposed to mean noise level of 62.5 dBA which was below the WHO guideline limit of 70dBA. The maximum and minimum values ranged from 60.0 dB(A) to 82.7 dB(A)See Table 4.8 for details. The proportion of respondents exposed to noise levels above the WHO guideline limit was 85% and 27.2% in Agbowo and Ajibode commercial areas as compared to 15% and 72.8% of respondents who were exposed to noise levels below the guideline limit. See Figure 4.9 for details

Plate 4.3: Risk Map for Generator Users in Agbowo Commercial Environment

KEY:

Risk Category	Risk Symbol	Range dB(A)	Sampling Points	Classified Locations
High Risk		>80dB(A)	Shops in Enclosed Complex (EC)	Agbowo 1 (AG1)
Medium Risk		70 – 80 dB(A)	Road Side Shops (RSS)	Agbowo 2 (AG2)
Low Rish		60 – 70 dB(A)	Single Street Shops (SSS)	Agbowo 3 (AG3)

Plate 4.4: Risk Map for Generator Users in Ajibode Commercial Environment

KEY:

Risk Category	**Risk Symbol**	**Range dB(A)**	**Sampling Points**	**Classified Locations**
High Risk	H	>80dB(A)	Road Side Shops (RSS)	Ajibode 2 (AJ2)
Medium Risk	M	70 – 80 dB(A)	Single Street Shops (SSS)	Ajibode 3 (AJ3)
Low Rish	L	60 – 70 dB(A)	Shops in Enclosed Complex (EC	Ajibode 1 (AJ1)

Table 4.6: Summary of noise levels across the time frame in Agbowo and Ajibode Commercial Areas

Business Location	Time Frame	Noise Level dB(A)				p-value
		Mean	Standard Deviation	Minimum	Maximum	
Agbowo	6am – 8am	68.9	5.9	56.7	98.7	p<0.05
	11am – 1pm	84.4	8.7	68.5	101.4	
	4pm – 6pm	75.9	6.4	61.6	93.7	
Ajibode	6am – 8am	58.5	4.2	50.0	69.8	p<0.05
	11am – 1pm	69.9	4.6	59.5	86.0	
	4pm – 6pm	67.6	7.9	50.1	82.1	

Table 4.7 Mean noise level at workers position

Business Area	Noise level dB(A)				p-value
	Mean	Standard deviation	Minimum	Maximum	
Agbowo	81.0	8.74	63.6	99.2	p<0.05
Ajibode	62.5	4.65	60.0	82.7	

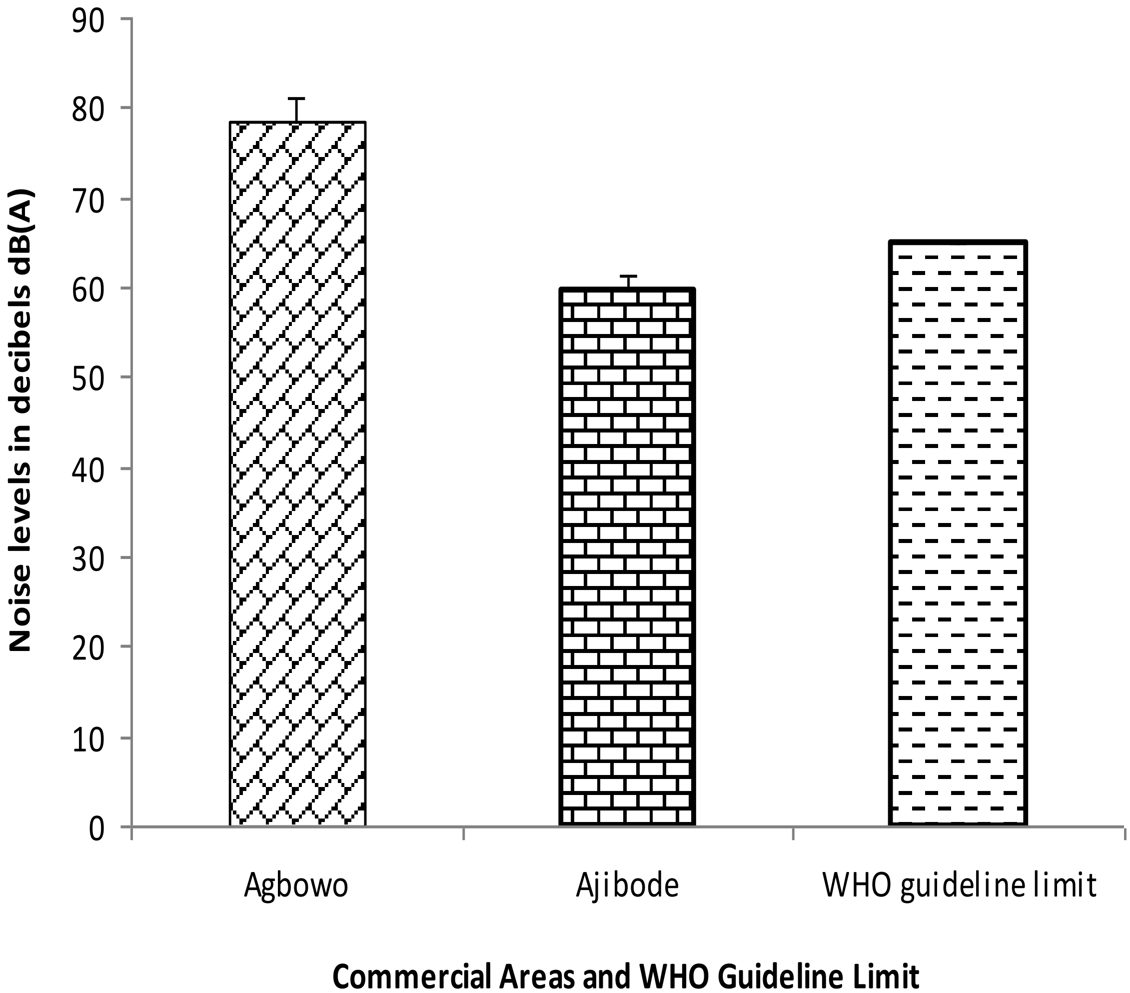


Figure 4.4: Mean Noise Levels in Agbowo and Ajibode showing standard errors in comparison with WHO guideline limit

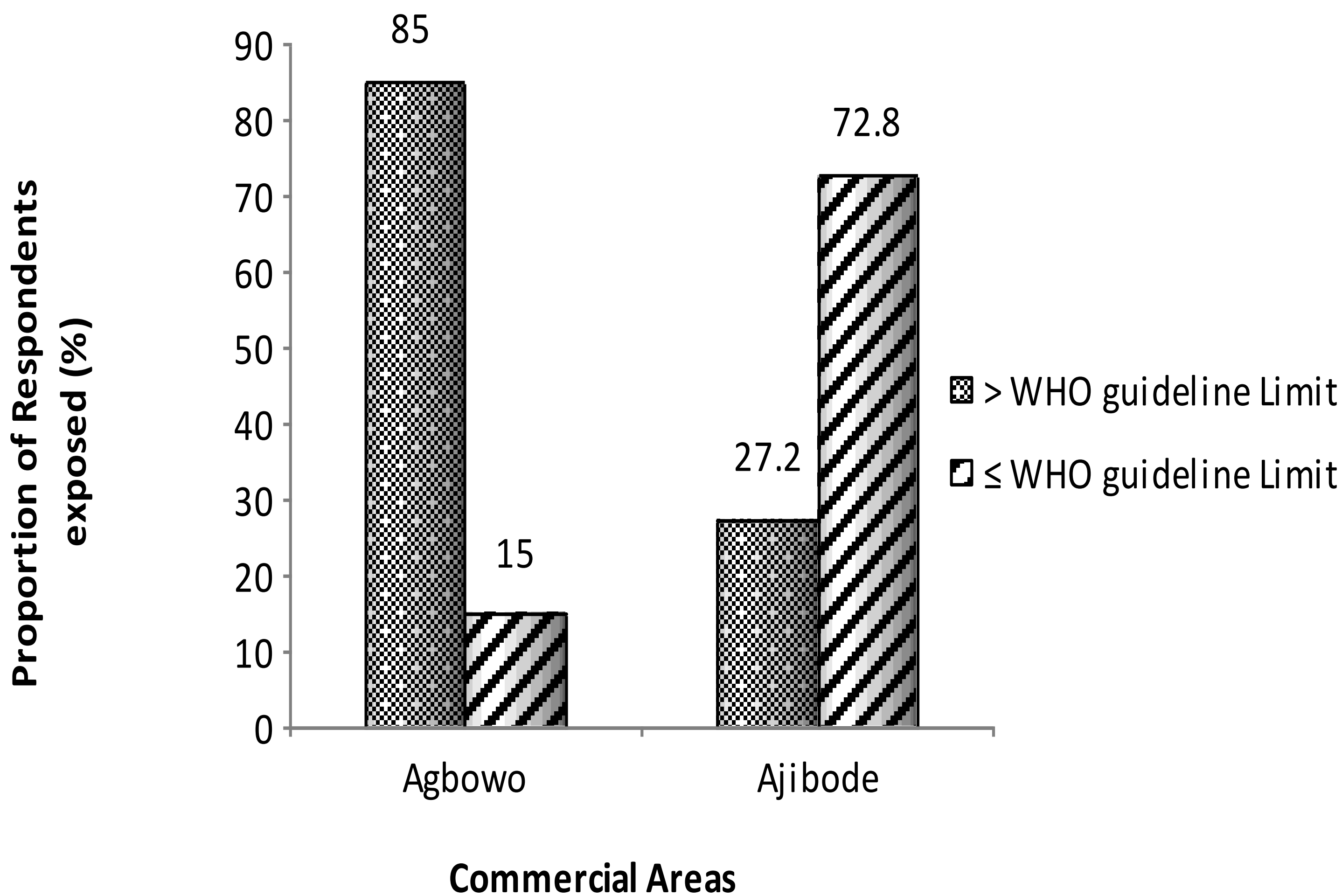


Figure 4.5: Proportion of Respondents in Agbowo and Ajibode exposed to noise levels above the WHO guideline limit

4.8 Traffic Density

A significant difference in the number of vehicles across the sampling time frame were observed for Agbowo and Ajibode commercial areas respectively. Generally, Agbowo had high traffic counts/hour (2760, 3175, 3992) across the sampling time frame as compared with medium range traffic counts/hour in Ajibode (804, 819, 694).

In Agbowo, Motorcycles inreased across the sampling time frame: [951.6 ± 483, 1397.1 ± 651.6, 1571.4 ± 789.6], a similar trend was observed in the number of Cars in Agbowo [1423.4 ± 705.6, 1829.8± 514.1, 2001.2± 554.2]. The reverse was the case for trucks and buses: [32.9± 20.1, 84.9± 50.71, 47.6± 24.2] and [351.7± 135.7, 403.8± 167.8, 373.4± 125.0].

In Ajibode, cars [564.2± 221.4] were higher in the morning when compared to motorcycles [201.7± 69.7], buses [22.9± 10.5], and truck [15.4± 7.9]. At 11-1pm, motorcycles were higher in number [550.5± 201.2] as compared to cars [177.3± 60.9], trucks [33.7± 14.9] and buses [57.9± 20.6]. At 3-6pm, cars [409.8± 150.6] were higher when compared to motorcycles [229± 150.7], truck [40.8± 26.2] and buses [20.7± 12.8]. See Table 4.10

Table 4.8: Traffic Counts (density) during sampling period

LOCATION	TYPES	6am – 8am		11am – 1pm		4pm – 6pm		p-value
		Mean	SD	Mean	SD	Mean	SD	
Agbowo	**Motorcycle**	951.6	482.3	1397.1	651.6	1571.4	789.6	P=0.000 $p<0.05$
	Cars	1423.4	705.6	1829.8	514.1	2001.2	554.2	
	Truck	32.9	20.1	84.9	50.71	47.6	24.2	
	Buses	351.7	135.7	403.8	167.8	373.4	125.0	
Ajibode	**Motorcycle**	201.7	69.7	550.5	201.2	222.9	150.7	P=0.000 $p<0.05$
	Cars	564.2	221.4	177.3	60.9	409.8	150.6	
	Truck	15.4	7.9	33.7	14.9	40.8	26.2	
	Buses	22.9	10.5	57.9	20.6	20.7	12.8	

SD: Standard deviation

4.9 Background Noise levels

4.9.1 Morning Noise readings (6-8am)

The highest mean noise levels recorded in Agbowo (70.5 dB) and Ajibode (60.8 dB) were obtained on Saturday and Wednesday respectively. Lowest mean noise levels measured in Agbowo (61.8 dB) and Ajibode (53.7 dB) were both obtained on Monday. See figure 4.6 for details

4.9.2 Midday Noise readings (11am-1pm)

The highest mean noise levels recorded in Agbowo (93.7 dB) and Ajibode (90.3 dB) were obtained on Wednesday and Saturday respectively. Lowest mean noise levels measured in Agbowo (81.4 dB) and Ajibode (72.9 dB) were obtained on Saturday and Wednesday respectively. See figure 4.7 for details

4.9.3 Evening Noise readings (4-6pm)

The highest mean noise levels recorded in Agbowo (80.8 dB) and Ajibode (82.8 dB) were both obtained on Wednesday. The lowest mean noise levels measured in Agbowo (72.1 dB) and Ajibode (60.2 dB) were obtained on Saturday and Monday respectively. See figure 4.8 for details

4.9.4 Weekly Pattern of noise readings in comparison with WHO guideline limit

Generally the mean noise levels in Agbowo across the week were above the WHO recommended guideline limit (70 dB), especially during the peak periods of the day (11am – 1pm), and showed only a drop in noise level (61.8 dB) below the WHO guideline limit on Monday around 6 – 8am. In Ajibode, Majority of the noise readings were below the WHO guideline limit (53.7 dB, 60.2 dB, 60.8 dB, 58.6 dB and 66.8 dB), while only four noise readings (74.7 dB, 72.9 dB, 82.8 dB and 90.2 dB) were above the WHO guideline limit and was observed mostly around the peak periods (11am – 1pm). See figure 4.9 for details

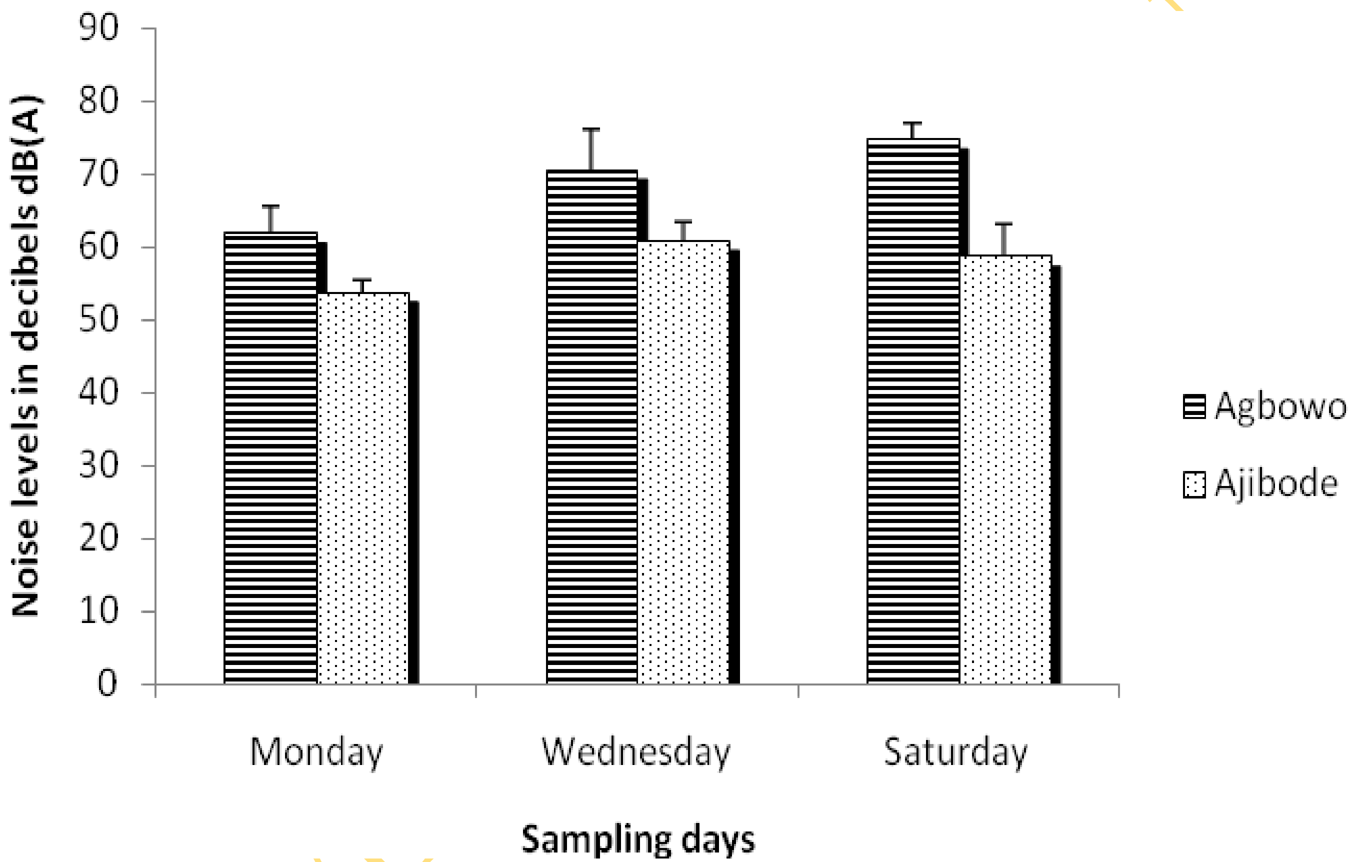


Figure 4.6: Background Noise level between 6am and 8am at Agbowo and Ajibode during a three day/week period

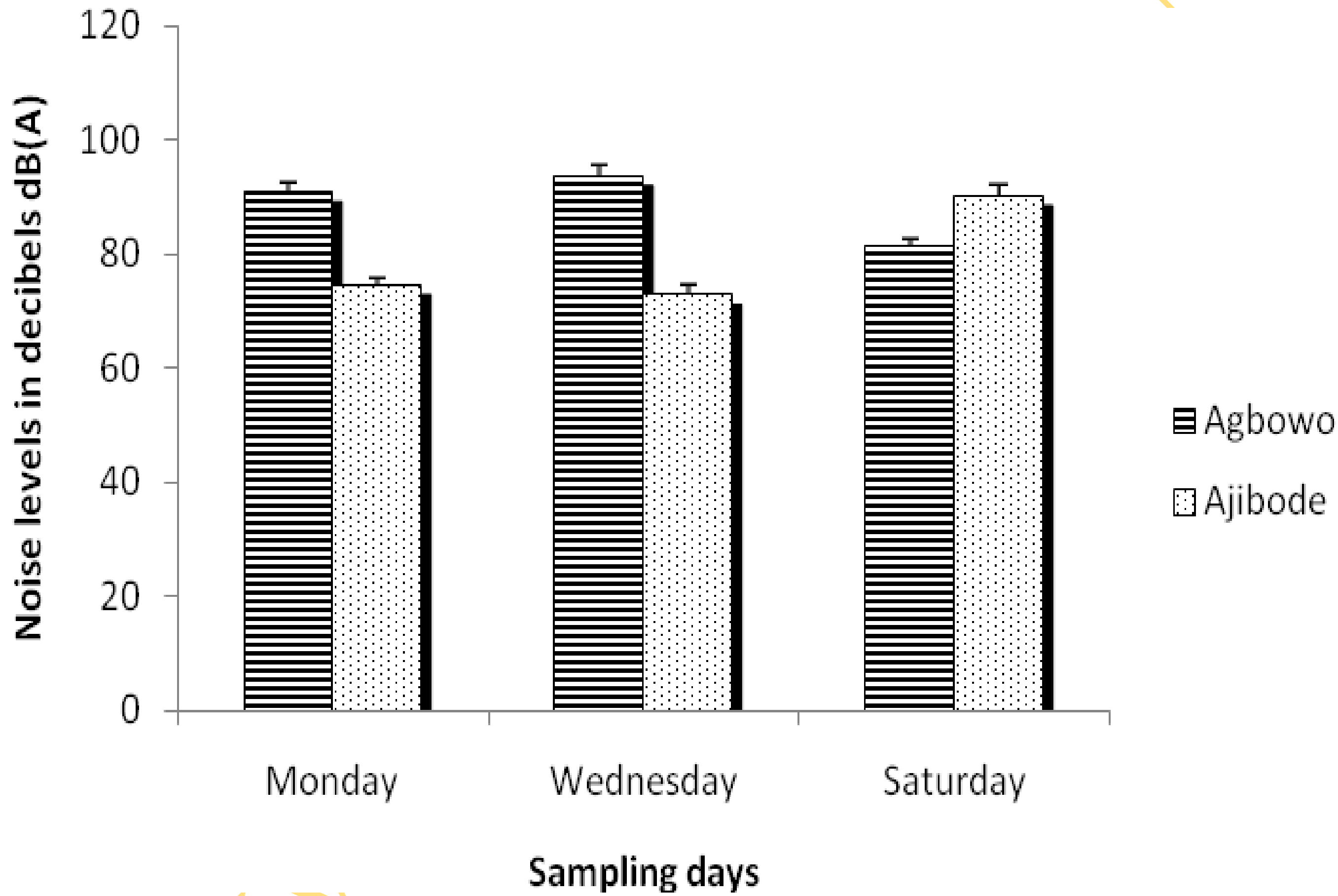


Figure 4.7: Background noise levels between 11am and 1pm at Agbowo and Ajibode during a three day/week period

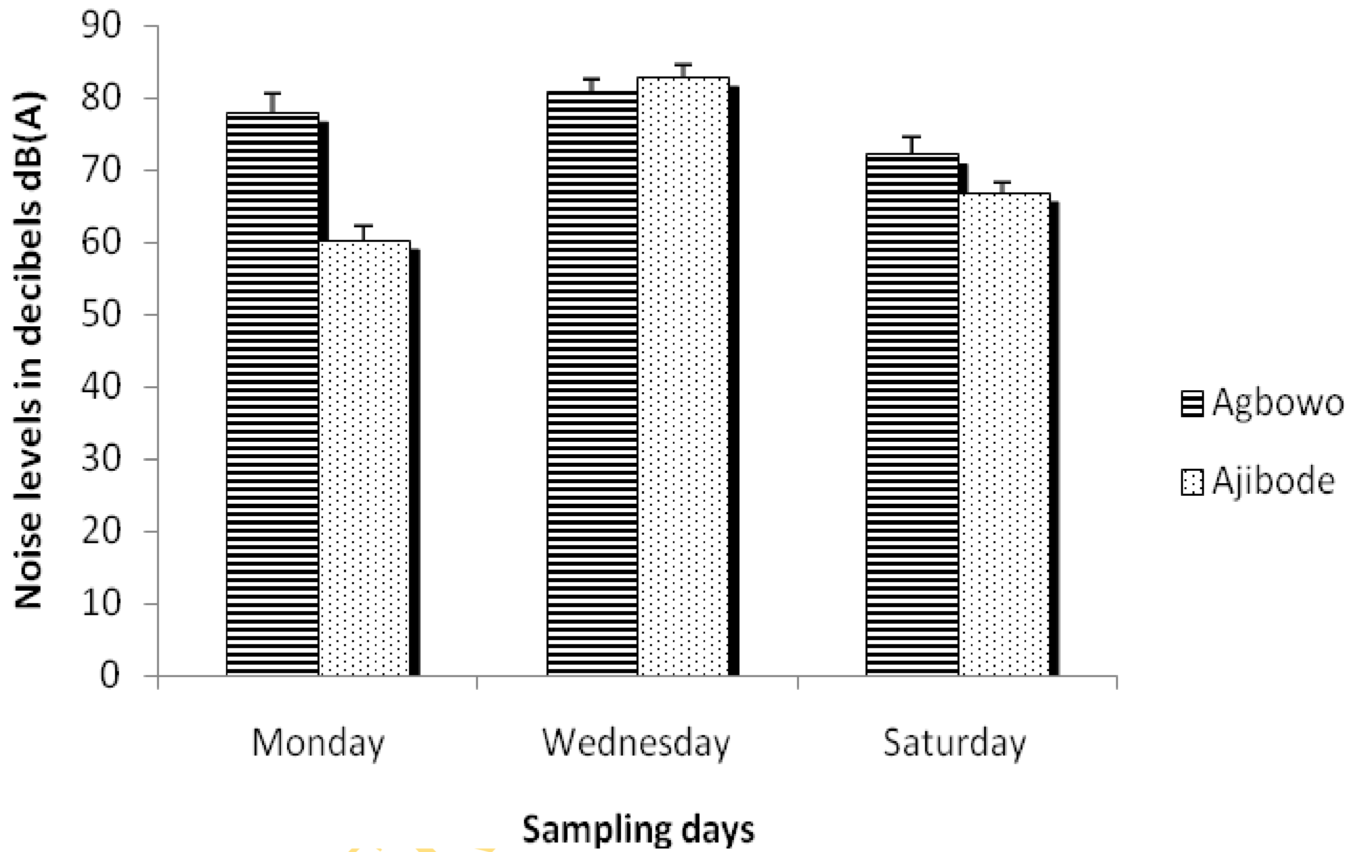


Figure 4.8: Background noise levels between 4pm and 6pm at Agbowo and Ajibode during a three day/week period

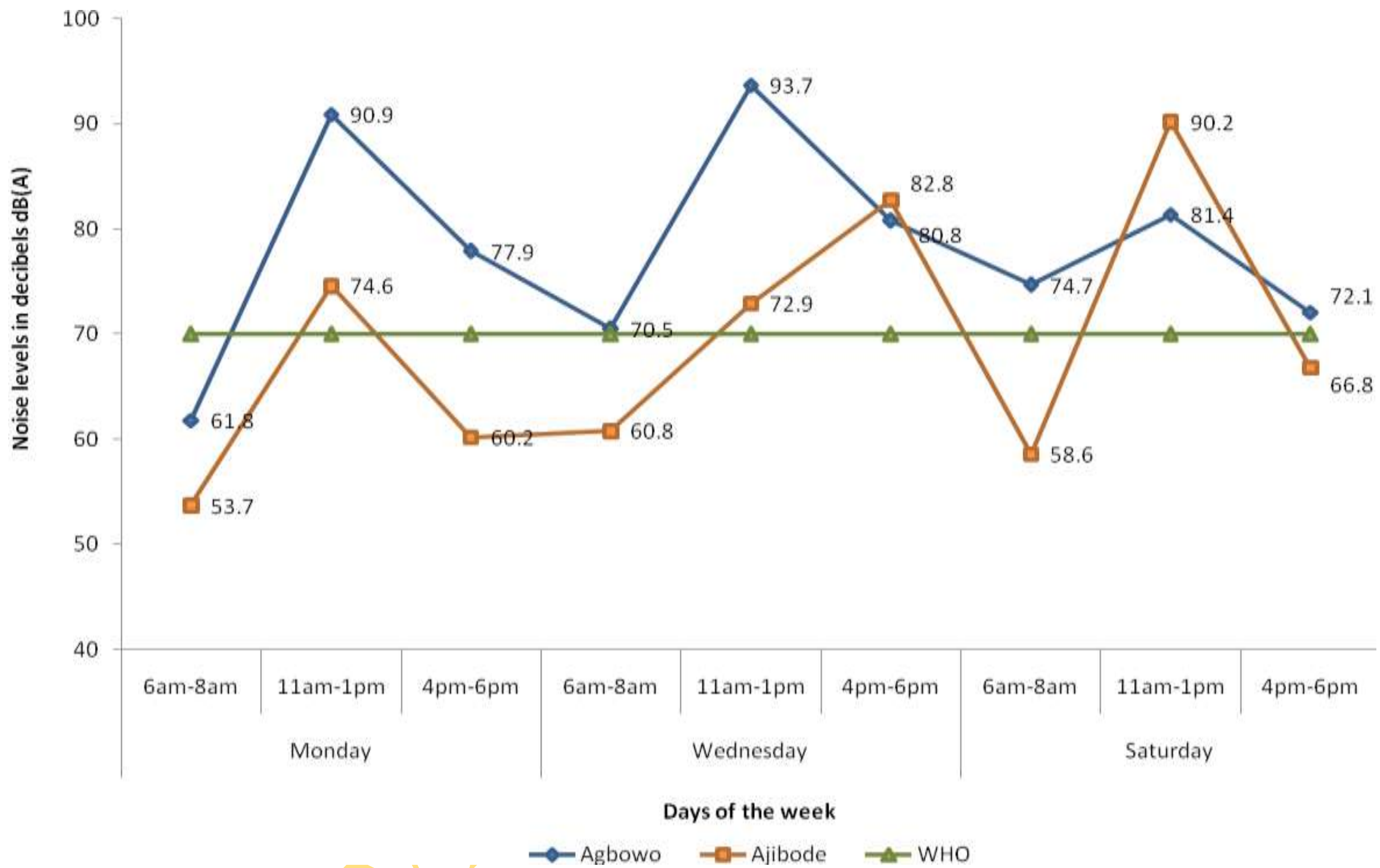


Figure 4.9: Weekly Pattern of Mean Noise Levels at Agbowo and Ajibode areas in comparison with WHO guideline limit

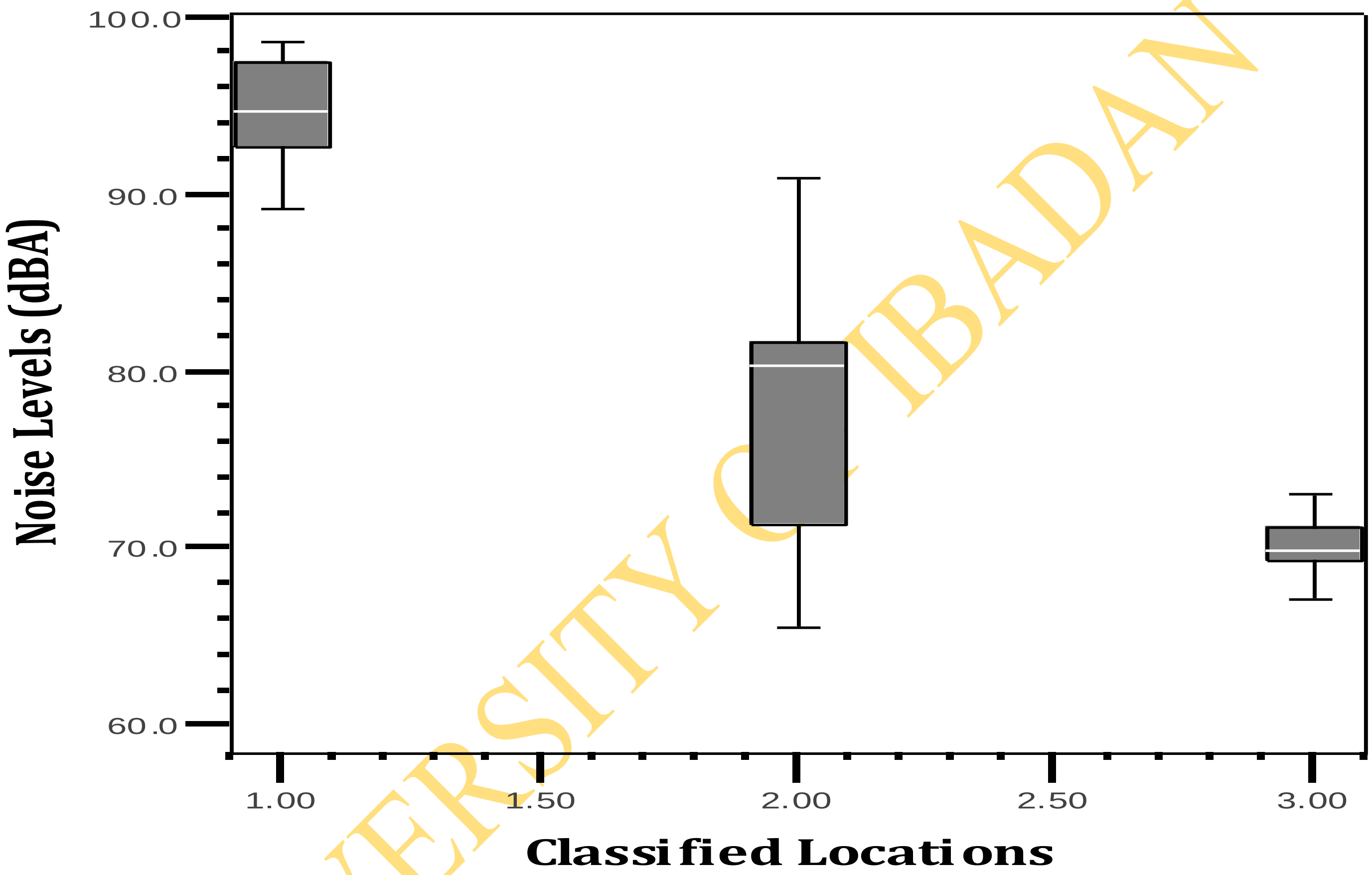
4.10 Background Noise levels in Classified Locations

4.10.1 Mean Noise Levels in Agbowo

The box plot in figure 4.10 illustrates the mean noise levels in enclosed, road side and street/dispersed locations. This is represented by the first, second and third quartile (Q1, Q2 and Q3 respectively) for the total sampling period. The median value is represented by horizontal white line drawn within each box. Mean noise level in enclosed, roadside and dispersed locations were 98.7, 80.4 and 69.2 dBA respectively. The Median (Q2) for enclosed, roadside and dispersed locations were 95.2, 80.1 and 72.1 dBA respectively.

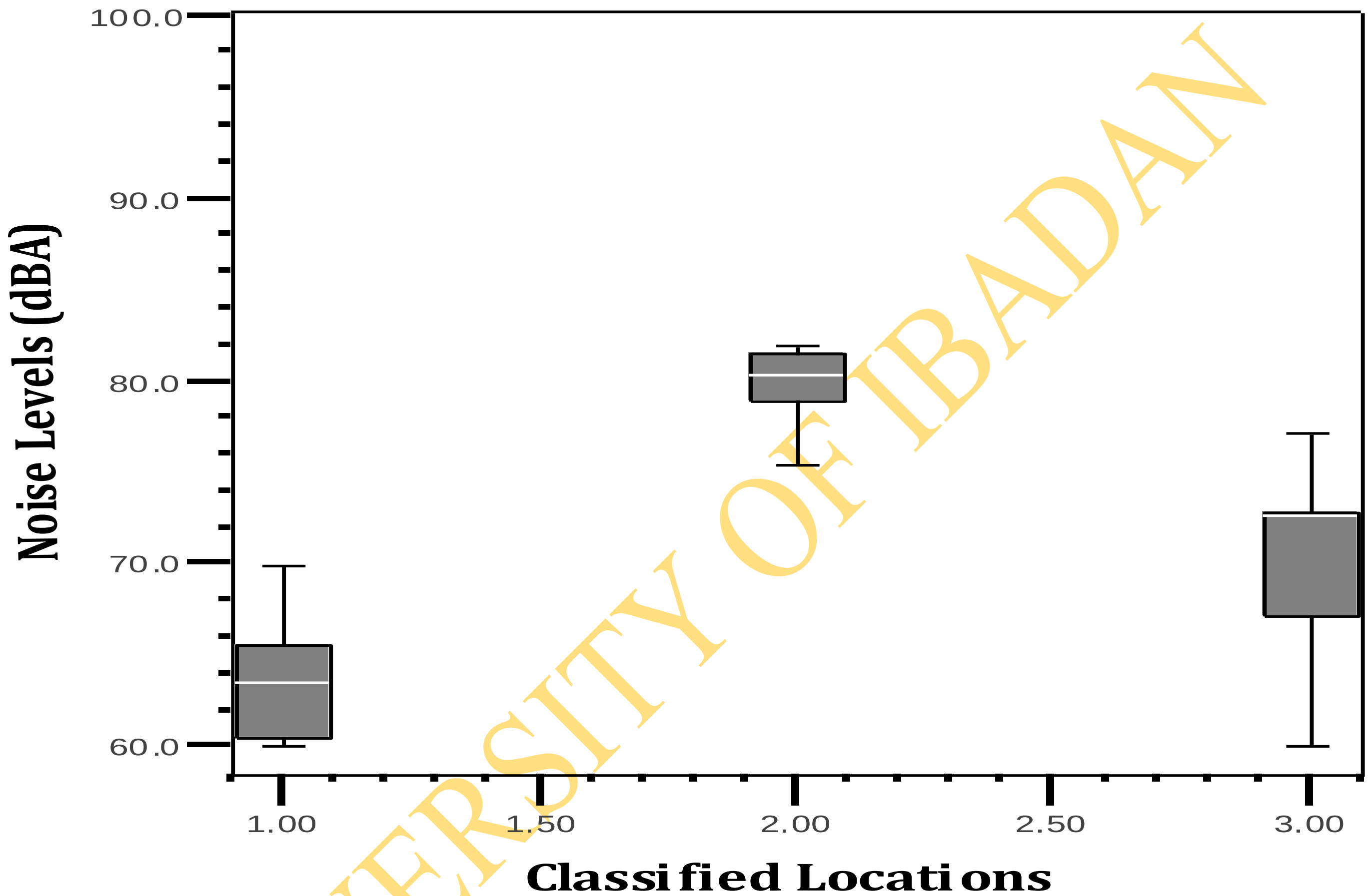
4.10.2 Mean Noise Levels in Ajibode

The box plot in figure 4.11 illustrates the mean noise levels in enclosed, road side and street/dispersed locations. This is represented by the first, second and third quartile (Q1, Q2 and Q3 respectively) for the total sampling period. The median value is represented by horizontal white line drawn within each box. Mean noise level in enclosed, roadside and dispersed locations were 60.2, 81.7 and 72.8 dBA respectively. The Median (Q2) for enclosed, roadside and dispersed locations were 64.5, 80.0 and 72.1dBA respectively.



(1.00: Enclosed, 2.00: Roadside, 3.00: Dispersed)

Figure 4.10: Mean Noise Levels across the three classified locations in Agbowo



(1.00: Enclosed, 2.00, Roadside, 3.00: Dispersed)

Figure 4.11: Mean Noise Levels across the classified locations in Ajibode

4.11 Socio-demographic Characteristics of respondents

The socio-demographic characteristics of the participants are presented in Table 4.1. The age of participants in both business locations ranged from 14 to 39 years with a mean age of 25.14 ± 5.60 years. Majority 394(76.8%) were above 20 years of age while those below 20 years of age were 121(23.5%). Agbowo business area comprised 175 (57.9%) male and 129 (42.4%) female whose age range was between 14-39years and a mean age of 25.3±5.3 years. While Ajibode business area comprised 112(53.1%) male and 99(46.9%) female whose age range was between 14-39years and a mean age of 24.8±5.8 years. See figure 4.13 for details

Christianity 206(67.8%) was the main religion practiced in Agbowo followed by Islam 97(31.9%) and traditional religion 1(0.3%), while in Ajibode Christians constituted 138(65.4%), Islam 70(33.2%) and traditional religion 3(1.4%). Yoruba was the major ethnic group in Agbowo 207(68.1%) and Ajibode 176(83.4%) as this was followed by Ibo (Agbowo: 15.8% Ajibode: 9.5%) and Hausa (Agbowo: 5.6%, Ajibode: 2.4%).

In Agbowo, majority 295(97.0%) of the respondents had formal education while a few 9(3.0%) had no formal education. This was similar at Ajibode where a majority 205(97.2%) had formal education while 6(2.8%) had no formal education.Among the respondents in Agbowo 166(54.6%) had secondary education, 113(37.2%) had tertiary education, 16(5.3%) had primary education and 9(3.0%) had no education. While in Ajibode, about 142(67.3%) had secondary education, 43(20.4%) had tertiary education, 20(9.5%) had primary education and 6(2.8%) had no education. See Table 4.11 for details

Majority of respondentsin Agbowo 271(89.2%) and Ajibode 138(65.7%) said that they did not use hearing protective devices while at work because it would interfere with their hearing. While few respondents in Agbowo 33(10.8%) and Ajibode 73(34.3%) attributed not using HPDs due to the discomfort it causes. See figure 4.14 for details

Table 4.9: Demographic characteristics of Participants.

Demographic Characteristics	Category	Agbowo		Ajibode	
		Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
Sex	Male	174	57.2	112	53.1
	Female	130	42.8	99	46.9
Religion	Christianity	206	67.8	138	65.4
	Islam	97	31.9	70	33.2
	Traditional	1	0.3	3	1.4
Ethnic group	Yoruba	207	68.1	176	83.4
	Hausa	17	5.6	5	2.4
	Ibo	48	15.8	20	9.5
	Edo	14	4.6	6	2.8
	Benue	18	5.9	4	1.9
Educational status	None	9	3.0	15	2.9
	Primary	16	5.3	36	7.0
	Secondary	166	54.6	308	59.8
	Tertiary	113	37.2	156	30.3

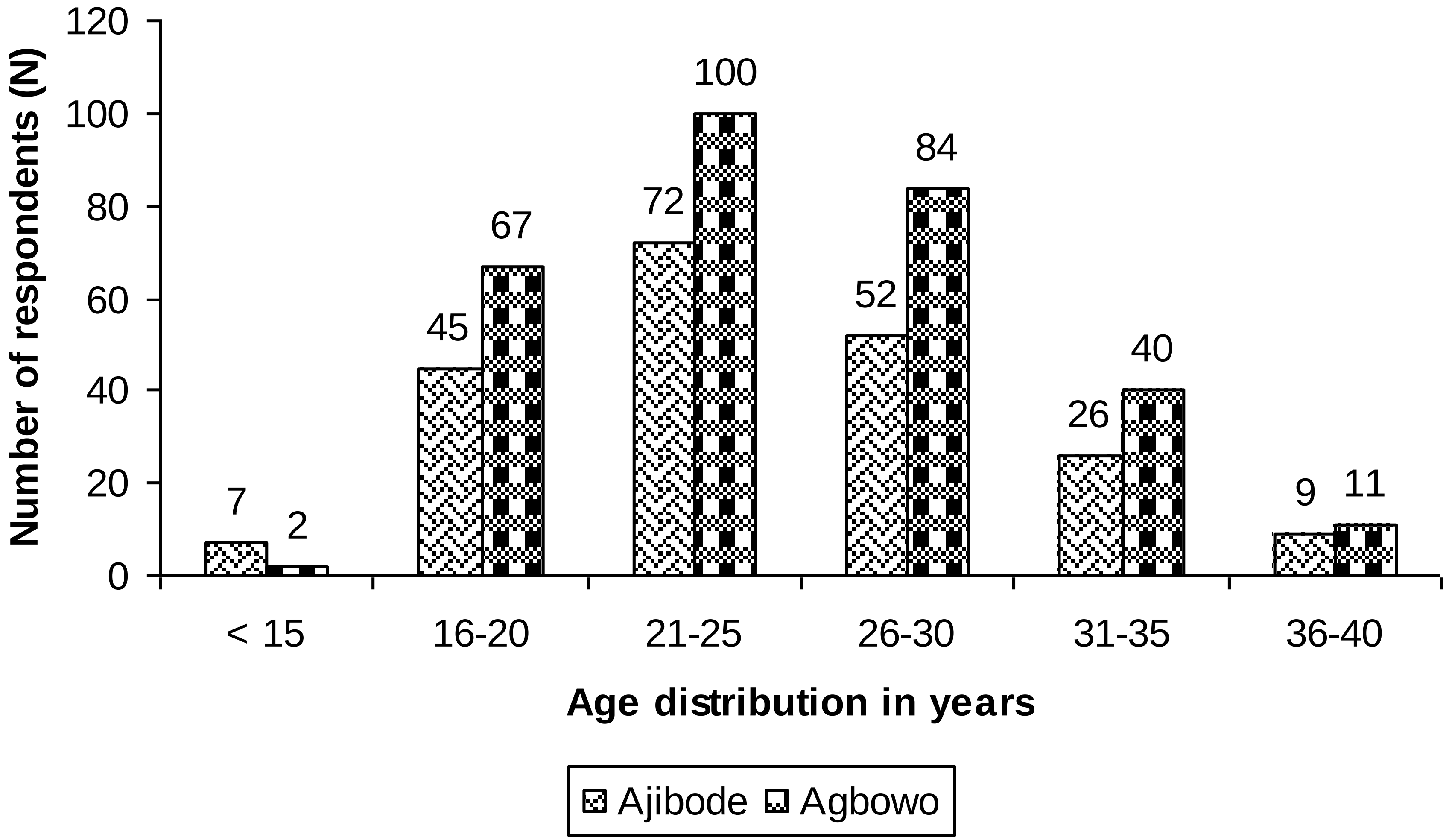


Figure 4.12: Age Distribution of the Participants in Agbowo and Ajibode Commercial Areas

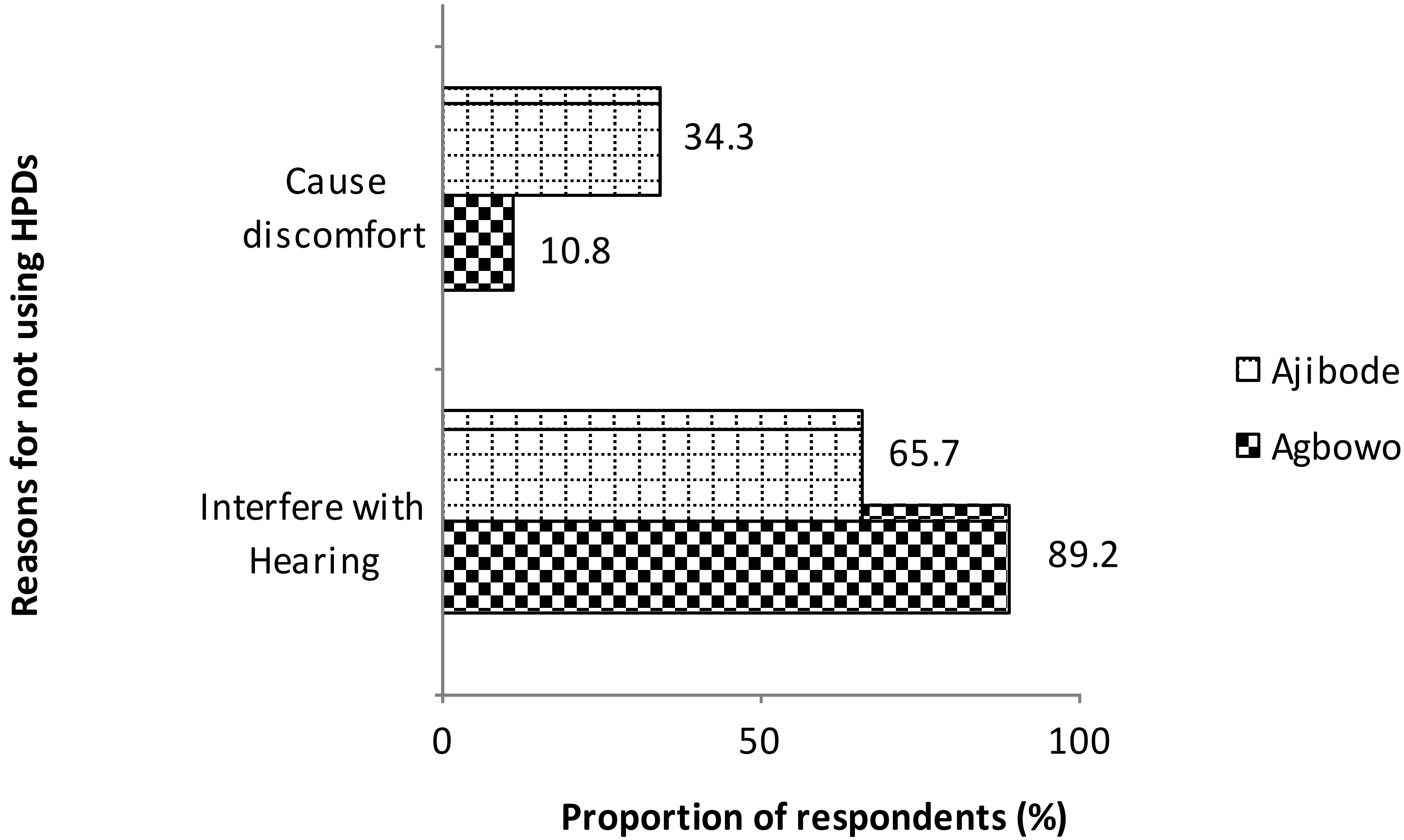


Figure 4.13: Reasons for not using Hearing Protection Devices (HPDs) in Agbowo and Ajibode commercial area

4.12 Occupational Characteristics

The Occupational characteristics of the respondents are presented in Table 4.5. A large number of respondents in Agbowo 299(98.4%) and Ajibode 209(99.1%) do not use ear protection devices while at work, while only few respondents 2(0.9%) and 5(1.6%) in Ajibode and Agbowo use ear protective devices. Sales representatives 148(70.1%) was the main duties of respondents in Ajibode followed by data analyst 33(15.6%) and computer technicians 30(14.2%) while in Agbowo, majority 167(54.9%) were data analyst followed by sales representatives 104(34.2%) and computer technicians 33(10.9%).

A large majority of the respondents in Ajibode 179(84.8%) and Agbowo 216(71.1%) had spent between 4 to 8 years in their present occupation which was followed by 72 (23.7%) and 21(10.0%) in Agbowo and Ajibode who had spent 1 to 3 years in their present occupation. However very few respondents in Agbowo 16(5.3%) and Ajibode 11(5.2%) had spent less than a year in their present occupation. Majority 186(61.2%) of the respondents in Agbowo spend more than eight hours at work followed by 84(27.6%) and 34(11.2%) who spend 8 hours and less than 8 hours at work respectively. In Ajibode, Majority 117(55.5%) spend more than eight hours at work while a few 39(18.5%) and 55(26.1%) spend less than eight hours and eight hours at work respectively.

Among the respondents in Agbowo, 291(95.7%) use generator for business activity with the mean number of hours of electric geneator being 5.49±1.69 hours. On the other hand at Ajibode, 135(64.0%) of respondents use electric generator for business and the mean number of hours of electric generator use was 2.1 ± 1.07 hours. Among the respondents, 244(80.3%) in Agbowo and 55 (26.1%) in Ajibode considered their workplace noisy, while 60(19.7%) in Agbowo and 156(73.9%) in Ajibode did not. Also, 231(76.0%) of respondents in Agbowo and 14(6.6%) of respondents in Ajibode prefered a quieter workplace.See Table 4.12 for details.

4.12.1 Relationship between hours at work and respondents hearing status

The null hypothesis states that there is no significant relationship between hours at work and respondents hearing status. The results showed that there was no significant relationship between hours spent at work and respondents hearing status in both Agbowo and Ajibode business areas ($p>0.05$). The null hypothesis therefore cannot be rejected. See Table 4.13 for more details.

4.12.2 Relationship between hearing threshold at different frequencies with the duration of exposure (years at work) and age of Respondents

The duration of exposure correlated positively with the threshold of hearing at all the frquencies (500Hz, 1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz and 8000Hz) which gave coefficients of (r= 0.369, 0.406, 0.363, 0.247, 0.202, 0.180, 0.176, and 0.202) at $P<0.01$ and $P<0.05$ respectively.

The Age correlated positively with the threshold of hearing at all frequencies (500Hz, 1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz and 8000Hz) which gave coefficients of (r= 0.322, 0.296, 0.248, 0.212, 0.185, 0.145, 0.187, and 0.164) at $P<0.01$ and $P<0.05$ respectively. See table 4.14 for details. The Noise at worker's position was not significant at all the frequencies

Table 4.10 : Occupational characteristics of Respondents

Occupational Characteristics	Category	Agbowo		Ajibode	
		Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
Use of ear protection device	Yes	5	1.6	2	0.9
	No	299	98.4	209	99.1
Main Duties at work	Data Analyst	167	54.9	33	15.6
	Computer technician	33	10.9	30	14.2
	Sales person	104	34.2	148	70.1
Duration of work experience (Years at work)	< 1 year	16	5.3	11	5.2
	1-3 years	72	23.7	21	10.0
	4-8 years	216	71.1	179	84.8
Hours at work	< 8 hours	34	11.2	39	18.5
	8 hours	84	27.6	55	26.1
	> 8hours	186	61.2	117	55.5
Utilization of electric generator for business activity	Yes	291	95.7	135	64
	No	13	4.3	76	36
Is your work environment so noisy that you have to raise your voice to communicate	Yes	231	76	14	6.6
	No	73	24	197	93.4

Table 4.11 Relationship between hours spent at work and Respondents hearing status

Business Area	Hours at work	Hearing Status			df	X^2	P-value
		Impaired (>50)	Normal (≤50)	Total			
Agbowo	8 hours	8(72.7%)	3(27.3%)	11(100.0%)	2	0.81	p>0.05
	8 hours	24(80.0%)	6(20.0%)	30(100.0%)			
	> 8 hours	61(74.4%)	21(25.6%)	82(100.0%)			
Ajibode	< 8 hours	2(12.5%)	14(87.5%)	16(100.0%)	2	0.96	p>0.05
	8 hours	12(44.4%)	15(55.6%)	27(100.0%)			
	> 8 hours	15(36.6%)	26(63.4%)	41(100.0%)			

Table 4.12 Correlation Analysis showing relationship between hearing threshold at different frequencies for both ears with Respondents age and Years at work

Frequency of both ears (Hertz)	Age	Years at work	Noise at Worker's Position
500	0.322** (0.000)	0.369** (0.000)	0.097(0.165)
1000	0.296** (0.000)	0.406** (0.000)	0.044(0.530)
1500	0.248** (0.000)	0.363** (0.000)	0.092(0.190)
2000	0.212**(0.002)	0.247** (0.000)	0.106(0.128)
3000	0.185** (0.008)	0.202** (0.000)	0.125(0.074)
4000	0.145* (0.037)	0.180** (0.010)	0.126(0.072)
6000	0.187** (0.007)	0.176* (0.011)	0.102(0.146)
8000	0.164* (0.019)	0.202** (0.004)	0.071(0.312)

**** Correlation is significant at 0.01, *Correlation is significant at 0.05**

4.13 Pattern of Generator Use

Among the respondents in Agbowo that use generators at work, the mean number of hours of electric geneator use was 5.49±1.69 hours, while in Ajibode electric generator was used for 2.1±1.07 hours. Majority of the respondents in Agbowo 240(78.9%) also utilized electric generator at home with mean hours of use as 4.17±2.32 hours, while 130(61.6%) of respondents in Ajibode had generators at home with mean number of hours of use as 3.18±1.00 hours. Also, 251(82.6%) of respondents in Agbowo and 91(43.1%) of respondents in Ajibode had neighbours at home who also utilize electric generators and the mean number of hours of electric generator use was 3.67±1.31 hours and 3.43±1.47 hours respectively. See table 4.15 for details.

The mean cost of generator maintainance in Agbowo was 6,946 ± 3,628.6 Naira, while in Ajibode it was 3,476 ± 1,598.7 Naira. Majority of the respondents in both business areas Agbowo 172(58.3%) and Ajibode 100(72.5%) maintained their generators at least twice a month, while few in Agbowo 20(6.8%) and Ajibode 2(1.4%) maintained their generators daily. See Figure 4.15 for details .

Majority of the respondents in Agbowo (81%) place their elecric generator outdoors during operation as compared to those in Ajibode (40%). In Agbowo (60%) of generator users place their generators indoors as compared to 19% of generator users in Ajibodewhile. see Figure 4.16 for details.

Table 4.13: Pattern of Generator Use

Business Location	Category	Hours of Use			
		Mean	**Standard Deviation**	**Minimum**	**Maximum**
Agbowo	At Work	5.49	1.69	1	12
	At Home	4.17	2.32	2	3
	By Neighbours	3.67	1.31	2	4
	Duration of Generator use (Months)				
	At Work	23.5	8.76	3	48
	At Home	25.4	5.39	15	39
	Generator Maintainance Cost (Naira)				
	Category	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
	At Work	6,946	3,628.6	2,000	15,000
	Hours of Use				
Ajibode	**Category**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
	At Work	2.10	1.1	1	7
	At Home	3.18	1.0	3	5
	By Neighbours	3.43	1.5	2	4
	Duration of Generator use (Months)				
	At Work	24.9	8.7	2	48
	At Home	24.8	5.8	14	39
	Generator Maintainance Cost (Naira)				
	Category	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
	At Work	3,476	15,98.7	1,500	10,000

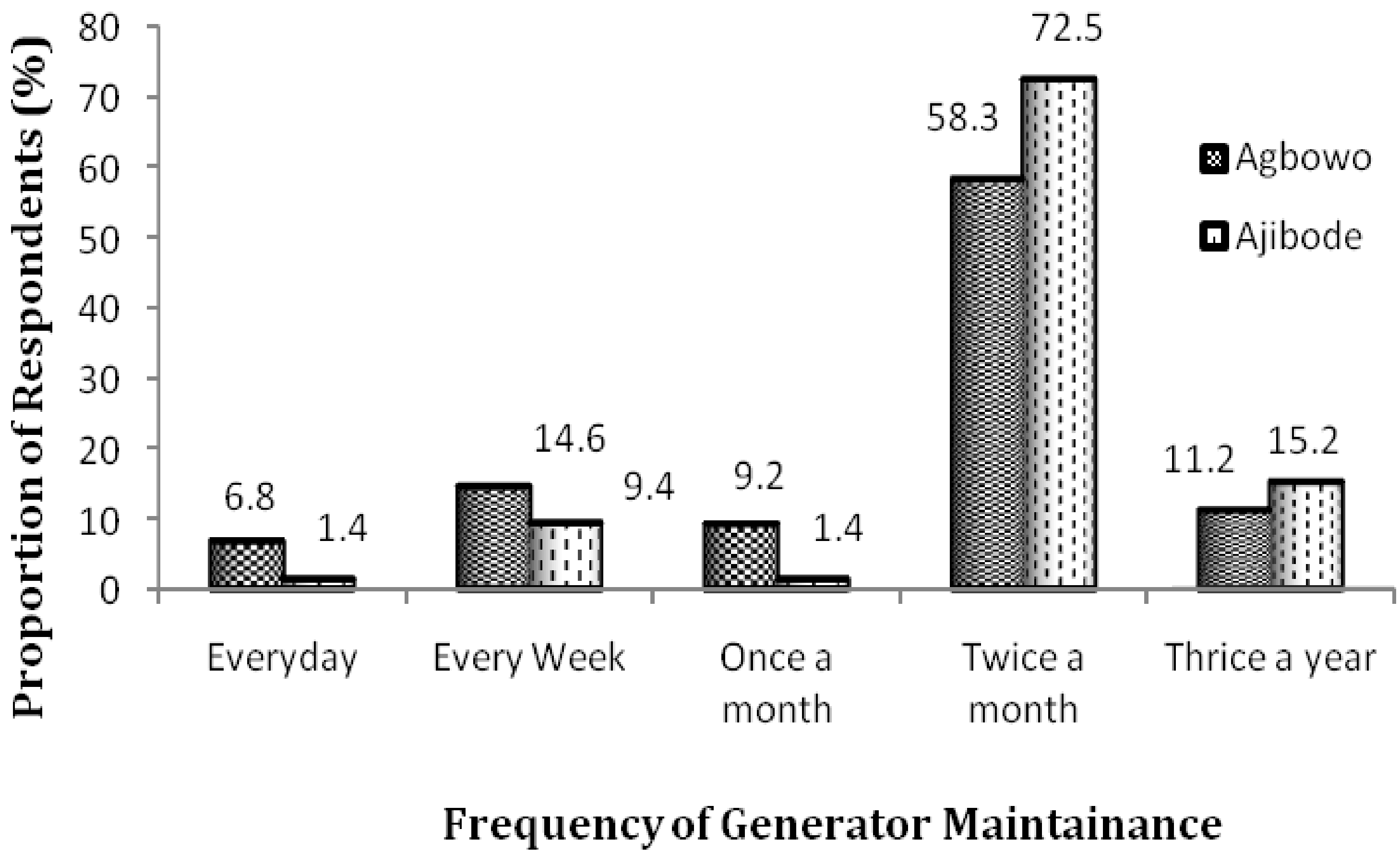


Figure 4.14: Level of Generator Maintenance in Agbowo and Ajibode

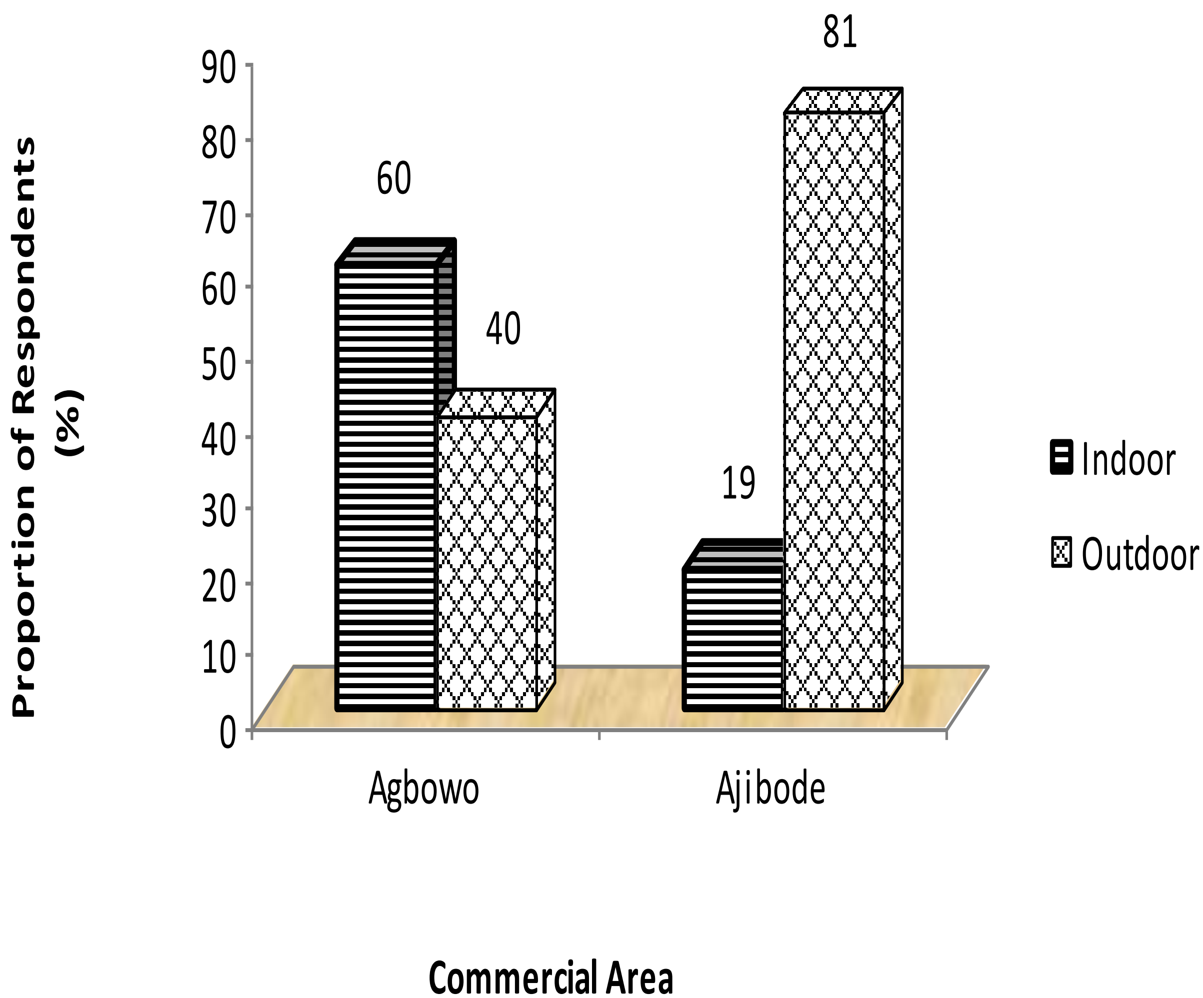


Figure 4.16: Position of Generators while in Operation

4.14 Participants Knowledge on the hazards associated with generator use

Generally, more respondents in Agbowo 162(53.3%) as compared to Ajibode 58(27.5%) scored above the 50th percentile and therefore had good knowledge, while 142(46.7%) in Agbowo and 153(72.5%) in Ajibode scored below the 50th percentile and therefore had poor knowledge. See Table 4.18 for details.

Table 4.8 higlights participants knowledge on the hazards associated with generator use. More than half of respondents in Agbowo 173(56.9%) and Ajibode 186(86.2%) understood that "utilization of electric generators poses great harm to the health of the public", while a large proportion of participants in Agbowo 143(47%) and Ajibode 179(84.8%) indicated that "mechanical devices such as generators produce noise". Majority of the participants in Agbowo 252(82.9%) and Ajibode 183(86.7%) were knowledgeable of the fact that "noise from electric generator can cause harm to the ear", while a large proportion of the respondents in Agbowo 225(74.0%) and Ajibode 121(57.3%) believed that noise from an electric generator can bring about conflict among neighbours.

A high proportion of respondents in Agbowo 277(91.1%) and Ajibode 153 (91.9%) did not believe that filling an electric generator with fuel while in use could pose any danger. Almost an equal proportion of participants in Agbowo 224(73.7%) and Ajibode 165(78.2%) agreed that "the utilization of electric generator can degrade the environment", with only a few of the participants in Agbowo 46(15.1%) and Ajibode 71(33.6%) actually agreeing to the fact that "global warming could be one of the outcomes of generator use". A little above half of the participants in Agbowo 159(52.3%) believed that "carbon monoxide poisoning can result from generator use". A large proportion of respondents in Agbowo 198(68.1%) and Ajibode 159(75.4%) disagreed that "generator utilization could cause malaria", while a small proportion of respondents in Agbowo 21(6.9%) and 20(9.5%) agreed that "noise from an electric generator can cause hearing loss". Majority of the participants in Agbowo 187(61.5%) and Ajibode 106 (50.2%) agreed that "fire outbreak can result from generator use". Majority of participants in Agbowo 173(56.9%) and Ajibode 186(88.2%) believed "avoidance was a way of protection against generator noise", while few of the participants in Agbowo 52(17.1%) and Ajibode 28(13.3%) did not believe that personal protective equipments cannot protect someone against the adverse health effect of noise and fumes from generator. In Agbowo, a small proportion of participants 85(28.0%) as compared to the majority in Ajibode 131(62.1%) agreed that “work rotation could protect a worker from the adverse effect of noise”. A small proportion of participants in Agbowo 79(26%) and Ajibode 90(42.7%) disagreed that “utilizing electric generator indoor can protect one from its harm” as compared to majority of participants in Agbowo 277(91.1%) and Ajibode 194(91.9%) who where of the opinion that outdoor placement of generator while in use cannot protect one from its adverse health effect. See Table 4.16 for details

4.14.1 Relationship between educational status and level of knowledge on the hazards associated with the use of electric generator.

The null hypothesis states that there is no significant relationship between educational status and level of knowledge on hazards associated with electric generator. The result shows that there is a no significant relationship between educational status and level of knowledge among participants in both Agbowo and Ajibode business area. Therefore, the null hypothesis cannot be rejected. See Table 4.17 for details

4.14.2 Relationship between Commercial area and level of knowledge

There was a significant relationship between location of commercial area and respondents level of knowledge. In Agbowo, a large number had good knowledge 162(53.3%) as compared to those who had poor knowledge 142(46.7%). In Ajibode, 153(72.5%) had poor knowledge as compared to 58(27.5%) which had Good knowledge. See Table 4.18 for details.

4.14: Respondents Knowledge on the hazards associated with generator use

Variable	Options	Agbowo N(%)	Ajibode N(%)	Total
The Utilization of electric generators does pose harm to human health	True	173(56.9)	186(88.2)	359
	False	131(43.1)	25(10.8)	156
Mechanical devices such as grinding machines, car engines and electric generators produce noise	True	143(47.0)	179(84.8)	322
	False	161(53	32(15.2)	193
The Noise from an electric generator can cause harm to the ear	True	252(82.9)	183(86.7)	435
	False	52(17.1)	28(13.3)	80
There is a heightened public concern over the influx of generators into the country as well as their use	True	85(28.0)	131(62.1)	216
	False	219(72.1)	80(37.9)	299
The utilization of generators at home can cause conflict among neighbours	True	225(74.0)	121(57.3)	346
	False	79(26)	90(42.7)	169
Filling an electric generator with fuel while it is in operation can lead to an explosion	True	27(8.9)	17(8.1)	44
	False	277(91.1)	153(91.9)	430
Global warming can occur due to generator use	True	46(15.1)	71(33.6)	117
	False	258(84.8)	140(66.4)	398
Carbon monoxide poisoning can occur due to generator use	True	159(52.3)	67(31.8)	226
	False	145(47.7)	144(68.2)	289
Malaria can occur due to generator use	True	97(31.9)	52(24.6)	149
	False	198(68.1)	159(75.4)	357

Table 4.14 Continued

Variable	Options	Agbowo N(%)	Ajibode N(%)	Total
Regular generator maintainance can reduce the noise it produces	True	21(6.9)	20(9.5)	41
	False	283(93.1)	191(90.5)	474
Fire outbreak can occur due to poor usage of generators	True	187(61.5)	106(50.2)	223
	False	117(38.5)	105(49.8)	292
Knowledge on Protective Practices				
Are you aware that you can be protected from generator noise?	True	224(73.7)	165(78.2)	389
	False	80(26.3)	46(21.8)	126
Avoidance is a way of protection from hazards of generator use	True	173(56.9)	186(88.2)	359
	False	131(43.1)	25(11.8)	156
Utilization of Personal Protective devices such as ear plugs and ear muffs cannot protect one from generator noise	True	252(82.9)	183(86.7)	435
	False	52(17.1)	28(13.3)	80
Work rotation is a way of protection from hazards of generator noise	True	85(28.0)	131(62.1)	216
	False	219(72.1)	80(37.9)	299
Utilizing your generator indoor is a way of protecting oneself from hazards associated with its use	True	225(74.0)	121(57.3)	346
	False	79(26)	90(42.7)	169
Utilizing your generator outdoor is a way of protecting oneself from hazards associated with its use	True	277(91.1)	194(91.9)	471
	False	27(8.9)	17(8.1)	44

Table 4.15 Relationship between educational status and level of knowledge

Business Area	Educational Status	Range of scores			df	X^2	P-value
		Poor	Good	Total			
Agbowo	**No Formal**	5(55.6%)*	4(44.4%)*	9(100.0%)*	1	0.75	>0.05
	Formal	145(49.2%)*	150(50.8%)*	295(100.0%)*			
Ajibode	**No Formal**	2(33.3%)*	4(66.7%)*	6(100.0%)*	1	1.00	>0.05
	Formal	68(33.2%)*	137(66.8%)*	205(100.0%)*			

*** Row percentage was used.**

Table 4.16 Relationship between Commercial area and level of knowledge

Business Area	Range of scores			df	X^2	P-value
	Poor	Good	Total			
Agbowo	142(46.7%)	162(53.3%)	211(100.0%)	1	0.042	$p<0.05$
Ajibode	153(72.5%)	58(27.5%)	304(100.0%)			

*** Row percentage was used.**

4.15 Perception of risk associated with exposure to generator noise

Table 4.19 highlights the perception of participants towards the risk associated with exposure to the noise from electric generators. Majority of the participants in Agbowo 200(65.8%) and Ajibode 157(74.4%) agreed that "noise at work was a major contributor to the loss of quality life by worker". A large proportion of participants in Agbowo 254(83.6%) and Ajibode 166 (78.7%) considered it a major disability to lose one's hearing as majority in Agbowo 239(78.6%) and Ajibode 192(91.0%) agreed that "exposure to high noise levels from generator over a long time could affect the hearing capacity. In Agbowo 143(47%) disagreed that "the chance of developing hearing loss at their workplace was low" as compared to a little above half of particpants in Ajibode 123(58.3%) who agreed that chance of hearing loss was low in their work environment. Majority of the participants in Agbowo 115(37.8%) disagreed that generators were a blessing to mankind as compared to those in Ajibode 90(42.7%) who felt indifferent. A large proportion of participants in Agbowo 204(67.1%) and Ajibode 109(51.7%) felt it was neccessary to reduce noise from generator as majority [Agbowo: 132(43.4%) and Ajibode: 79(37.4%)] disagreed that annual hearing test cannot warn a person against potential hearing loss. See table 4.19 for details.

4.16 Perceived Concern for NIHL in relation to other Health Conditions

Generally, few respondents in both Agbowo(7.70%) and Ajibode(5.0%) were less concerned about Noise Induced Hearing Loss as compared to other Health conditions. Similar proportion of respondents (31%) in both Agbowo and Ajibode were concerned about cancer as compared to 45.7% and 30.6% in Agbowo and Ajibode who were concerned about accidents. Majority in Ajibode (32%) as compared to Agbowo (15%) were concerned about chemical burn. See figure 4.17 for details

4.17 Relationship between Commercial area and Perception of respondents

There was a significant relationship between location of commercial area and respondents perception. In Agbowo, a large number had negative perception 156(51.3%) as compared to those who had positive perception 148(48.9%). In Ajibode, 173(82%) had negative perception as compared to 38(18.0%) which had positive perception. See Table 4.20 for details.

Table 4.17: Perception of risk associated with exposure to generator noise

Variable	Options	Agbowo N(%)	Ajibode N(%)	Total
Noise at workplace is a major contributor to a worker's loss of quality of life	Agree	200(65.8)	157(74.4)	357(69.3)
	Indifferent	40(13.2)	22(10.4)	62(12.0)
	Disagree	64(21.1)	32(15.2)	96(18.6)
It is considered a major disability to lose one's hearing capacity	Agree	254(83.6)	166(78.7)	420(81.6)
	Indifferent	25(8.2)	21(10.0)	46(8.9)
	Disagree	25(8.2)	24(11.4)	49(9.5)
Exposure to high levels of noise from an electric generator can cause hearing disability	Agree	239(78.6)	192(91.0)	431(83.7)
	Indifferent	29(9.5)	7(3.3)	36(7.0)
	Disagree	36(11.8)	12(5.7)	48(9.3)
A business operator's chance of developing hearing disability from this workplace is very low	Agree	83(27.3)	123(58.3)	206(40.0)
	Indifferent	78(25.7)	35(16.6)	113(21.9)
	Disagree	143(47.0	53(25.1)	196(38.1)
The workers performance is not affected by the noise from an electric generator	Agree	76(25.0)	45(21.3)	165(32.0)
	Indifferent	43(14.1)	77(36.5)	120(23.3)
	Disagree	185(60.9)	89(42.2)	230(44.7)
Despite the hazards associated with the use of electric generators, it is a blessing to mankind	Agree	132(43.4)	76(36.0)	208(40.4)
	Indifferent	57(18.8)	90(42.7)	147(28.5)
	Disagree	115(37.8)	45(21.3)	160(31.1)
It is not necessary to reduce the noise from electric generators	Agree	65(21.4)	64(30.3)	129(25.0)
	Indifferent	35(11.5)	38(18.0)	73(14.2)
	Disagree	204(67.1)	109(51.7)	313(60.8)
Hearing test done annually cannot warn against possible hearing loss	Agree	112(36.8)	48(22.7)	160(31.1)
	Indifferent	60(19.7)	84(39.8)	144(28.0)
	Disagree	132(43.4)	79(37.4)	211(41.0)

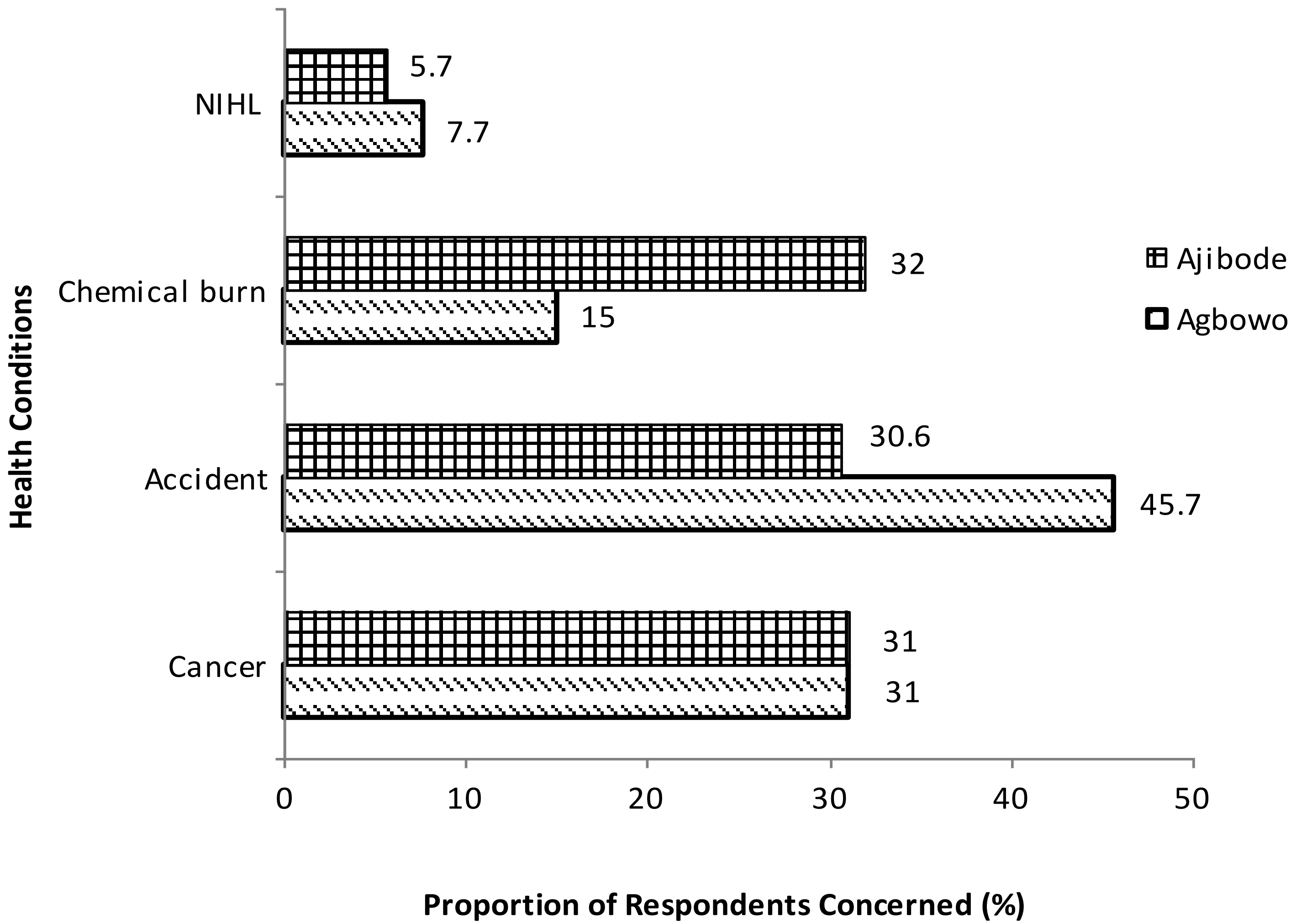


Figure 4.16: Perceived severity NIHL in comparison with other health conditions at Agbowo and Ajibode commercial areas

Table 4.18: Relationship between Commercial area and Perception of respondents

Business Area	Range of scores			df	X^2	P-value
	Negative	**Positive**	**Total**			
Agbowo	156(51.3%)	148(48.7)	304(100.0%)	1	0.039	$p<0.05$
Ajibode	173(82.0%)	38(18.0%)	211(100.0%)			

*Row percentages were used

4.18 Non auditory health effects experienced by study participants

Figure 4.10 illustrates the common non auditory health effects experienced by participants in Agbowo and Ajibode while working with electric generators. A larger proportion in Agbowo (58.1%) and Ajibode (41.9%) indicated that they experienced headache while the generator was in use.. Of those who experienced symptoms, more than half (66.1%) and slightly less than half (33.9%) of participants in Agbowo and Ajibode experienced tiredness while the generator was on. Majority of the participants in Agbowo (64.5%) and slightly less than half of those in Ajibode (35.5%) indicated that they experienced inability to sleep. Above half of the respondents in Agbowo (66.9%) and less than half of the respondents in Ajibode (33.1%) had experienced irritability.

Above half of participants in Agbowo (67.3%) and one third those in Ajibode (32.7%) experienced lack of concenteration and a majority of the participants in Agbowo (60.3%) and few in Ajibode (39.7%) experienced aggressive response (annoyance) during working hours. Slightly less than half of the respondents in Agbowo (43.5%) and above half in Ajibode (56.5%) had ever experienced speech interference while working with generator. Poor social interaction was recorded for 56.3% and 43.8% of participants in Agbowo and Ajibode respectively. See Figure 4.18 for details.

4.19 Respondents Auditory health conditions prior to commencement of study

Table 5.1 highlights the health information of respondents**.** Almost equal proportion of participants in Agbowo 283(93.1%) and Ajibode 193(91.5%) reported at least a good health status when asked how they rated their health state. Similarly, almost equal proportion of participants in Agbowo 270(86.8%) and Ajibode 174(82.5%) did not agree “that their respectve jobs had affected their health”. Majority in Agbowo 211(69.4%) and Ajibode 184(87.2) reported that they had at least a good hearing function. A large proportion of participants in Agbowo191(62.9%) and Ajibode 156(73.9%) reported hearing difficulty while at work, while majority in Agbowo 303(99.7%) and Ajibode 210(99.5%) reported no hearing difficulty before they started working in their present job.

A high proportion of participants in Agbowo 301(99.0%) and Ajibode 208(98.6%) reported never having done an audiometric test before. Almost equal proportion in Agbowo 155(73.5%) and Ajibode 213(70.1%) indicated willingness to undergo a free audiometric test. See table 4.21

4.19.1 Relationship between different variables associated with generator users and the development of hearing impairment

The relationship between whether a user of electric generator would develop a symptom and many variables (age, sex, business location, knowledge and duration of work experience) was further analysed using multivariate logistic regression.

Socio-demographic variables such as age was not statistically significant, while sex was statistically significant (OR: 2.72; CI: 1.35 – 5.49; $p < 0.005$). The implication being that; males are about three times more likely to develop hearing impairment as compared to their female counterparts in relation to exposure to generator noise.

Respondents business area (OR: 5.94; CI: 3.2 – 10.8: $p < 0.000$). The implication being that; Generator users in Agbowo are about six times more likely to develop hearing impairment as compared to their counterparts in Ajibode in relation to exposure to generator noise. Work duration experience was statistically not significant ($p > 0.05$). See table 4.22 for details.

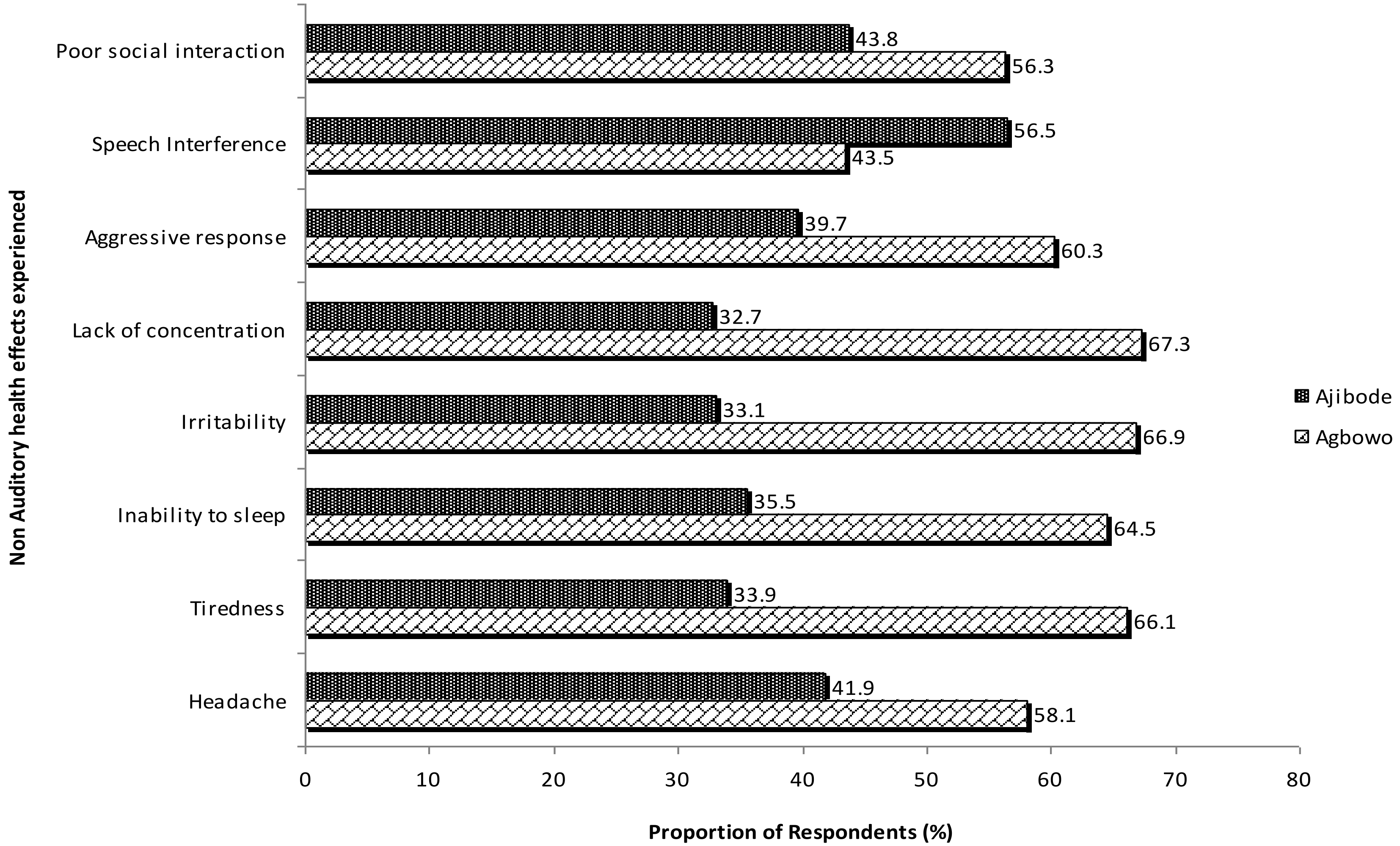


Figure 4.17: Comparison of non-auditory health effects experienced among Respondents at Agbowo and Ajibode

Table 4.19: Respondents Auditory health conditions prior to the commencement of the study

Variable	Options	Agbowo N(%)	Ajibode N(%)	Total
How would you rate your health status?	Excellent	5(1.6)	7(3.3)	12
	Good	283(93.1)	193(91.5)	476
	Fair	16(5.3)	11(5.2)	27
Do you think working here has negatively affected your ability to hear properly?	Yes	6(2.0)	17(8.1)	23
	No	270(88.8)	174(82.5)	444
	Dont know	27(8.9)	20(9.5)	47
How would you rate your hearing function?	Excellent	2(0.7)	9(4.3)	11
	Good	211(69.4)	184(87.2)	395
	Fair	91(29.9)	18(8.5)	109
Do you find it difficult to hear clearly while at work?	Yes	191(62.9)	55(26.1)	246
	No	113(37.2)	156(73.9)	269
Did you have hearing problem before you started working here?	Yes	1(0.3)	1(0.5)	2
	No	303(99.7)	210(99.5)	513
Have you ever done an audiometric test to determine your hearing? Function	Yes	3(1.0)	3(1.4)	6
	No	301(99.0)	208(98.6)	509

Table 4.20 Relationship between multiple variables associated with generator users developing hearing impairment

Variables	df	Sig	Exp(B)	95% CI for EXP(B)	
				Lower	Upper
Socio-demographic features					
Age	1	0.595	0.824	0.404	1.681
Sex	1	0.008	2.72	1.35	5.49
Business Area	1	0.000	5.943	3.248	10.831
Work duration experience	1	0.121	1.864	0.849	4.093
Scores					
Knowledge	1	0.363	0.721	0.357	1.458
Perception	1	0.113	1.825	0.867	3.842

4.20 Audiometric status of Generator Users

Pure tone audiometry (air conduction) was carried out on a total of 206 study participants from both Agbowo and Ajibode business areas based on the number of those that volunteered to undergo the audiometric test and who reported daily generator use. They comprised 122 respondents from Agbowo and 84 respondents from Ajibode. The audiometry was done on both ears of the respondents. A pure tone average (PTA) was calculated over a frequency of 500, 1000. 2000Hz for both ears of the respondents. The PTA for both ears was then added up and the hearing values were compared to the standard (≤50). A total of 29(23.6%) and 55(65.6%) respondents in Agbowo and Ajibode had hearing values < 50 dB, while about 94(76.4%) and 29(34.5%) respondents in Agbowo and Ajibode had hearing values > 50 dB indicating hearing impairment.

The pure tone average of both ears in Agbowo and Ajibode were 59.6 ± 11.7 dB and 44.5 ± 14.7 dB respectively. (See Fig 4.19). The pure tone average of the right ear for respondents in Agbowo and Ajibode were 31.4 ± 6.86 dB and 23.1 ± 7.26 dB respectively. While the pure tone average of the left ear for respondents in Agbowo and Ajibode were 28.3 ± 6.60 dB and 21.5 ± 8.40 dB respectively. On the right ear 98(79.7%) and 31(36.9%) respondents in Agbowo and Ajibode had hearing values > 25 dB, indicating hearing impairment. On the left ear 76(61.8%) and 28(33.3%) respondents in Agbowo and Ajibode had hearing values > 25 dB, also indicating hearing impairment. See figure 4.20 and 4.21 for details.

The comparison of respondents pattern of hearing on the right ear at various frequencies with the standard is presented in figure 4.22. At frequencies of 500Hz to 8000Hz, the hearing level of Agbowo respondents was above normal threshold of 25dB. The hearing level of Ajibode respondents was below the normal threshold for all frequencies except at 500Hz for the right ear. The comparison of respondents pattern of hearing on the left ear at various frequencies with the standard is presented in figure 4.23. At frequencies of 500Hz to 8000Hz, the hearing level of Agbowo respondents was above normal threshold of 25dB. The hearing level of Ajibode respondents was below the normal threshold for all frequencies except at 500Hz and 1000Hz for the left ear.

4.20.1 Relationship between hearing status for both ears and years at work for both male and female generator users

The table 4.23 shows the distribution of the proportion of respondents hearing status for both ears over the different exposure periods. In Agbowo, by 4 – 8 years of working majority of the respondents had hearing impairment [Males: 47(87.0%); Females: 34(87.2%].

In Ajibode, the case was different as male respondents 9(64.3%) who have worked for 1 – 3 years had significantly higher hearing impairment compared to those who had worked 4 -8 years 5(35.7%). Among females, the reverse was the case as respondents 6(40.0%) who had worked for 1 – 3 years had a significantly lower hearing impairment when compared to females respondents 8(53.3%) who had worked 4 – 8 years. See Table 4.23 for details

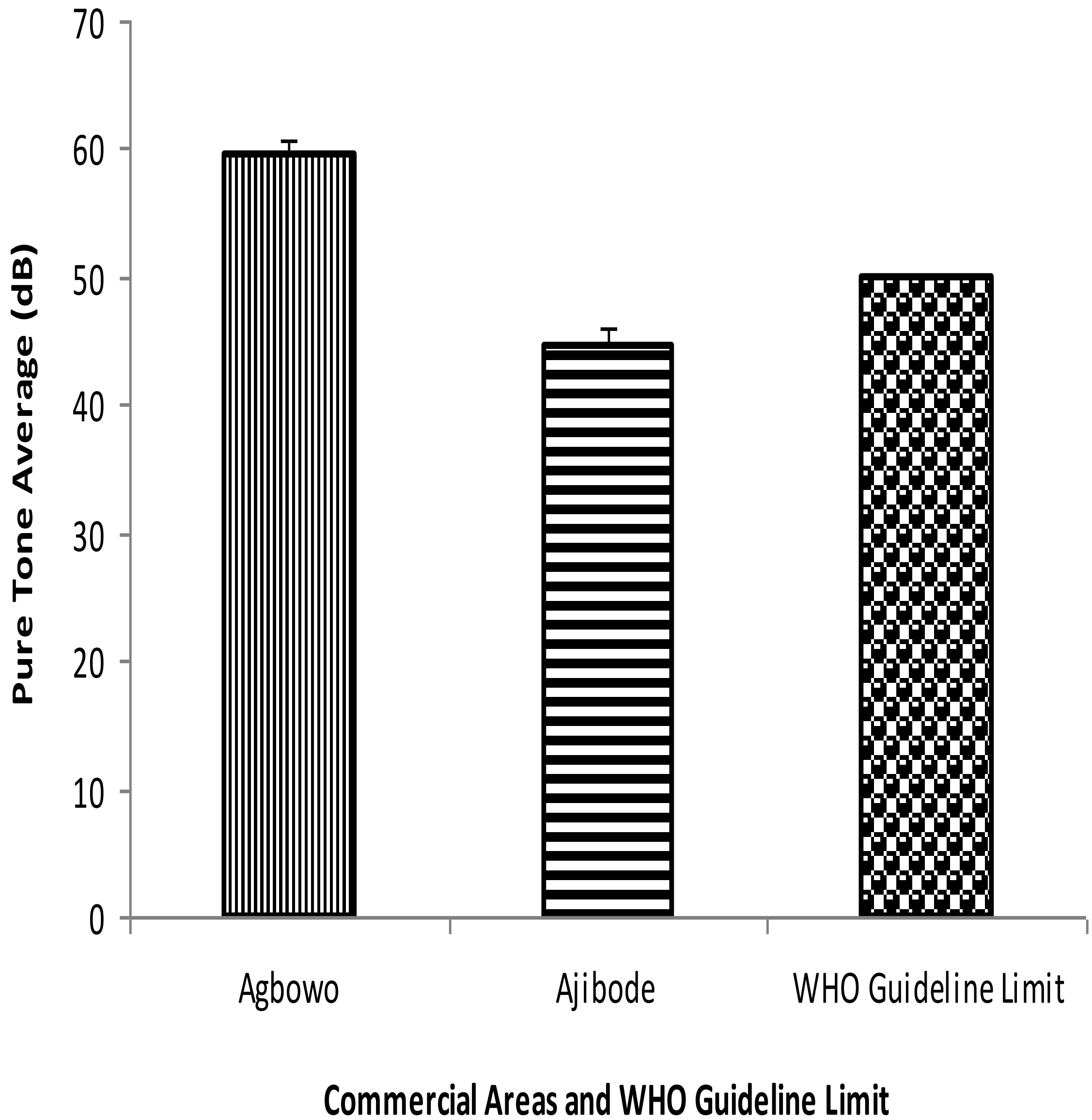


Figure 4.18: Mean Pure Tone Average for both ears in Agbowo and Ajibode in comparison with WHO guideline limit

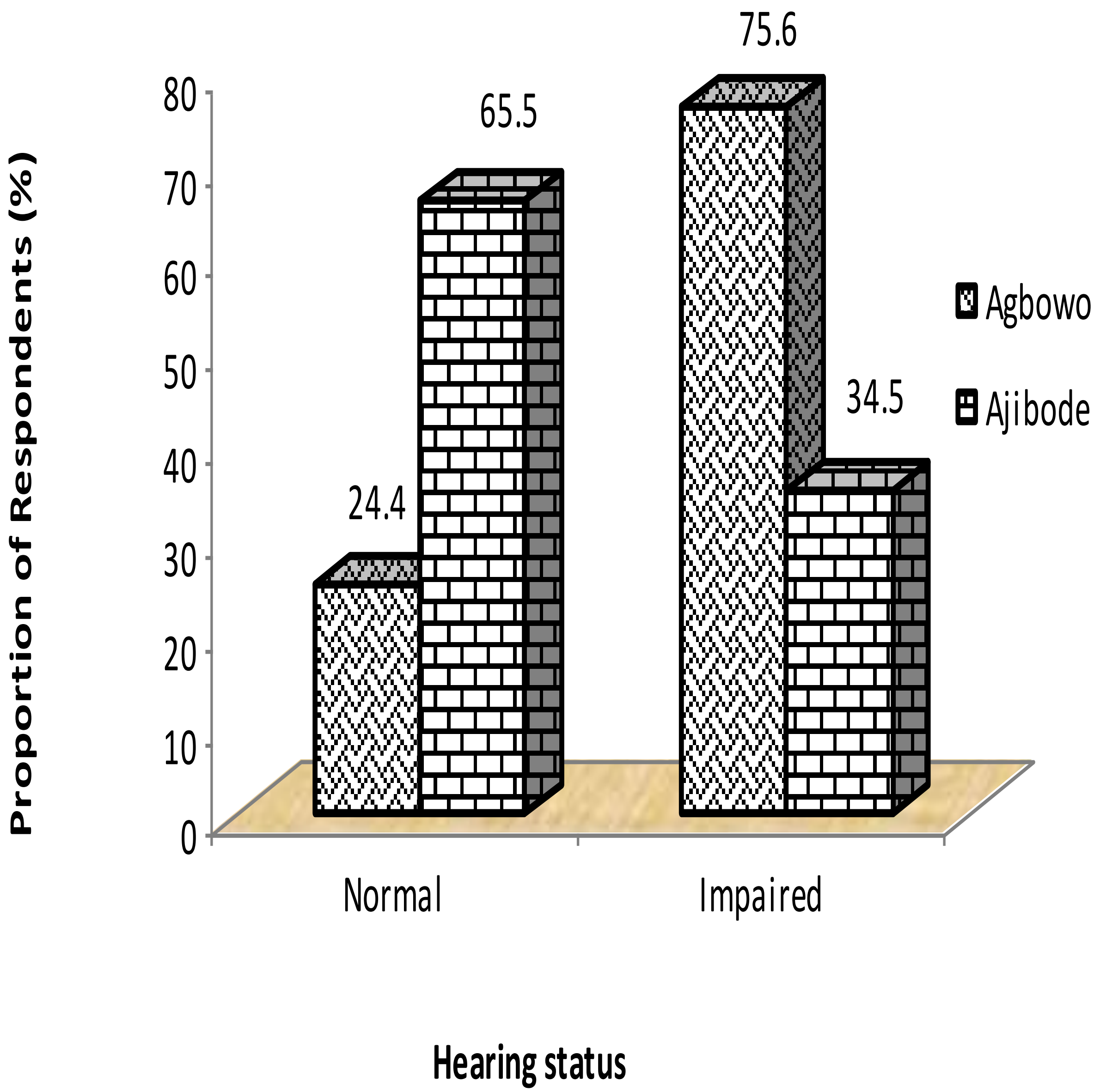


Figure 4.19: Audiometric status of respondents' right ear

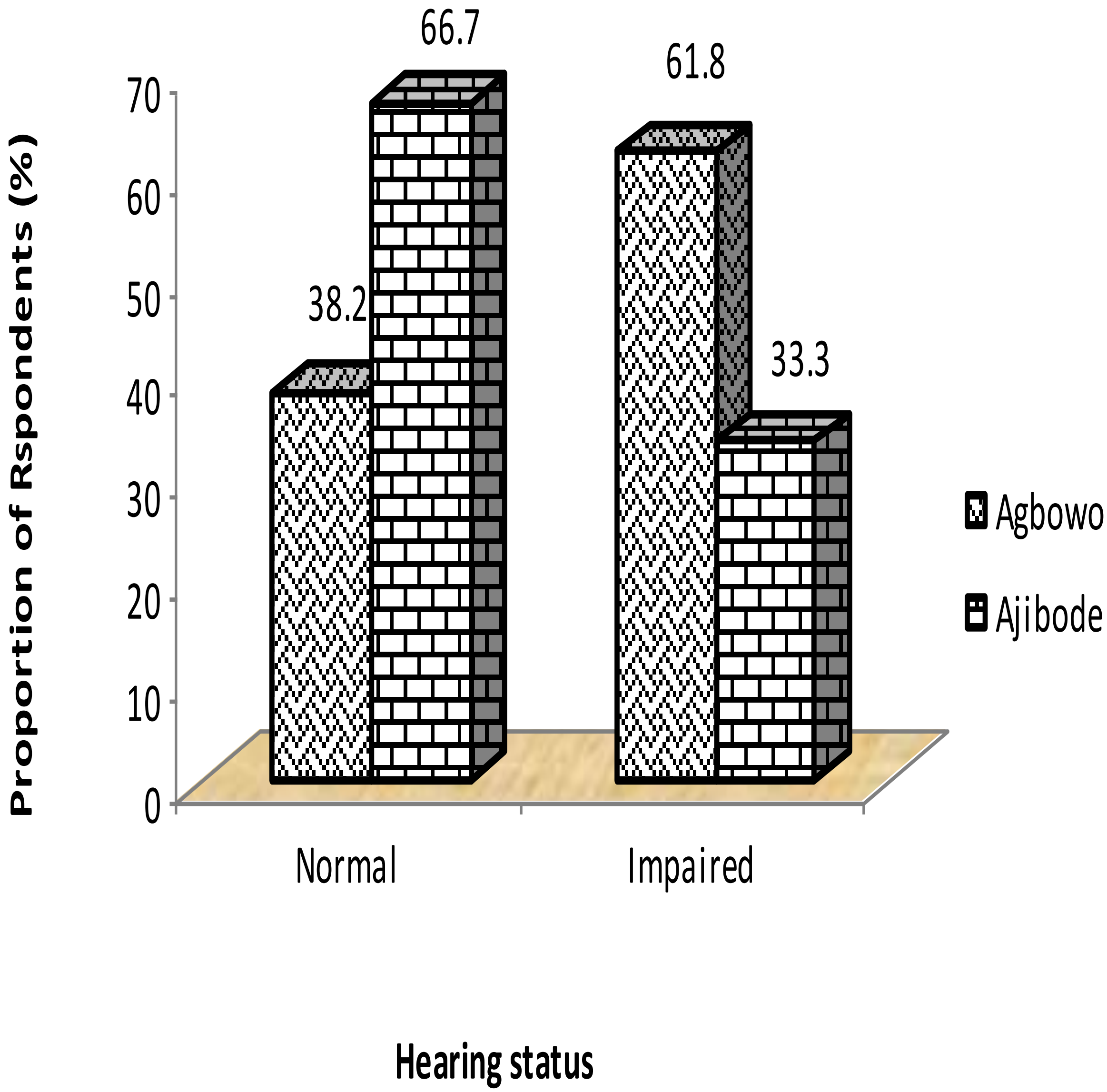


Figure 4.20: Audiometric status of respondents' left ear

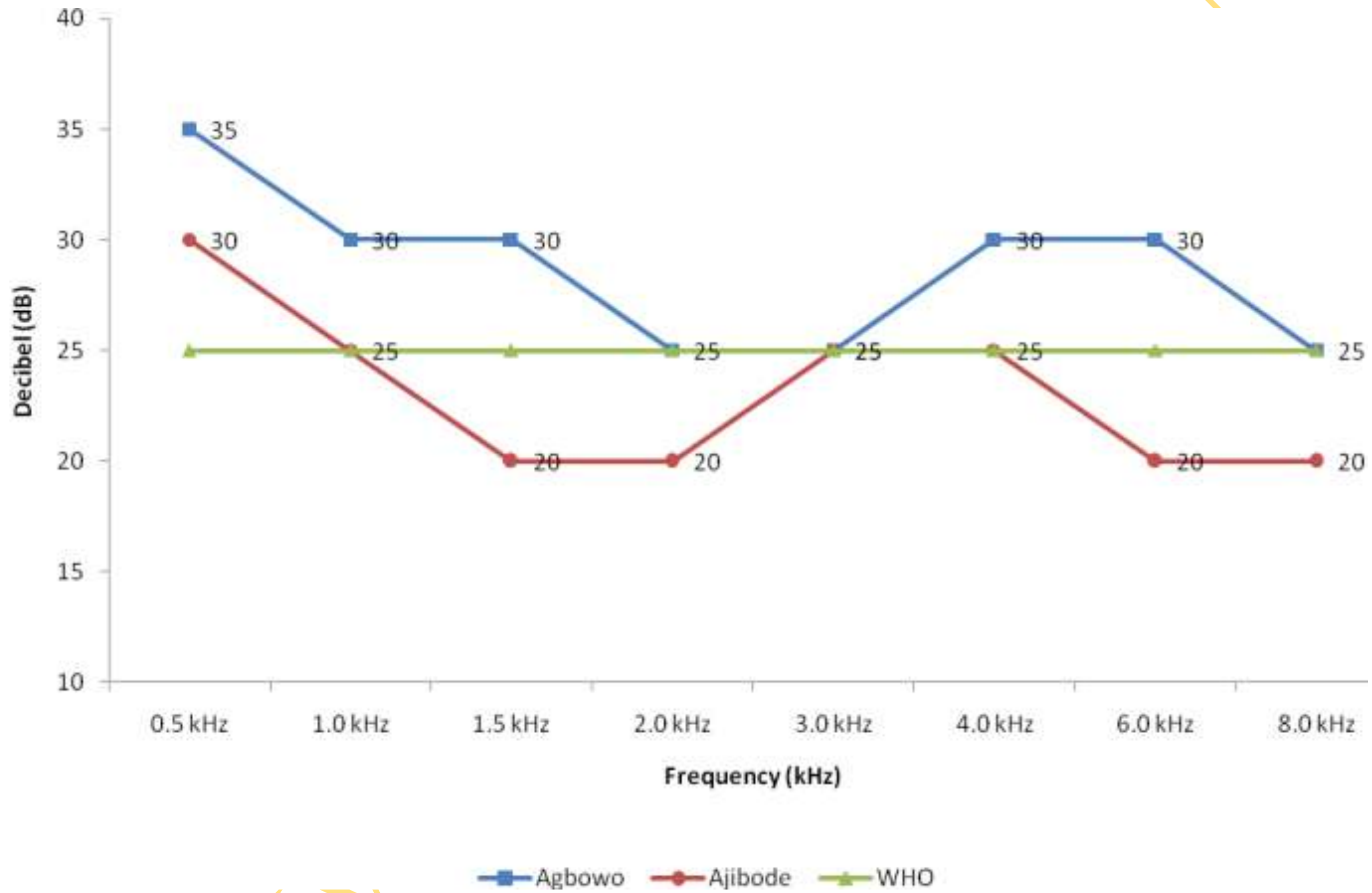


Figure 4.21: Mean hearing level at various frequencies for the right ear of respondents at Agbowo and Ajibode in comparison with WHO Standard threshold for normal hearing.

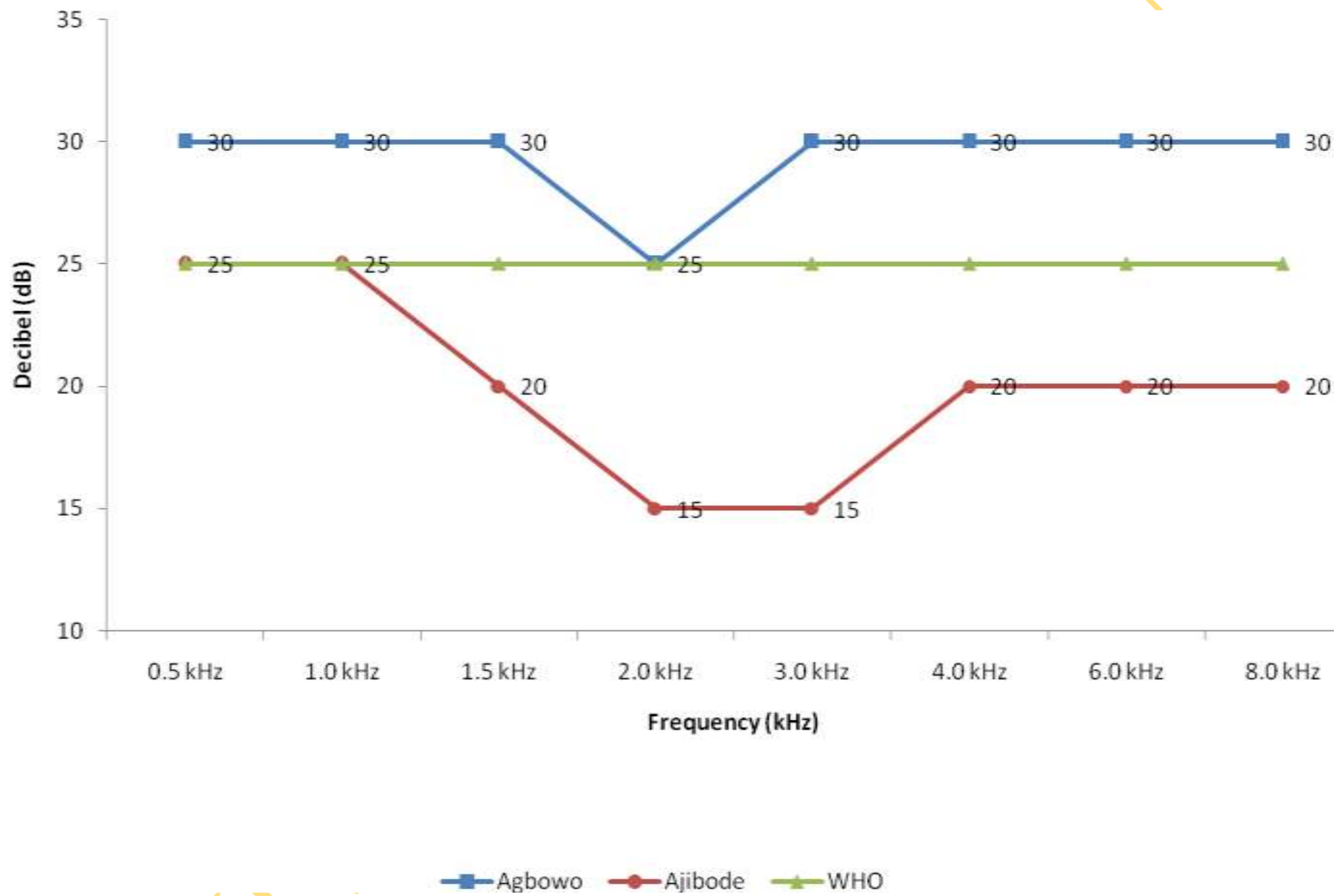


Figure 4.22.: Mean hearing level at various frequencies for the left ear of respondents at Agbowo and Ajibode in comparison with WHO Standard threshold for normal hearing

Table 4.21: Hearing status for both ears at different period of exposure to generator noise for the male and female participants

Business location	Sex	Hearing status (Both ears)	Period of Exposure (years) < 1year N(%)	1-3 years N(%)	4-8 years N(%)	Total N(%)	p-value
Agbowo	**Male**	Normal	0 (0.0)	1(4.2)	23(95.8)	24(100)	p>0.05
		Impaired	2(3.7)	5(9.3)	47(87.0)	54(100)	
		Total	2(2.6)	6(7.7)	70(89.7)	78(100)	
	Female	Normal	0(0.0)	0(0.0)	5(100)	5(100)	
		Impaired	1(2.6)	4(10.3)	34(87.2)	39(100)	
		Total	1(2.3)	4(9.1)	39(88.6)	44(100)	
Ajibode	**Male**	Normal	5(13.5)	19(51.4)	13(35.1)	37(100)	p>0.05
		Impaired	0(0.0)	9(64.3)	5(35.7)	14(100)	
		Total	5(9.8)	28(54.9)	18(35.3)	51(100)	
	Female	Normal	2(11.1)	9(50.0)	7(38.9)	18(100.0)	
		Impaired	1(6.7)	6(40.0)	8(53.3)	15(100.0)	
		Total	3(9.1)	15(45.5)	15(45.5)	33(100.0)	

CHAPTER FIVE

DISCUSSION

5.1 Characteristics and Pattern of use of Electric Generators in Study location

The erratic power supply was the main reason why majority of the respondents in Agbowo and Ajibode possesed electric generators at home and at work. Makinde *et al.*, 2008 recorded similar findings in their study. According to them, there was high level of domestic generator use in Anyigba community in Ilorin, Nigeria. Although this study is different in terms of the setting, but is indicative of the fact that there is need for urgent government intervention in the area of power supply to curb the utilization and high dependence on generator

The observation that Petrol engine generators (Tiger electric generators) are the most popular brand of generators used in both Agbowo and Ajibode commercial areas contradicted the findings of a recent study conducted by Tyler (2002), which found out that the urban incidence of diesel generators is between 96% to 98% and constitutes the major source alternative power supply as compared to petrol engines. Mogal et al., (2011) also described diesel engine generators as widely used in industrial plants and facilities in official residential buildings. This preference for petrol over diesel generators in this study may be due to the rising and unstable cost of diesel, which makes it unaffordable for commercial users. The high number of diesel engine generators observed in Agbowo as compared to Ajibode may not be unconnected with the increased need to power heavy and numerous electrical appliances (Oparaku, 2003) such as computers, photocopiers, scanners and printers.

Respondents in Agbowo reported high running cost for their generators (terms of fueling and servicing) as compared to their counterparts in Ajibode. This could be attributed to the rising and unstable cost of diesel fuel in Nigeria as price range between 1.5 to 4 times the official prices and thus a large disparity in price of what can be obtained in reality (Oparaku, 2003). Overuse and poor conditions of generators in Agbowo may be responsible for the high cost of generator maintenance (servicing and repairs). This buttresses the need for urgent government intervention in the supply of public electricity in order to meet the needs of small scale business in Nigeria. High proportion of poor conditioned generators in Agbowo as compared to Ajibode may be responsible for the high mean noise levels produced among generators in Agbowo as compared to Ajibode. Parvathi and Navaneetha, (2003) who reported that electric generators with engine conditions such as leaking silencer and engine exhaust, absence of rubber mounts can increase the level of noise emitted from generators.

The absence of generator enclosure observed for generators in Agbowo further contributed to the problem of noise within Agbowo commercial area. A similar study conducted by Franklin *et al.,* (2006) reported the effect of cabin enclosure on A-weighted equivalent sound pressure level on farm tractors. The study revealed about 76 dB (A) for cabbed tractors as opposed to 92 dB (A) for non-cabbed tractors. The author observed a 16 dB (A) reduction in noise level. Similarly, another study conducted by Cuesta and Pedro (2003) revealed that enclosing a generator can reduce the noise produced by up to 10dB. This study further emphasizes the need for generator enclosure which would serve as individual effort towards noise reduction from generators.

5.2 Work Environment Noise Levels and Related Health Effect

According to the International Programme on Chemical Safety (WHO, 1994), an adverse effect of noise is defined as a change in the morphology and physiology of an organism that results in impairment of functional capacity, or an impairment of capacity to compensate for additional stress, or increases the susceptibility of an organism to the harmful effects of other environmental influences.

The highest noise level measured in both Agbowo and Ajibode was around 11am -1pm, which was above the WHO guideline limit of 70dB(A) for a commercial environment. This may not be unconnected with the fact that respondents have the highest level of patronage and majority of the generators are in operation around that time frame. In addition, Agbowo and Ajibode are close to traffic prone areas, which could contribute to the overall noise levels.

The closeness of Agbowo and Ajibode to the University of Ibadan has contributed to the intense levels of business activity going on around both commercial environments. This may have contributed to the high mean noise level measured. Agbowo commercial area is also close to a major road (Oyo road). Traffic density obtained in Agbowo was high and revealed significant difference across the sampling time frame as motorcycles and cars increased and were high around the 11am -1pm time frame. A study conducted by Ibhaziebo et al., 2008 among Motor bike riders in benin, Nigeria corroborates this findings, revealing high noise levels of about 100 ± 10 dB 9(A) observed in motorbike parks especially around noon (12pm). Similarly, Ana et al., 2009 revealed high noise levels in areas with high traffic density in Ibadan. This may have contributed to the noise levels observed around Agbowo commercial area.

Mean noise level emitted from electric generator in operation in Ajibode 91.2dB(A) and Agbowo 100.5 dB(A) has serious public health implications and could result in deleterious auditory conditions such as hearing impairment (WHO, 1993; Berglund and Lindvall 1995; Goines and Hagler, 2007). Non auditory conditions such as annoyance may also occur. A recent study conducted by Onuu and Tawo (2006) revealved highest noise level of 99 dB(A) from generator houses in quarries and neighbouring communities. They author further reported over 80% of respondents experienced frequent annoyance episodes such as

Majority of the respondents in Agbowo who had hearing impairment had been in their present occupation for at least an average of five years (5.41 ± 1.51 years) and have been continously exposed to generator noise for an avearge of 6 hours everyday. The World health Organisation, 1999 report states that prolonged exposure to noise levels can cause permanent threshold shift or hearing impairment. Similarly, a recent study conducted by Ighoroje et al., (2004) among Nigerian traders further corroborates this findings and is indicative of the fact that continous exposure to high noise level has the potential to increase ones vulnerability to hearing impairment.

Non auditory health effects of noise pollution include interference with speech communication; disturbance of rest and sleep; psycho-physiological, mental-health and performance effects; effects on residential behaviour and annoyance; as well as interference with intended activities (WHO, 1994).

Many of the respondents in Agbowo had to raise their voices to communicate with colleagues at work. This is evident by the fact that raising one's voice usually occurs when the ambient noise level is above 85 dB (A) (Ahmed et al., 2004). This is understandable due to the high noise levels measured in this area. Lazarus, (1990) stated that the difference between speech level and interfering noise should be 15-18 dBA, furthermore it is recommended that the speech to noise ratio should be at least 15dBA (WHO, 1995). This study shows that difference between mean noise level produced from generators (interfering noise) in Agbowo (100.5dBA) and Ajibode (91.2dBA) and the speech level (50dBA for 1m away) is well above 15dBA. The implication of these finding is that noise from generators can interfere with speech communication. Therefore urgent government intervention is needed to control the noise levels emitted from generators in these commercial areas, as well as in residential areas. Adequate methods of ensuring compliance with standards should be put in place so that generators which do not meet the required standard are not allowed to operate and law breakers are heavily fined.

The proportion of respondents in Agbowo and Ajibode who had experienced sleep disturbance had also experienced irritability. Similar studies conducted by (Stansfield *et al*., 1996 and Guski *et al.*, 1999) revealed that high noise levels can cause insufficient sleep and rest which can also lead to mood shifts, irritability, and tertiary annoyance on members of the community. Berglund and lindvall, (1995) further corroborated these findings and revealed that few people, who were exposed to day time noise levels of 55 dB, reported that they had experienced sleep disturbance and mood shifts as compared to those who were exposed to noise levels below 50 dB. This may be responsible for the sleep disturbance and aggressive responses observed among respondents in this present study, especially in Agbowo where it was high as compared to Ajibode. This aggressive response could cause conflict among neighbours as majority of the respondents agreed to that fact.

5.3 Socio-demographic and Occupational Characteristics of Respondents

Age is a notable factor in noise induced hearing loss development, as older subjects above 40 years are reportedly at greater risk (NIOSH, 1998). The findings of this study revealed that, the mean age of participants in Agbowo and Ajibode was 25.3±5.3 years and 24.8±5.8 years. The age range was between 14 to 39 years. This mean age of respondents in both business areas is indicative of a relatively young population under forty years that form the working population in this study. In line with the United Nations age group clasification (2005a), adults of working age fall under the following age group (15 - 59) years. A previous study conducted among Nigerian traders revealed a mean age of 24 ± 1.3 years with age range between 14 to 40 years (Ighoroje et al., 2004). Similarly another study conducted by bisong *et al.*, (2004) among operators of grinding machine revealed mean age of 31.2 ± 1.83 years with age range of between 14 to 60 years.

Large proportion of male respondents in Agbowo and Ajibode commercial areas may be due to the nature of the job, which requires some physical exertion such as standing for long hours and operating the generator. Bisong *et al.*, 2004 and Ighoroje *et al.*, 2004 reported large proportion of male respondents as compared to females. In addition, the proportion of respondents with tertiary education in both commercial locations was high and one may attribute this to the closeness of the University campus to this commercial areas and probably the nature of the work which requires some degree of education. A similar finding was observed by Makinde *et al.*, 2008 who reported high proportion of male respondents (71.3%) with tertiary education (82.6%) as compared with females in a community based survey on social and health hazards associated with generator use.

The none usage of hearing protection devices (HPDs) among respondents in this study were attributed to reasons such as “it might interfere with hearing” and “it would cause a form of discomfort”. A similar finding was observed by Hong et al., (2008) who conducted a study on firefighters. Although the reasons are similar, the author opined that the level of education (formal) had a clear association with use of HPDs, as the lower educational level resulted in lower HPD use. This contradicted the findings of this study as respondents in both Agbowo and Ajibode had formal education, with majority having tertiary education (Agbowo: 37.2%

and Ajibode: 30.3%) and yet they did not use HPDs. These findings necessitates the need for urgent and strict environmental laws that would help to ensure that generator users protect themselves from high noise levels, furthermore the initiation of an awareness programme to further educate generator users on the benefits of using HPDs as well the demerits of not protecting their ear would go a long way to curb this dangerous practice. Hearing protection devices (HPDs) have been described as top choice for prevention of NIHL in workplaces (Hetu, 1994; Leinster *et al.*, 1994 and WorkSafeBC, 2009)

5.4 Knowledge relating to generator noise and preventive practice

High level of awareness observed among generator users in Agbowo and Ajibode on the use of hearing protection devices to protect oneself from hearing loss was not surprising as some of them were observed using clothes and scarves to cover their ears. However none of the respondents were observed using proper hearing protection devices. In a study conducted by Ologe *et al.*, 2005 in a steel rolling mill in Nigeria, the author reported that less than half of the workers properly use their Hearing Protection Devices (HPDs), and attributed this finding to the fact that they were poorly monitored and lacked adequate information. Similarly, Fisher and Fisher in 1992 suggested that risk-reduction behaviour is a result of the information people have about prevention measures. This was supported by another study carried out among South African miners, which showed that arbitrary use of hearing protection was based mainly on the workers personal perception to noisy situations (Kahan and Ross, 1994). The result of this present study is not surprising as the Federal Environmental Protection Agency (FEPA) whose statutory responsibility is to enforce the use of HPDs in noisy work environments is ineffective and requires immediate attention.

Onsite observations in this present study revealed that in extreme situations some of the workers were engaged in using either clothes or scarves to cover their ears, nonetheless having good knowledge on the use of ear plugs and earmuffs in Agbowo(82.9%) and Ajibode(86.7%). This is consistent with the research of Akande and Ologe, (2003) and Olajide, (2006) carried out in Nigeria, where individuals were observed to use cotton wool or wraps of clothing to protect their ears, while some women tie their headgear over their ears.

A study conducted by Amedofu *et al* (1998) on hearing impairment among workers in a surface gold mining company in Ghana, revealed that noise induced hearing loss is absolutely preventable through the consistent and proper use of ear protection such as ear-plugs and earmuffs. The effectiveness of hearing protective equipment in preventing noise induced hearing loss is greatly dependent on the correct use and wearing of the equipment (Sulkowiski et al., 2007).

The present study showed that majority of the respondents had good knowledge on the preventive practices such as work rotation and isolation of generator, but the knowledge of these preventive practices was not reflected in their day to day activities while working with electric generators, as many of them still placed their electric generators indoor when it is operation. Similar findings was observed among operators of music recording/retail centres (Ologe et al., 2005). Respondents claimed they were aware of link between loud music and hearing loss, but recorded a noise level was 96 ± 2.5 dB(A) which was above recommended standard and thus capable of damaging the ear. The author was of the opinion that lowering the music volume was within the control of the operator and yet this was not done, suggesting that being enlightened may not guarantee the practice of preventive behaviour and use of HPDs, rather individual desire to change is important.

5.5 Perception of risk towards generator noise exposure and hearing loss

Effective behavioral change is facilitated by greater knowledge, experience, and personal risk perception (Gregson *et al.*, 1998). The findings of this present study revealed that majority of the respondents in Agbowo and Ajibode considered or perceived hearing loss to be a serious health problem. A Swedish study involved a sample of workers (majority: males) in manufacturing industry and measured perception almost the same way as I did (item: I think it would be big problem if I lost my hearing). It reported that the majority (90%) of respondents considered hearing loss to be a serious health problem (Svensson et al., 2004). Although, the subjects of this study were different (in terms of occupation, workplaces etc.), they arrived at similar findings as this present study. The implication of this is that nobody wants to go deaf but being deaf is something they can live with considering their actions.

However, majority of the respondents in this study considered NIHL as a less concerning hazard than other health conditions such cancer, accident and chemical burn. A pilot study conducted by Davies and Shoveller (2007) among workers in a beverage industry also corroborated this findings revealing that noise was considered a low priority among other issues such as accidents, poor sanitation, product quality and absenteeism. Similarly, a recent study on firefighters on noise exposure and hearing loss (Oisaeng *et al.*, 2008) showed that fire fighters thought that noise and NIHL was a major occupational health problem; however when asked to name the major problems in terms of mortality and workdays lost, NIHL turned out to be a low priority hazard compared to other health problems.

The lower level of concern about noise induced hearing loss (NIHL) among the respondents compared to other health problems/diseases can be explained by the fact that risk perception is influenced by a lot of factors including dread, control, or extent of damage/severity of consequences (Sjöberg *et al.,* 2004). Thus, the lower ranking of NIHL among a given set of hazards or diseases may be a reflection of the relative contributions of these factors. Risk perception is influenced by dread (Sjöberg *et al.*, 2004), and cancer is viewed as a dreadful disease. Moreover, perception of risk is thought to be higher for events that can have catastrophic effects or events on which people have little control (Sjöberg *et al.*, 2004). Thus, proportions assigned by the respondents in Agbowo and Ajibode to chemical burns and accidents could be explained by this.

Respondents in Agbowo (47.6%) as compared to Ajibode (25.1%) perceived that “the chance of developing hearing loss at their workplace was not low” and on site investigation revealved that majority of the respondents did not take preventive action (Use of HPDs, enclosure of generator) against the risk. This findings contradicted those of Lee et al., (2005) who suggested that perceived severity, perceived vulnerability and benefits are likely to motivate individuals to take preventive action. Although, perceived vulnerability may have influenced respondents in Agbowo (67.1%) and Ajibode (51.7%) to feel it was neccessary to reduce the noise from electric generators, it did not motivate them to protect themselves from the harmful effect of noise by using hearing protective devices (HPDs) or enclosing their generators. This finding is indicative of the fact that, the effect of noise on hearing is slow and insidious and many neglect their health until a large threshold shift (hearing loss) has occured. Since there is a greater concern about developing hearing loss at Agbowo commercial area, this can act as a motivational factor in taking preventive actions as suggested by Lee *et al.*, 2005. The above result is meaningful as respondents in Agbowo consider themselves at risk of developing hearing loss, the government should seize this opportunity to enlighten them of the importance of their hearing ability on the general quality of their life and provide adequate means of noise reduction strategies for generators in this commercial environment.

5.6 Hearing Impairment among respondents

The prevalence of hearing impairment was appreciably high among the proportion that participated in the audiologic evaluation. A higher prevalence of hearing impairment was detected among respondents in Agbowo (76.2%) as compared to their counterpart in Ajibode (34.5%). Logistic regression also revealed that generator users in Agbowo were about 6 times more likely of developing hearing impairment than those in Ajibode. This finding was not surprising considering the high level of noise recorded in Agbowo as compared to Ajibode. Similar studies conducted among African workers (Ighoroje et al., 2004; Boateng and Amedofu, 2004; Bisong et al; 2004) revealed higher prevalence of hearing impairment among workers in noisy environments. A recent study conducted among machinist in Ibadan also revealed an appreciable high prevalence of 26.5% and 29.6% among machinist and resaw workers respectively (Enweasor, 2008).

The results of hearing impairment from this study showed that at 4-8years of exposure, over 66.4% of the workers had developed hearing impairment. Although the result was not statistically significant, logistic regression revealed that workers who have spent 4-8 years working in Agbowo business area are about two times more likely to develop hearing impairment than their counterparts who had spent less number of years in Ajibode. This is in agreement with the findings of Ighoroje et al., (2004) who in a case study on Nigerian traders found hazardous noise levels above 90dB, and further demonstrated that over 90% of traders who had worked for a period of over five years had developed hearing impairment. This implies that increased exposure to noise level increases vulnerability to hearing impairment.

In Ajibode, hearing impairment was slightly more among respondents who had spent 1-3 years (17.9%) as compared to those who had spent 4-8 years (15.5%) contradicts the findings of Anomoharan at al (2009) who reported that both the sound level and duration of exposure determines the ability to damage hearing. The variation observed in here may be due to other factors such as genetic or hormonal.

This study examined the hearing status for each ear revealing a large proportion of hearing impairment on the right ear for participants in Agbowo (87.8%) as compared to Ajibode (45.2%) within 4-8 years at work. The outcome of this study was at variance with the report of Satterfield et al., (2001) who noted that hearing impairment on the right ear was less than when compared to the left ear among soldiers. However, Ighoroje et al., 2004 who reported hearing impairment asymmetry among some industrial workers with the right ear more affected suggested that the source and direction of the sound was closer to the right ear in the subjects studied. It is yet uncertain which of the two ears is more susceptible to damage by noise, but persistent stimulation of any ear and firing of the hair cells can lead to wear, tear and adaptive changes (Satterfield, 2001). This difference relative to the findings of this study can be explained by the positioning of the weapons by these soldiers. The possible reason for this asymmetry in this present study is uncertain, as the position of generator users and the generator varies.

Noise Induced hearing loss (NIHL) occurred mostly at higher frequency range of 3000-6000Hz. NIHL was also seen at lower frequencies such as 2000Hz. Findings in this study were consistent with similar work done by Ighoroje *et al.,* (2004) who reported noise induced hearing loss at higher frequencies among Nigerian traders. Similarly, Ibhazehiebo *et al.,* (2008) who conducted a study on impact of noise on commercial motor bike riders also observed noise induced hearing loss at higher frequencies. This suggest that majority of the respondents are developing noise induced hearing loss which is usually observed at higher frequency (especially at 4000Hz) and spreads to lower frequency levels

In Agbowo a slightly higher proportion of females (87.2%) as compared to males (87%) by hearing impairment. Whereas in Ajibode the highest proportion was recorded for male

(64.3%) as compared to females (53.3%). The onset of impairment appears faster in the males than the females exposed to same noise source. The basis of this difference is uncertain; hence more studies would be required to establish this trend. However McFadden (1999) had also reported a sex differences in the onset of hearing impairment in Chinchillas. He suggested it may be due to differences between the acoustical properties between the outer and middle ear ruling out differences in noise exposure history, recreational activities, and dietary factors since the study was carried out among chinchillas and not humans.

Furthermore, correlation of duration of exposure with hearing loss at various frequencies shows a significant positive correlation at all the frequencies from 500Hz to 8000Hz. This implies that the duration of exposure to generator noise is important in the aetiology of hearing impairment found among generator users. With time and further exposure, their hearing loss will worsen and probably lead to more severe deafness. This in line with the findings of Bisong et al., (2004) who in a study on hearing acuity of grinding machine operators found significat positive correlation between duration of exposure to grinding machine noise and hearing impairment. On the contrary, positive correlation was found only at frequencies of 2000Hz and 4000Hz. This difference may be due to the lenght of hours at which this grinding machine operators use the machine as compared to generator users.

Age also correlated significatly with hearing impairment at all the frequencies from 500Hz to 8000Hz. This confirms that hearing impairment worsens with age (Erway *et al.*, 1996 and Mather *et al.*, 2005), even though the respondents were relatively young (14-39). This study further corroborates the findings of Bisong et al., (2004), who age matched respondents to control confounders. Although, respondents in this present study were not age matched, correlation was significant and showed that increase in age was closely associated with increased hearing threshold. Multivariate analysis (logistic regressin) showed that age was not significantly associated with hearing loss of respondents in Agbowo and Ajibode.

Significant elevation of hearing threshold at all frequencies (500Hz to 8000Hz) for air conduction indicates that generator noise is capable of causing both low and high frequency hearing loss (mild to moderate deafness) in Agbowo as compared to Ajibode. This further emphasizes the urgent need of government intervention through the development of a consistent, transparent policy that would regulate the influx and utilization of generators in the country

5.7 Implication of findings on Environmental Health Management

This research sugguest that multiple interventions are required in tackling the problem of noise exposure from electric generators. The use of generator in Nigeria is inevitable due to the epileptic power supply and high demand for electricity. Nevertheless, users must engage in preventive strategies to reduce the risk associated with exposure to generator noise. According to Tandon *et al*., (1998), the main sources of noise in a generator are the cooling fan cover, silencer shell, silencer cover and engine crankcase. Poor conditions of these parts can lead to doubling effect of the sound produced. Generator users must be made aware of this information so as to ensure that those parts of their generators are protected and measures to reduce or attenuate the noise from those parts be implemented.

The FEPA (1991) regulation requires employers to provide employees with proper protection against the effects of noise exposure when sound levels exceed an 8-hour time weighted average (TWA) of 90 dBA (Permissible Exposure Level). The protective measures may be provided either through engineering controls. Engineering noise controls which involves controlling the hazard at the source should be adopted. Such measures include modifications of the machinery, the workplace operations, and the layout of the workroom. In fact, the best approach for noise hazard control in the work environment, is to eliminate or reduce the hazard at its source of generation, either by direct action on the source or by its confinement (NIOSH, 1996).

If these control measures fail to reduce the noise within the acceptable limits, personal protective equipment shall be provided and used. As a consequence, personal protective devices are often the sole means to protect the hearing of workers. Hearing protective devices (HPDs) can work as a short-term solution to prevent NIHL if their use is carefully planned, evaluated, supervised, and consistent [NIOSH, 1998; Arezes and Miguel, 2002]. If engineering controls are insufficient, OSHA requires employers to provide employees with HPDs.

The Occupational Safety and Health Administration (OSHA) provides for standards to protect the hearing health of workers exposed to noise on the job. These standards require that workers be included in a hearing conservation program when exposed to 85 dBA and greater time-weighted average TWA the use of hearing protection becomes mandatory (OSHA, 1983). Additionally, NIOSH (1998) recommends that whenever employee noise exposures equal or exceed an 8-hour (TWA) sound level of 85 dBA (action level), the employer shall develop and administer a Hearing Conservation Program (HCP). This program can be implemented and enforced by the Federal Ministry of Environment (FEPA) on commercial settings that use generators for business activity. This would go a long way in reducing noise pollution from electric generators and create awareness on noise induced hearing loss. The hearing conservation program involves 5 stages namely:

Noise Monitoring*:* All continuous, intermittent and impulsive sound levels from 80 to 130 dBA shall be integrated into the computation of the 8-hr TWA. Employees exposed at or above action levels shall be notified of results of monitoring. Daily or weekly noise monitoring of these commercial environments would ensure strict compliance to noise regulation. Surveillance of workplace noise exposure is vital to prevention of NIHL because it can identify the most problematic industries and occupations, and because it can be used to evaluate the effectiveness of intervention activities (Tak, 2009)

Audiometric Testing: Baseline audiograms would be obtained before the commencement of exposure to workplace noise. Informing employees when audiogram indicates a standard threshold shift which is work related.

Hearing Protection Devices: Employees exposed to noise levels at or above an 8-hour TWA of 85dBA or 90 dBA shall wear hearing protectors. This shall be done with proper fitting and supervision. Noise Induced Hearing loss (NIHL) can be prevented by the consistent use of HPDs (NIOSH, 1996).

***Education and Training**:* Annual training would be required for all workers exposed to noise levels at or above an 8-hour TWA of 85 dBA. Relevant information should be provided on effects of noise, advantages of ear protection and audiometric testing. The awareness of commercial business operators on the hazards associated with generator noise must be raised using factual and evidence-based information on Noise Induced Hearing Loss (NIHL).

Health education is suggested to be an important tool in the prevention of occupational diseases (Porru et al., 1993). Thus, an educational campaign should be undertaken to educate workplace stakeholders about NIHL and Engineered Noise Control (ENC). The campaign should focus on educating workplace stakeholders about ENC and its effectiveness. They should also be made aware of the place of HPD in the hierarchy of control measures. Moreover, they also need to be educated about the limitations of HPD and what impact these limitations (tightness of fit and protection lost due to not wearing HPD for the entire shift) have on the effectiveness of HPD. They should also be educated about the effectiveness of hearing tests.

***Record Keeping**:*The National Environmental Standards and Regulations Enfocement Agency (NESREA) should retain noise exposure measurements for at least two years. This would include worker details and noise levels and audiologic evaluation results which should be done throughout the duration of the workers stay on the job

Designing and Fabrication of new engines and by setting a noise limits at least 5–10 dB (A) below the prescribed standard can be helpful in controlling noise exposure level (Okah, 1996). This would involve a collaborative effort between manufacturers of electric generators and government towards the control of noise in our environment. Furthermore, the implementation of the Hearing Conservation Program into the small scale businesses which are usually overlooked by Government would help prevent hearing loss. The combination of strategies ensures that weaknesses of one are counterbalanced by the strengths of the others.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The research explored the work environment noise levels as determined the proportion of hearing impairment among generator users in Agbowo and Ajibode commercial areas. This study suggest that noise levels in Agbowo and Ajibode commercial areas were significantly different. Excessive noise levels measured in Agbowo commercial area were in excess of about 20dB(A) when compared with noise levels in Ajibode. Noise levels in Agbowo commercial area was higher than the WHO guideline limit for office work environment as compared to Ajibode. Audiometric tests suggested hearing impairment in both commercial locations, but a higher proportion in Agbowo. Respondents in Agbowo are relatively more exposed to noise from electric generators, particularly those running on diesel fuel compared to petrol engine, than in Ajibode, and this was associated with increased hearing impairment as determined by audiometry. Generator users in Agbowo are vulnerable to hearing impairment as the risk of developing hearing impairment in Agbowo was six times that of Ajibode. The level of vulnerability increased with years of service as majority of those who had worked for longer years had hearing impairment as compared to those who had worked for less number of years..

The level of knowledge of generator hazards was generally high among respondents in Agbowo and Ajibode with majority being knowledgeable of the effects of noise exposure on their health and also aware of the insidious onset and slow developmental pace of noise induced hearing loss (NIHL). However, they had poor knowledge about the harmful level of noise at work. Majority of respondents in both Agbowo and Ajibode considered noise induced hearing loss (NIHL) to be of lower concern compared to other health effects. A dichotomy between knowledge and practice was observed in this study. The results show high degree of knowledge among generator users on the hazards of generator noise, but this was not reflected in self protective practices, as onsite observations revealed non use of hearing protective devices (HPDs) and working at close distances with generators.

Considering the important role that hearing plays in our lives, the following recommendations are made at individual and government levels:

6.2 Recommendations

Exposure Reduction at Individual level

Individuals should try to reduce their exposure to noise from electric generators which could be achieved through the following ways:

1. Health education is an important tool in prevention of occupational disease/injury, therefore an educational campaign should be undertaken to educate users of generator and stakeholders on hazards associated with generator use and related environmental issues.
2. Generator users must regulate the use of generators, by reducing the number of hours they operate it.
3. Generators should be not be placed inside residential buildings to to avoid exposure to excessive noise levels.
4. Generator sets should be maintained regularly while old ones should be replaced.
5. Avoid chronic exposure to generator noise especially from diesel engines since it produces higher noise levels than petrol engines.
6. Short breaks should be taken as often as possible to avoid continuous exposure to generator noise, especially during peak periods of the day 11am – 1pm
7. Determine your hearing function regularly with the aid of an audiometer once every six months.
8. Consult a physician upon experiencing symptoms in relation to generator use.

For Government

Based on the findings of this study, it can be recommended that the federal Government should as a matter of urgency properly address the problem of**:**

1. Erratic power supply in view to ameliorate hazards associated with generator use.
2. Excessive generator use in commercial settings, as efforts should be made to reduce the number of hours of use.

3. Ensuring that generators meet the standards in terms of noise level produced, condition of engine and exhaust
4. Inadequate manpower and utilities like vehicles for the ministry of environment which would have ensured compliance through enforcement of rules and regulation guiding ownership and use of generator
5. Importation of generators; Nigeria currently ranks first in Africa, therfore the importation of generators into the country must be halted, so that adequate attention would be given to developing our nations power sector.

6.3 Future Outlook

1. A case control study would be ideal to establish or show a strong relationship between participants exposed to constant generator noise source and the development of hearing loss in comparison with another group that is not exposed to generator noise.
2. There is need to carry out a similar study among generator users at home in order to compare data and proffer effective solutions that would be more generalizable.
3. An interventional study is required to determine effective strategies that could be used in reducing and controlling the noise from electric generators
4. The commercial areas used in this study were both located in Ibadan, and as such, it is not reasonable to make a generalization of the findings for the entire country. As this study appears to be the first of its kind, the results should be validated by further studies in future.

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APPENDICES

Appendix I

ENVIRONMENTAL HEALTH SURVEY

QUESTIONNAIRE ON WORK ENVIRONMENT NOISE LEVEL AND AUDITORY STATUS OF GENERATOR USERS IN AGBOWO AND AJIBODE COMMERCIAL AREAS OF IBADAN, NIGERIA

SERIAL NO_______

Dear Respondent,

Yesufu Luqman Alegbema is my name and I am a post graduate student with specialization in Environmental Health in the Faculty of Public Health, College of Medicine, University of Ibadan. I am presently on a research titled "**Work Environment Noise Level and Auditory Status of Generator Users in Agbowo and Ajibode Commercial areas**". This research is purely for academic purpose. The findings will be of immense benefit in the area of noise exposure from generator. Feel free to express your opinion and I assure you that your responses will never be traced to you. If you would like to participate in the presentation of the data, a book will be given to you where your phone number will be entered and you would be contacted in due course.

Thanks for your co-operation.

YESUFU Luqman Alegbema

INSTRUCTION: PLEASE TICK (√) OR FILL IN ANSWERS WHERE APPROPRIATE

SECTION A: SOCIO – DEMOGRAPHIC INFORMATION

1. Age of respondent (as at last birthday)____________
2. Sex: 1. Male [ ] 2. Female [ ]
3. Religion: 1. Christianity [ ] 2. Islam [ ] 3. Traditional [ ]
   4. Others (specify) ____________
4. Ethnic group: 1. Yoruba [ ] 2. Hausa [ ] 3. Ibo [ ]
   4. Others (please specify) ______________________
5. What are your main duties here?
   1. Sales person [ ] 2. Electronic repairer [ ] 3. Data analyst [ ]
   4. Others (specify) **---**
6. Work location? 1. Agbowo [ ] 2. Ajibode [ ]
7. Educational Status 1. None [ ] 2. Primary [ ] 3. Secondary [ ] 4. Tertiary [ ]

8. How long have you been in this occupation?_______________

1. <6months [ ] 2. >6months [ ] 3. More than a year [ ]

9. How many hours in a day are you at work? _________________

10. Do you wear hearing protection devices while at work? 1. Yes [ ] 2. No [ ]

10A If No to (10), Why? ____

11. Do you consider your workplace noisy? 1. Yes [ ] 2. No [ ]

12. If (11) is Yes, would you like a quieter workplace? 1. Yes [ ] 2. No [ ]

13. If (11) is No, why?____

SECTION B: PATTERN OF GENERATOR USE

(Please continue with this section if you use a generator at work or at home)

---

14. Do you use an electric generator for business? 1. Yes [ ] 2. No [ ]

14A. If Yes to 14. State the reason why ___________________________

15. What type of electric generator do you posses at work?

1. Petrol [ ] 2. Diesel [ ] 3. Diesel and Petrol [ ]

16.On the average, how many hours in a day Do you use you generator for______

17. How long have you been using this generator?____________(months)

18. Do you service your generator regularly? 1. Yes [ ] 2. No [ ]

19. if yes, how often?

1. Everyday [ ] 2. Everyweek [ ] 3. Once a month [ ] 4. Twice a month [ ]

5. Others____________________________________

20. Do you possess an electric generator at home? 1. Yes [ ] 2. No [ ]

21. If yes, where do you place it?

	OPTION	**YES [√]**	**NO [√]**
1	Indoor		
2	Outdoor		

22. Is your electric generator at home put in an enclosure? 1. Yes [ ] 2. No [ ]

23. On the average, how many hours in a day do you use your electric generator at home?

____

24. Do your neigbours at home possess an electric generator? 1. Yes [ ] 2. No [ ]

25. How many hours in a day do they use it?___________________________________

SECTION C: KNOWLEDGE INFORMATION (MULTIPLE CHOICE ANSWER)

INSTRUCTION: For each question, please tick (√) all that applies

26. The utilization of electric generators does pose harm to human health?
    1. True [ ] 2. False [ ] 3. Dont know [ ]
27. Mechanical devices such as grinding machines car engines and electric generators produce noise? 1. True[ ] 2. False [ ] 3. Dont know [ ]
28. The Noise from an electric generator can cause harm to the ear? 1. True[ ] 2. False [ ] 3. Dont know [ ]
29. There is a heightened public concern over the influx of generators into the country as well as there use? 1. True[ ] 2. False [ ] 3. Dont know [ ]
30. The utilization of generator at home can cause conflict among neighbours? 1. True[ ] 2. False [ ] 3. Dont know [ ]
31. Filling an electric generator with fuel while it is in operation can lead to an explosion? 1. True[ ] 2. False [ ] 3. Dont know [ ]
32. Are you aware that you can be protected from generator noise? 1. True[ ] 2. False [ ] 3. Dont know [ ]
33. Global warming can occur due to generator use? 1. True[ ] 2. False [ ] 3. Dont know [ ]
34. Carbon monoxide poisoning can occur due to generator use?
    1. True [ ] 2. False [ ] 3. Dont know [ ]
35. Malaria can occur due to generator use? 1. True[ ] 2. False [ ] 3. Dont know [ ]
36. Regular generator maintanance can reduce the noise from generator?
    1. True [ ] 2. False [ ] 3. Dont know [ ]
37. Fire outbreak can occur due to poor usage generator?
    1. True[ ] 2. False [ ] 3. Dont know [ ]
38. Blindness could result from generator usage? 1. True [ ] 2. False [ ] 3. Dont know [ ]
39. Electric shock can occur due to generator usage? 1. True[ ] 2. False [ ] 3. Dont know [ ]
40. Avoidance is a way of protection from hazards of generator use?
    1. True [ ] 2. False [ ] 3. Dont know [ ]
41. Utilization of Personal Protective devices such as ear plugs and ear muffs cannot protect one from generator noise? 1. True[ ] 2. False [ ] 3. Dont know [ ]
42. Work rotation is a way of protection from hazards of generator noise?
    1. True [ ] 2. False [ ] 3. Dont know [ ]

43. Utilizing your generator indoor is a way of protecting oneself from hazards associated with its use? 1. True[ ] 2. False [ ] 3. Dont know [ ]

44. Utilizing your generator outdoor is not a way of protecting oneself from hazards associated with its use? 1. True[ ] 2. False [ ] 3. Dont know [ ].

45. Please give other methods you know that can protect a worker from noise from generator

____

46. Are you aware of any safe sound level for work environment 1. Yes [ ] 2. No [ ]

47. if Yes to (46) please give the sound level details ________________________________

SECTION D: PERCEPTION INFORMATION

Please indicate how much you agree or disagree with each statement in a scale from 1 (strongly agree) to 5 (strongly disagree). Please tick your responses. (√)

Strongly agree **(SA)** Agree **(A)** Undecided **(UD)** Disagree **(D)** Strongly disagree **(SD)**

		(SA)	**(A)**	**(UD)**	**(D)**	**(SD)**
48	Noise at work is a major contributor to a worker's loss of quality of life					
49	It is considered a major disability to lose one's hearing capability.					
50	Exposure to high levels of noise from an electric generator can cause hearing disability					
50	A business operator's chance of developing hearing disability from this workplace is very low					
51	The workers performance is not affected by the noise from an electric generator					
52	Despite the hazards associated with the use of electric generators, it is a blessing to mankind					
53	It is not necessary to reduce the noise from electric generators					
54	Hearing test done annually cannot warn against possible hearing loss					

55 Please indicate how serious/concerning to you (mark "1" beside the category that you think to be the most serious/concerning one and "4" the least serious/concerning one)

A. Cancer ___
B. Accident ___
C. Chemical Burn ___
D. Noise Induced Hearing loss ____

SECTION E: HEALTH STATUS INFORMATION

Please tick [√] as appropriate the option that represents your opinion.

56. How would you rate your health status? 1. Excellent[ ] 2. Good [ ] 3. Fair [ ]

57. Do you think working here has negatively affected your health? 1.Yes[ ] 2. No [ ] 3. Dont know[ ]

58. How would you rate your hearing function? 1. Excellent[ ] 2. Good [ ] 3. Fair [ ]

59. Do you find it difficult to hear clearly while at work? 1. Yes [ ] 2. No [ ]

60. Did you have hearing problem before you started working here? 1. Yes [ ] 2. No [ ]

61. Have you ever suffered fromany of the any of the health conditions in the table below while working with an electric generator?

	Noise related health problems	**Yes**	**No**	**Never**
a.	Tinnitus (ringing in the ear)			
b.	Ear pains			
c.	Headaches			
d.	Tiredness			
e.	Inability to Sleep well			
f.	Irritability/ Easily annoyed			
g.	Lack of concentration/forgetfulness			
h.	Aggressive/rude response to situations			
I.	Speech Interference			
j.	Poor social interaction/not friendly			

62. Are you presently on any drug? 1 Yes[ ] 2. No [ ]

63. If "Yes", please name the drug_______________________________________

64. Have you ever done an audiometric test to determine your hearing function?

1. Yes [ ] 2.No[ ]

65. Would you like a free audiometric test to determine your hearing status?

1. Yes [ ] 2. No [ ]

Appendix II

OBSEVATIONAL CHECKLIST 1

DATA FORM FOR GENERATOR CHARACTERISTICS AND DISTANCE FROM RESPONDENTS POSITION

AG1	AG2	AG3	AJ1	AJ2	AJ3

Serial No..

Date..

Generator User Sex and Age ....

1. Generator Type (Make)..
2. Generator Model Number..
3. Generator Engine (Petrol/Diesel)...
4. Generator Location (Indoor/Outdoor)...
5. Generator Age in terms of how long it has been used for (months)......................
6. Noise measurement of Generator

Ambient Noise Level of Electric Generator dB(A)	Environmental Noise Level of Electric Generator when turned on dB(A)

7. Distance of Generator from User position...(ft)
8. Generator Sound Attenuation

Feature	**Yes**	**No**
Enclosed		
Greater than 5m away		

9. Condition of Generator Parts

Features	**Poor (√)**	**Good (√)**	**Absent (√)**
Rubber mounts			
Silencer			
Alternator			
Crankcase			
Cooling fan cover			
Spark plug			
Frame			

10. Other Environmental Noise Sources within Location

Noise Source	Present	Absent	Distance From Shop (Ft)
Traffic			
Religious Centre			
Music Outlet			
Industry			
Market			
Mechanic Workshop			

11. Dimension of shop

Section	Feets(Ft)
Ceiling Height	
Shop Length	
Shop Width	
Window Length	
Window Width	
Door Length	
Door Width	

12. Hourly Traffic every 15 minutes

Types	6-8am	11-1pm	3-6pm
Motorcycles			
Cars			
Trucks			
Buses			

Appendix III

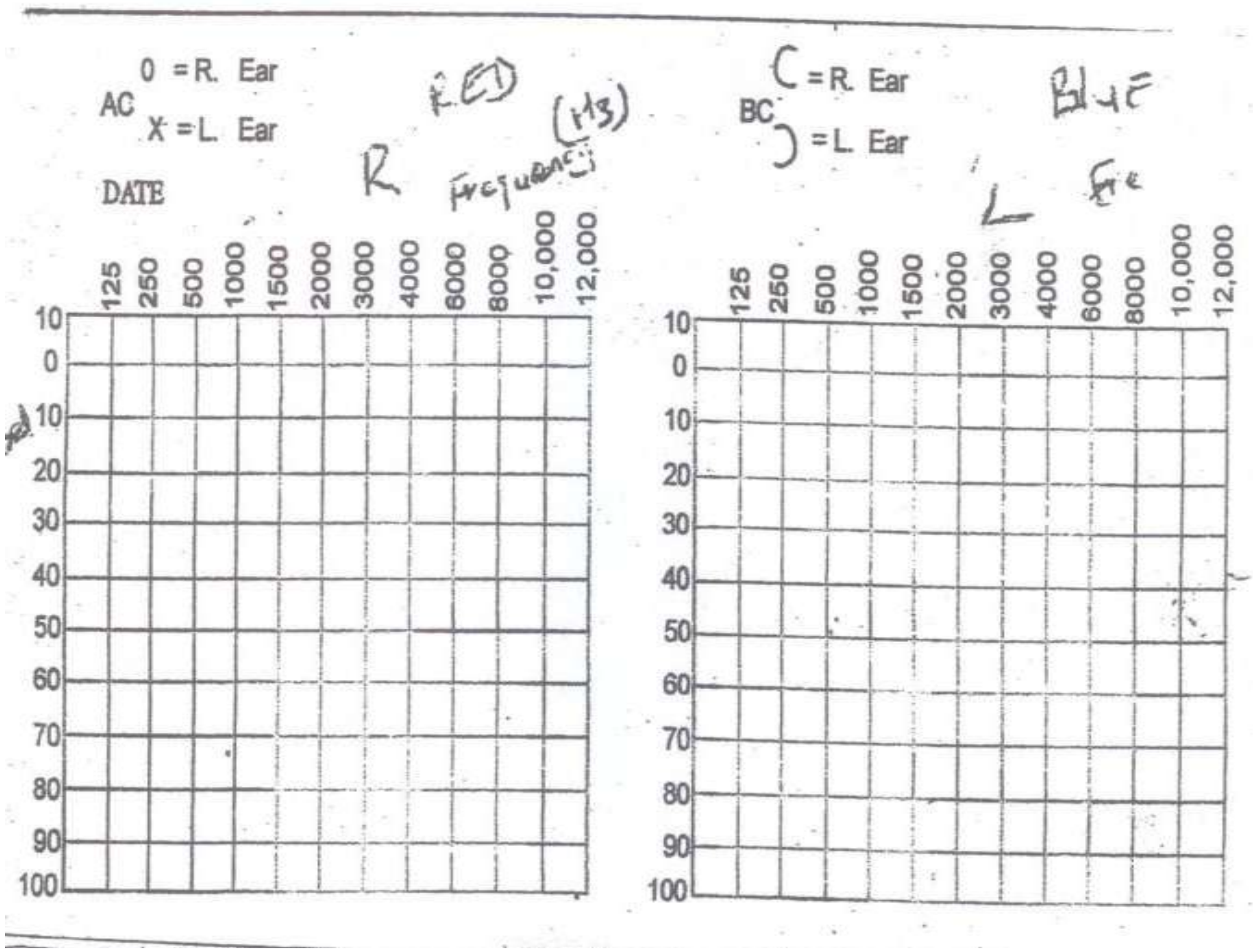
AUDIOMETRIC SCREENING FORM

Form No.......................................

Code No.......................................

Occupation...................................

Sex...



Appendix IV

INFORMED CONSENT

IRB Research Approval Number UI/EC/08/0134

This Approval will elapse on …11../…12…/…2009….

Title of Research:

Work Environment Noise Levels and Auditory status of Generator Users in Agbowo and Ajibode Commercial Areas of Ibadan, Ibadan, Nigeria

Name and Affiliation of Researcher:

This study is being conducted by Mr Yesufu Luqman Alegebema, Department of EMSEH, Faculty of Public Health, College of Medicine, University of Ibadan.

Purpose(s) of Research:

To determine the noise levels from electric generators and the potential auditory and non-auditory effects associated with its use

Procedure of the research, what shall be required of each participants and approximate total number of participants that would be involved in the research:

This research would be divided into three phases. Proportional allocation will be applied to the various identified strata based on the population. In the first phase, the researcher would characterize the generators and measure the noise levels from them. In the second phase every research participant would be expected to complete a questionnaire and there would be about 515 participants (Agbowo: 304 and Ajibode: 211). In the third phase about 40%(206) of the participants would be enrolled and allocated proportionally based on the stratification. This phase involves an exposure assessment (determination of the noise level determination from generator of respondent and Audiometric assessment to determine the hearing function of the research participants. Phase III participants would be selected on certain exclusion and inclusion criteria.

Expected duration of research and of participant(s) involvement:

This research will be expected to last for an approximately three months and we expect that you would not spend more than two days.

Risk(s):

It is expected that this research would pose no physical, biological or social harm to all the research participants as all the procedures involved are non invasive and no samples (blood, urine, saliva) are collected. It is understood that in the process of recall in phase 1 certain emotional harm might be experienced. This type of harm is not anticipated in this study.

Cost of Participating, If any, of joining the research:

Your participating in this research will cost you nothing but your small amount and effort.

Benefit(s):

This research would help you in determining the following

a) The noise level potentially exposed to from electric generator
b) The noise levels in the business environment which you are exposed to .
c) Determine the present hearing function of participants .

Confidentiality:

All information collected in the study would be given code numbers and no names will be collected. Phone numbers collected would only be used to contact the participants for Phase III and in the presentation of the findings only. This will ensure that no link would be established to you. As part of my responsibility to conduct this research properly, officials from the Oyo State Ministry of Health Ethical Review Committee may have access to these records.

Voluntariness:

Your participation in this research is entirely voluntary.

Consequences of participant's decision to withdraw from research:

You can also choose to withdraw from the research at anytime. Please note that some information that has be obtained about you before you choose to withdraw may have been modified or used in reports and publication. These cannot be removed anymore. However the researcher promise to make good faith efforts to comply with your wishes as much as is practicable.

Any apparent or potential conflict of Interest:

This research work is strictly for academic purpose and is self funded. No attempt is being made to favour any generator manufacturing company as non of these companies participated in any way in this study.

Statement of Person Obtaining Informed Consent:

I have fully explained this research work to ___________________________________

and have given sufficient information, including about risk and benefits, to make an informed decision.

Date_______________________ Signature_________________

Name_______________________________________

Statement of person giving Consent:

I have read the description of the research. I understand that that my participation in this research is voluntary. I know enough about the purpose, methods, risk and benefits of the research study to judge that I want to participate in it. I understand that I may freely stop being a part of the study at any time. I have received a copy of the consent form.

Date_________________________Signature________________

Name_________________________

Detailed contact information including contact address, telephone, fax, e-mail and any other contact information of researcher(s), institutional HREC and Head of Institution:

This research has been approved by the Oyo State Ministry of Health Ethical Review Committee and the UI/UCH Ethical Review Committee. If you have any question about your participation in this research you can contact the Principal Investigator Yesufu L.A. at the Department of EMSEH, College of Medicine, University of Ibadan. His phone number and email address are 08035739653 and esi_y7@yahoo.com respectively. You can also contact the Head of Department of EMSEH, College of Medicine, University of Ibadan.

Thanks.

Appendix V

APPROVAL OBTAINED FROM UI/UCH ETHICAL REVIEW COMMITTEE

INSTITUTE FOR ADVANCED MEDICAL RESEARCH AND TRAINING (IAMRAT)

COLLEGE OF MEDICINE, UNIVERSITY OF IBADAN. IBADAN, NIGERIA.

E-mail: imratcomui@yahoo.com

UI/UCH EC Registration Number: **NHREC/05/01/2008a**

NOTICE OF FULL APPROVAL AFTER FULL COMMITTEE REVIEW

Re: Work Environment Noise Levels and Auditory Status of Generator Users in Agbowo and Ajibode Commercial Areas of Ibadan, Nigeria.

UI/UCH Ethics Committee assigned number: UI/EC/11/0146

Name of Principal Investigator: **Luqman A. Yesufu**

Address of Principal Investigator: Department of EMSEH,
College of Medicine,
University of Ibadan, Ibadan

Date of receipt of valid application: 17/06/2011

Date of meeting when final determination on ethical approval was made: **20/10/2011**

This is to inform you that the research described in the submitted protocol, the consent forms, and other participant information materials have been reviewed and *given full approval by the UI/UCH Ethics Committee.*

This approval dates from 20/10/2011 to 19/10/2012. If there is delay in starting the research, please inform the UI/UCH Ethics Committee so that the dates of approval can be adjusted accordingly. Note that no participant accrual or activity related to this research may be conducted outside of these dates. *All informed consent forms used in this study must carry the* UI/UCH EC *assigned number and duration of* UI/UCH EC *approval of the study.* It is expected that you submit your annual report as well as an annual request for the project renewal to the UI/UCH EC early in order to obtain renewal of your approval to avoid disruption of your research.

The National Code for Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations and with the tenets of the Code including ensuring that all adverse events are reported promptly to the UI/UCH EC. *No changes are permitted in the research without prior approval by the* UI/UCH EC *except in circumstances outlined in the Code. The* UI/UCH EC *reserves the right to conduct compliance visit to your research site without previous notification.*

UI/UCH EC 20 2011 APPROVED COLLEGE OF MEDICINE, U.I.

Prof. A. Ogunniyi
Director, IAMRAT
Chairman, UI/UCH Ethics Committee
E-mail: uiuchirc@yahoo.com

Research Units ▪ Genetics & Bioethics ▪ Malaria ▪ Environmental Sciences ▪ Epidemiology Research & Service ▪ Behavioural & Social Sciences ▪ Pharmaceutical Sciences ▪ Cancer Research & Services ▪ HIV/AIDS

Appendix VI

NOISE LEVEL FROM ELECTRIC GENERATORS IN AGBOWO

S/N	Generator Name	Generator Condition	Generator Model	Sound Level dB(A)
1	**Tiger**	Good	TG 950	88.70
2		Poor	TG 950	78.50
3		Poor	TG 1000	75.80
4		Poor	TG 1000	79.30
5		Good	TG 1000	77.10
6		Good	TG 1000	76.20
7		Poor	TG 2.7kVA	103.20
8		Poor	TG 2.7kVA	94.30
9		Good	TG 5.5 kVA	96.50
10		Poor	TG 5.5 kVA	99.00
11		Poor	TG 2.2 kVA	74.20
12		Poor	TG 2.2 kVA	82.50
13		Poor	TG 2.3 kVA	73.70
14		Poor	TG 2.2 kVA	94.90
15		Good	TG 2.2 kVA	93.70
16		Poor	TG 2.2 kVA	94.70
17	Sifang	Poor	195 (10KLW)	88.60
18		Poor	295 (15KLW)	107.10
19		Poor	395 (20KLW)	95.10
20		Poor	195 (7.5KLW)	97.0

NOISE LEVEL FROM ELECTRIC GENERATORS IN AGBOWO (CONT'D)

S/N	Generator Name	Generator Condition	Generator Model	Sound Level dB(A)
21	Elepaq	Poor	LB 2200DX	88.90
22		Poor	LB 2200DX	88.60
23		Poor	-	107.10
24		Good	LB 2200DX	95.10
25		Good	LB 2200DX	120.00
26		Poor	LB 2200DX	110.00
27		Poor	-	99.90
28		Poor	LB 2900	99.90
29		Poor	-	110.00
30		Poor	LB 3700 DX	89.50
31		Poor	-	86.90
32		Poor	LB 3700 DXE	102.00
33		Good	LB 2900	98.00
34	Yamaha	Good	BX 3600 G	80.70
35		Poor	BX 3600 G	80.90
36		Poor	BX 3600 G	81.20
37		Poor	EF 4000	76.20
38		Good	EF 4100	78.10
39		Good	EF 4000	78.30
40		Poor	EF 4200	98.60
41		Poor	EF 4000	105.30

NOISE LEVEL FROM ELECTRIC GENERATORS IN AGBOWO (CONT'D)

S/N	Generator Name	Generator Condition	Generator Model	Sound Level dB(A)
42	Sumec	Poor	SPG 3000 2.5KVA	79.40
43		Poor	SPG 3000 2.5KVA	110.00
44		Poor	SPG 3000 2.5KVA	80.20
45		Good	SPG 3000 2.5KVA	90.50
46		Good	SPG 3000 2.5KVA	89.40
47		Poor	SPG 3000 E1	76.00
48		Poor	SPG 3000 E1	71.00
49		Poor	SPG 3000 E1	96.70
50		Poor	SPG 3000 E1	109.20
51		Poor	SPG 3000 E2	71.00
52		Poor	SPG 3000 2.5KVA	116.40
53		Poor	SPG 3000 2.5KVA	71.40
54		Good	SPG 3000 E1	129.40
55	Lister	Poor	195 (7.5KLW)	99.90
56	Lister	Good	295 (15KLW)	99.90
57	Delma	Poor	195 (7.5KLW	110.00
58	Imex	Poor	195 (7.5KLW)	110.5
59	Mackfort	Poor	295 (15KLW)	100.10
60	Mackfort	Poor	195 (7.5KLW)	105.1
61	Imex	Poor	195 (7.5KLW)	99.70
62	Imex	Poor	195 (7.5KLW)	120.0

Appendix VII

NOISE LEVEL FROM ELECTRIC GENERATORS IN AJIBODE

S/N	Generator Name	Generator Condition	Generator Model	Sound Level dB(A)
1	**Tiger**	Good	TG 950	88.7
2		Poor	TG 950	78.5
3		Poor	TG 950	75.80
4		Poor	TG 950	79.30
5		Good	TG 950	77.10
6		Good	TG 1000	76.20
7		Poor	TG 1000	103.20
8		Poor	TG 1000	94.30
9		Good	TG 2.7 kVA	96.50
10		Poor	TG 2.7 kVA	99.00
11		Good	TG 2.7 kVA	74.20
12		Good	TG 2.7 kVA	82.50
13		Good	TG 2.7 kVA	73.70
14		Good	TG 2.2 kVA	99.00
15		Good	TG 2.2 kVA	74.20
16		Poor	TG 2.2 kVA	72.50
17		Good	TG 950	73.70
18		Poor	TG 950	81.70
19		Poor	TG 950	82.00
20		Poor	TG 950	63.90

NOISE LEVEL FROM ELECTRIC GENERATORS IN AJIBODE (CONT'D)

S/N	Generator Name	Generator Condition	Generator Model	Sound Level dB(A)
21	Elepaq	Good	LB 2900	101.00
22		Good	LB 2900	99.10
23		Good	LB 2900	98.00
24		Good	LB 2900	96.00
25		Good	LB 2900	71.90
26		Good	LB 2900	79.30
27		Good	LB 3700 DX	77.00
28		Good	LB 3700 DX	70.50
29		Good	LB 3700 DX	75.00
30		Good	LB 3700 DX	100.20
31	Sumec	Poor	SPG 3000 2.5KVA	79.40
32		Poor	SPG 3000 2.5KVA	110.00
33		Poor	SPG 950	80.20
34		Good	SPG 950	90.50
35	Sifang	Good	195 (7.5KLW)	95.00
36		Poor	195 (7.5KLW)	94.90
37		Poor	195 (7.5KLW)	99.50
38	Yamaha	Good	EF 4200	98.70
39		Good	EF 4200	98.00
40		Good	EF 4200	97.50

Appendix VIII

AUDIOMETRY OF RIGHT AND LEFT EAR OF AGBOWO GENERATOR USERS

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
1	50.00	40.00	25.00	38.30	40.00	40.00	25.00	35.00	73.30	> 50	Impaired
2	35.00	30.00	10.00	25.00	30.00	20.00	20.00	23.30	48.30	<50	Normal
3	40.00	40.00	20.00	33.30	35.00	30.00	10.00	25.00	58.30	> 50	Impaired
4	35.00	25.00	20.00	26.60	25.00	20.00	15.00	20.00	46.60	<50	Normal
5	40.00	40.00	30.00	38.30	30.00	40.00	25.00	31.60	69.90	> 50	Impaired
6	35.00	30.00	10.00	25.00	30.00	15.00	10.00	18.30	43.30	<50	Normal
7	35.00	25.00	20.00	26.60	30.00	25.00	10.00	21.60	48.20	<50	Normal
8	50.00	45.00	30.00	41.60	40.00	30.00	25.00	31.60	72.60	> 50	Impaired
9	45.00	40.00	30.00	40.00	45.00	35.00	30.00	36.60	76.60	> 50	Impaired
10	35.00	35.00	10.00	26.60	40.00	30.00	10.00	26.60	53.20	> 50	Impaired
11	40.00	35.00	20.00	31.60	30.00	35.00	20.00	28.30	59.90	> 50	Impaired
12	30.00	15.00	5.00	16.60	30.00	20.00	15.00	21.60	38.20	<50	Normal
13	45.00	35.00	30.00	36.60	40.00	30.00	20.00	30.00	66.60	> 50	Impaired
14	45.00	35.00	30.00	36.60	50.00	45.00	40.00	45.00	81.60	> 50	Impaired
15	40.00	35.00	20.00	31.60	40.00	45.00	30.00	38.30	69.90	> 50	Impaired
16	45.00	50.00	35.00	43.30	35.00	35.00	35.00	35.00	78.30	> 50	Impaired
17	45.00	14.00	30.00	40.00	40.00	35.00	35.00	35.00	75.00	> 50	Impaired

AUDIOMETRY OF RIGHT AND LEFT EAR OF AGBOWO GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
18	50.00	45.00	40.00	45.00	35.00	30.00	15.00	26.60	71.60	> 50	Impaired
19	45.00	35.00	30.00	40.00	40.00	30.00	20.00	30.00	66.60	> 50	Impaired
20	45.00	40.00	25.00	36.60	35.00	30.00	15.00	26.60	63.20	> 50	Impaired
21	40.00	35.00	20.00	31.60	40.00	30.00	25.00	31.60	63.20	> 50	Impaired
22	50.00	45.00	30.00	46.60	40.00	35.00	25.00	33.30	79.90	> 50	Impaired
23	45.00	35.00	20.00	33.30	35.00	35.00	20.00	30.00	63.30	> 50	Impaired
24	45.00	35.00	20.00	33.30	40.00	40.00	30.00	36.60	61.60	> 50	Impaired
25	30.00	30.00	15.00	25.00	55.00	55.00	50.00	53.30	98.30	> 50	Impaired
26	50.00	50.00	35.00	45.00	35.00	35.00	25.00	33.30	58.30	> 50	Impaired
27	35.00	30.00	10.00	25.00	40.00	40.00	25.00	35.00	78.30	> 50	Impaired
28	55.00	45.00	30.00	43.30	45.00	45.00	35.00	41.60	88.20	> 50	Impaired
29	50.00	50.00	40.00	46.60	25.00	25.00	35.00	28.30	56.60	> 50	Impaired
30	30.00	30.00	25.00	28.30	35.00	35.00	30.00	33.30	61.60	> 50	Impaired
31	30.00	35.00	20.00	28.30	30.00	35.00	20.00	28.30	54.90	> 50	Impaired
32	30.00	30.00	20.00	26.60	25.00	20.00	20.00	21.60	46.60	<50	Normal
33	30.00	25.00	20.00	25.00	35.00	30.00	25.00	30.00	55.00	> 50	Impaired
34	30.00	30.00	15.00	25.00	25.00	30.00	25.00	26.60	63.20	> 50	Impaired
35	30.00	30.00	30.00	30.00	30.00	20.00	20.00	23.30	53.30	> 50	Impaired

AUDIOMETRY OF RIGHT AND LEFT EAR OF AGBOWO GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
36	35.00	35.00	40.00	36.60	45.00	40.00	35.00	40.00	76.60	> 50	Impaired
37	40.00	40.00	30.00	36.60	45.00	40.00	25.00	40.00	71.60	> 50	Impaired
38	35.00	30.00	30.00	31.60	40.00	35.00	25.00	33.30	64.90	> 50	Impaired
39	30.00	35.00	30.00	31.60	40.00	35.00	30.00	35.00	66.60	> 50	Impaired
40	35.00	35.00	25.00	31.60	25.00	30.00	25.00	26.60	63.20	> 50	Impaired
41	40.00	35.00	35.00	36.60	45.00	35.00	25.00	35.00	73.30	> 50	Normal
42	45.00	40.00	30.00	38.30	35.00	35.00	20.00	30.00	56.60	> 50	Impaired
43	30.00	25.00	25.00	26.60	30.00	30.00	20.00	26.60	63.20	> 50	Impaired
44	40.00	35.00	35.00	36.60	30.00	30.00	25.00	28.30	61.60	> 50	Impaired
45	30.00	30.00	25.00	28.30	35.00	30.00	30.00	31.60	74.90	> 50	Impaired
46	45.00	40.00	45.00	43.30	30.00	30.00	20.00	26.60	64.90	> 50	Impaired
47	40.00	35.00	40.00	38.30	30.00	20.00	30.00	26.60	61.60	> 50	Impaired
48	40.00	35.00	30.00	35.00	30.00	25.00	25.00	26.60	61.60	> 50	Impaired
49	40.00	40.00	30.00	36.60	30.00	30.00	40.00	33.30	69.90	> 50	Impaired
50	40.00	35.00	35.00	36.60	30.00	20.00	20.00	23.30	59.90	> 50	Impaired
51	30.00	25.00	30.00	28.30	30.00	25.00	25.00	26.60	54.90	> 50	Impaired
52	20.00	30.00	25.00	25.00	30.00	30.00	20.00	26.60	51.60	> 50	Impaired

AUDIOMETRY OF RIGHT AND LEFT EAR OF AGBOWO GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
53	35.00	30.00	30.00	31.60	30.00	30.00	25.00	28.30	59.90	> 50	Impaired
54	35.00	30.00	30.00	31.60	35.00	25.00	20.00	26.60	58.20	> 50	Impaired
55	30.00	25.00	30.00	28.30	30.00	30.00	20.00	26.60	54.90	> 50	Impaired
56	35.00	30.00	25.00	30.00	25.00	20.00	20.00	20.00	50.00	<50	Normal
57	35.00	30.00	30.00	31.60	40.00	35.00	35.00	36.60	68.20	> 50	Impaired
58	40.00	30.00	30.00	33.30	40.00	35.00	30.00	35.00	68.30	> 50	Impaired
59	30.00	25.00	25.00	26.60	35.00	20.00	20.00	21.60	48.20	<50	Normal
60	40.00	30.00	30.00	33.30	40.00	30.00	30.00	33.30	66.60	> 50	Impaired
61	40.00	35.00	35.00	36.25	30.00	30.00	25.00	28.30	64.90	> 50	Impaired
62	30.00	20.00	20.00	23.30	20.00	15.00	20.00	18.30	41.60	<50	Normal
62	35.00	30.00	30.00	31.60	30.00	25.00	15.00	23.30	54.90	> 50	Impaired
64	50.00	50.00	45.00	48.30	40.00	40.00	30.00	36.60	84.90	> 50	Impaired
65	35.00	30.00	20.00	28.30	30.00	20.00	15.00	21.60	49.40	<50	Normal
66	30.00	20.00	10.00	20.00	30.00	25.00	20.00	25.00	45.00	<50	Normal
67	30.00	30.00	25.00	25.00	30.00	25.00	15.00	23.30	48.30	<50	Normal
68	35.00	35.00	25.00	31.60	40.00	35.00	30.00	35.00	67.10	> 50	Impaired
69	40.00	30.00	20.00	33.30	30.00	30.00	15.00	25.00	58.30	> 50	Impaired
70	40.00	35.00	30.00	35.00	30.00	25.00	30.00	28.30	63.30	> 50	Impaired

AUDIOMETRY OF RIGHT AND LEFT EAR OF AGBOWO GENERATOR USERS (CONTD)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
71	35.00	30.00	25.00	30.00	30.00	30.00	30.00	30.00	60.00	> 50	Impaired
72	45.00	40.00	35.00	40.00	30.00	30.00	20.00	26.60	66.60	> 50	Impaired
73	50.00	40.00	35.00	41.60	35.00	40.00	35.00	40.00	81.60	> 50	Impaired
74	35.00	35.00	25.00	31.60	40.00	40.00	25.00	35.00	66.60	> 50	Impaired
75	40.00	40.00	25.00	35.00	30.00	30.00	25.00	28.30	63.30	> 50	Impaired
76	30.00	30.00	15.00	25.00	30.00	30.00	20.00	26.60	51.60	> 50	Impaired
77	40.00	40.00	20.00	35.00	35.00	35.00	25.00	31.60	66.60	> 50	Impaired
78	35.00	35.00	30.00	33.30	25.00	20.00	15.00	20.00	53.30	> 50	Impaired
79	40.00	35.00	25.00	33.30	30.00	25.00	10.00	21.60	54.60	> 50	Impaired
80	30.00	30.00	20.00	26.60	25.00	25.00	15.00	21.60	48.20	<50	Normal
81	15.00	25.00	15.00	20.00	25.00	15.00	5.00	18.30	38.30	<50	Normal
82	35.00	20.00	20.00	25.00	30.00	25.00	20.00	25.00	50.00	> 50	Impaired
83	30.00	25.00	20.00	30.00	40.00	40.00	35.00	38.30	63.30	> 50	Impaired
84	50.00	40.00	45.00	45.00	30.00	30.00	30.00	30.00	75.00	> 50	Impaired
85	50.00	40.00	35.00	41.60	30.00	30.00	25.00	28.30	69.90	> 50	Impaired
86	35.00	35.00	40.00	36.60	20.00	20.00	25.00	21.60	58.20	> 50	Impaired
87	35.00	30.00	30.00	31.60	30.00	20.00	15.00	21.60	53.20	> 50	Impaired

AUDIOMETRY OF RIGHT AND LEFT EAR OF AGBOWO GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
88	30.00	25.00	25.00	26.60	30.00	30.00	25.00	28.30	54.90	> 50	Impaired
89	35.00	30.00	40.00	35.00	35.00	35.00	40.00	36.60	71.60	> 50	Impaired
90	35.00	30.00	20.00	28.30	30.00	25.00	20.00	25.00	53.30	> 50	Impaired
91	35.00	30.00	15.00	26.60	30.00	30.00	10.00	23.30	49.90	<50	Normal
92	30.00	15.00	20.00	21.60	30.00	25.00	20.00	25.00	46.60	<50	Normal
93	35.00	30.00	20.00	28.30	30.00	25.00	30.00	35.00	70.00	> 50	Impaired
94	25.00	5.00	15.00	15.00	20.00	5.00	20.00	25.00	53.30	> 50	Impaired
95	35.00	30.00	30.00	31.60	35.00	30.00	.00	8.30	23.30	<50	Normal
96	30.00	30.00	15.00	25.00	25.00	20.00	20.00	28.30	59.90	> 50	Impaired
97	40.00	35.00	30.00	35.00	30.00	25.00	5.00	18.30	43.30	<50	Normal
98	35.00	30.00	15.00	28.30	30.00	25.00	10.00	21.60	56.60	> 50	Impaired
99	30.00	25.00	35.00	30.00	25.00	20.00	25.00	26.60	54.90	> 50	Impaired
100	30.00	25.00	25.00	26.25	25.00	25.00	20.00	21.25	51.25	> 50	Impaired
101	25.00	20.00	15.00	23.30	30.00	25.00	20.00	21.60	47.90	<50	Normal
102	30.00	25.00	25.00	26.60	25.00	20.00	20.00	25.00	48.30	<50	Normal
103	20.00	15.00	15.00	16.66	25.00	20.00	20.00	21.60	48.20	<50	Normal
104	35.00	30.00	30.00	31.60	30.00	20.00	20.00	21.60	38.32	<50	Normal

AUDIOMETRY OF RIGHT AND LEFT EAR OF AGBOWO GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
105	30.00	30.00	35.00	31.60	30.00	25.00	20.00	23.33	54.93	> 50	Impaired
106	20.00	15.00	15.00	16.60	20.00	30.00	20.00	25.00	56.60	> 50	Impaired
107	25.00	25.00	15.00	21.60	20.00	25.00	25.00	25.00	41.60	<50	Normal
108	30.00	20.00	20.00	23.33	25.00	30.00	15.00	20.00	41.60	<50	Normal
109	20.00	15.00	25.00	20.00	25.00	20.00	30.00	26.60	49.90	<50	Normal
110	40.00	30.00	30.00	33.30	30.00	25.00	20.00	23.30	43.33	<50	Normal
111	35.00	30.00	25.00	30.00	25.00	20.00	20.00	25.00	58.30	> 50	Impaired
112	35.00	30.00	20.00	28.30	35.00	35.00	10.00	18.33	48.33	<50	Normal
113	35.00	30.00	25.00	30.00	20.00	35.00	30.00	33.30	61.60	> 50	Impaired
114	30.00	35.00	30.00	31.60	30.00	35.00	25.00	26.60	56.60	> 50	Impaired
115	35.00	30.00	30.00	31.60	25.00	20.00	30.00	31.60	63.20	> 50	Impaired
116	35.00	30.00	30.00	31.60	25.00	20.00	10.00	18.30	49.90	<50	Normal
117	30.00	25.00	30.00	28.30	40.00	45.00	35.00	40.00	68.30	> 50	Impaired
118	35.00	30.00	30.00	31.60	35.00	30.00	30.00	31.60	63.20	> 50	Impaired
119	35.00	30.00	40.00	35.00	30.00	35.00	35.00	33.30	68.30	> 50	Impaired
120	35.00	25.00	20.00	25.00	30.00	30.00	45.00	35.00	60.00	> 50	Impaired
121	20.00	15.00	20.00	18.30	35.00	35.00	30.00	33.30	51.60	> 50	Impaired
122	30.00	30.00	30.00	30.00	30.00	25.00	20.00	25.00	55.00	> 50	Impaired

Appendix IX

AUDIOMETRY OF RIGHT AND LEFT EAR OF AJIBODE GENERATOR USERS

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
1	30.00	30.00	15.00	25.00	35.00	30.00	20.00	28.30	48.30	<50	Normal
2	30.00	35.00	20.00	28.30	30.00	25.00	10.00	21.60	49.90	<50	Normal
3	25.00	20.00	15.00	20.00	30.00	20.00	20.00	23.30	43.30	<50	Normal
4	20.00	20.00	5.00	15.00	20.00	10.00	5.00	15.00	30.00	<50	Normal
5	30.00	20.00	10.00	20.00	30.00	25.00	15.00	23.30	43.30	<50	Normal
6	20.00	25.00	20.00	21.60	35.00	25.00	15.00	25.00	46.60	<50	Normal
7	40.00	40.00	25.00	35.00	30.00	35.00	20.00	28.30	63.30	> 50	Impaired
8	40.00	40.00	30.00	36.60	30.00	25.00	30.00	25.00	61.60	> 50	Impaired
9	40.00	30.00	30.00	33.30	35.00	30.00	30.00	31.60	64.90	> 50	Impaired
10	25.00	20.00	20.00	21.60	25.00	20.00	20.00	21.60	43.20	<50	Normal
11	25.00	20.00	20.00	21.60	30.00	25.00	25.00	26.60	48.20	<50	Normal
12	35.00	30.00	30.00	31.60	35.00	30.00	25.00	30.00	61.60	> 50	Impaired
13	30.00	25.00	25.00	26.60	35.00	30.00	30.00	31.60	58.20	> 50	Impaired
14	30.00	25.00	25.00	26.20	25.00	20.00	20.00	21.60	48.20	<50	Normal
15	30.00	25.00	20.00	25.00	30.00	25.00	25.00	26.60	51.60	> 50	Impaired
16	25.00	20.00	20.00	21.60	30.00	25.00	25.00	26.60	48.20	<50	Normal

AUDIOMETRY OF RIGHT AND LEFT EAR OF AJIBODE GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
17	30.00	25.00	25.00	26.60	30.00	25.00	25.00	26.60	53.20	> 50	Impaired
18	30.00	25.00	25.00	26.60	25.00	20.00	20.00	21.60	48.20	<50	Normal
19	35.00	30.00	30.00	31.60	30.00	25.00	25.00	26.60	58.20	> 50	Impaired
20	35.00	30.00	30.00	31.60	35.00	30.00	30.00	31.60	63.30	> 50	Impaired
21	30.00	25.00	20.00	25.00	30.00	20.00	20.00	23.30	48.30	<50	Normal
22	20.00	30.00	30.00	26.60	30.00	25.00	20.00	25.00	51.60	> 50	Impaired
23	20.00	20.00	25.00	21.60	30.00	35.00	30.00	31.60	53.20	> 50	Impaired
24	45.00	40.00	40.00	41.60	45.00	40.00	40.00	41.60	83.20	> 50	Impaired
25	30.00	30.00	20.00	26.60	30.00	20.00	20.00	23.30	49.90	<50	Normal
26	35.00	35.00	20.00	30.00	25.00	20.00	20.00	21.60	51.60	> 50	Impaired
27	35.00	30.00	30.00	31.60	40.00	30.00	30.00	33.30	64.90	> 50	Impaired
28	5.00	10.00	10.00	8.33	20.00	10.00	5.00	11.60	19.93	<50	Normal
28	30.00	30.00	10.00	23.30	30.00	25.00	20.00	25.00	48.30	<50	Normal
30	20.00	15.00	10.00	13.30	20.00	10.00	15.00	15.00	28.30	<50	Normal
31	35.00	35.00	35.00	30.00	50.00	45.00	40.00	45.00	80.00	> 50	Impaired
32	30.00	25.00	25.00	26.60	35.00	30.00	30.00	31.60	58.20	> 50	Impaired
33	30.00	25.00	25.00	26.60	30.00	25.00	25.00	26.60	53.20	> 50	Impaired

AUDIOMETRY OF RIGHT AND LEFT EAR OF AJIBODE GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
34	35.00	30.00	30.00	31.60	40.00	35.00	35.00	36.60	68.20	> 50	Impaired
35	30.00	25.00	20.00	25.00	35.00	30.00	30.00	31.60	56.60	> 50	Impaired
36	35.00	30.00	30.00	31.60	30.00	25.00	25.00	26.60	58.20	> 50	Impaired
37	35.00	30.00	30.00	31.60	40.00	35.00	35.00	36.60	68.20	> 50	Impaired
38	30.00	30.00	15.00	25.00	20.00	10.00	5.00	11.60	36.60	<50	Normal
39	35.00	30.00	20.00	28.30	30.00	30.00	20.00	26.60	54.90	> 50	Impaired
40	40.00	30.00	25.00	31.60	25.00	20.00	15.00	20.00	51.60	> 50	Impaired
41	20.00	20.00	10.00	16.60	15.00	15.00	.00	10.00	26.60	<50	Normal
42	15.00	5.00	.00	5.00	15.00	5.00	5.00	5.00	10.00	<50	Normal
43	15.00	10.00	5.00	10.00	10.00	5.00	10.00	8.30	18.30	<50	Normal
44	29.00	10.00	15.00	15.00	20.00	20.00	5.00	15.00	30.00	<50	Normal
45	20.00	15.00	15.00	16.60	20.00	10.00	10.00	13.30	28.30	<50	Normal
46	20.00	25.00	25.00	21.60	25.00	25.00	15.00	21.60	43.20	<50	Normal
47	20.00	20.00	10.00	16.60	15.00	5.00	15.00	13.30	29.90	<50	Normal
48	25.00	20.00	15.00	20.00	15.00	5.00	.00	6.60	26.60	<50	Normal
49	40.00	40.00	30.00	36.60	25.00	15.00	15.00	18.30	54.90	> 50	Impaired
50	25.00	20.00	10.00	18.30	25.00	20.00	10.00	18.30	36.60	<50	Normal

AUDIOMETRY OF RIGHT AND LEFT EAR OF AJIBODE GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
51	30.00	25.00	15.00	23.30	25.00	25.00	10.00	20.00	43.30	<50	Normal
52	30.00	25.00	40.00	31.60	30.00	30.00	45.00	26.00	57.60	> 50	Impaired
53	20.00	15.00	10.00	15.00	20.00	20.00	15.00	18.30	33.30	<50	Normal
54	20.00	15.00	10.00	15.00	20.00	5.00	10.00	11.60	26.60	<50	Normal
55	25.00	20.00	10.00	18.30	20.00	20.00	10.00	16.60	34.90	<50	Normal
56	30.00	25.00	15.00	23.30	20.00	15.00	10.00	15.00	38.30	<50	Normal
57	15.00	20.00	10.00	15.00	20.00	20.00	15.00	18.30	33.30	<50	Normal
58	30.00	25.00	5.00	20.00	25.00	20.00	5.00	16.60	36.60	<50	Normal
59	30.00	25.00	15.00	23.30	15.00	20.00	10.00	15.00	38.30	<50	Normal
60	30.00	30.00	20.00	26.60	35.00	30.00	15.00	26.60	53.20	> 50	Impaired
61	25.00	25.00	10.00	20.00	15.00	10.00	10.00	11.60	31.60	<50	Normal
62	25.00	20.00	15.00	20.00	25.00	15.00	10.00	16.60	36.60	<50	Normal
63	25.00	30.00	15.00	25.00	25.00	25.00	15.00	21.60	44.90	<50	Normal
64	25.00	30.00	10.00	21.60	5.00	10.00	10.00	8.30	29.90	<50	Normal
65	30.00	25.00	15.00	23.30	20.00	20.00	10.00	20.00	43.30	<50	Normal
66	20.00	15.00	10.00	15.00	10.00	5.00	.00	5.00	20.00	<50	Normal
67	30.00	20.00	10.00	20.00	25.00	20.00	15.00	20.00	40.00	<50	Normal

AUDIOMETRY OF RIGHT AND LEFT EAR OF AJIBODE GENERATOR USERS (CONT'D)

S/N	Hearing levels of different frequencies at 20dB (Right)			Pure tone Average (PTA)	Hearing levels of different frequencies at 20dB (Left)			Pure tone Average (PTA)	L+R (PTA)	comment	Remarks
	500Hz	**1000Hz**	**2000Hz**		**500Hz**	**1000Hz**	**2000Hz**				
68	20.00	10.00	5.00	11.60	10.00	10.00	5.00	8.30	19.90	<50	Normal
69	25.00	10.00	10.00	15.00	25.00	10.00	10.00	15.00	30.00	<50	Normal
70	10.00	20.00	10.00	13.30	10.00	15.00	10.00	11.60	24.90	<50	Normal
71	20.00	30.00	25.00	25.00	25.00	15.00	15.00	18.30	43.30	<50	Normal
72	30.00	25.00	30.00	26.60	20.00	20.00	15.00	18.30	44.90	<50	Normal
73	30.00	30.00	20.00	26.60	30.00	20.00	15.00	21.60	48.20	<50	Normal
74	20.00	20.00	15.00	18.30	10.00	10.00	15.00	11.60	29.90	<50	Normal
75	20.00	20.00	5.00	15.00	20.00	15.00	10.00	15.00	30.00	<50	Normal
76	25.00	15.00	5.00	15.00	20.00	15.00	10.00	16.60	31.60	<50	Normal
77	25.00	20.00	10.00	18.30	20.00	20.00	10.00	16.60	34.90	<50	Normal
78	20.00	15.00	15.00	16.60	20.00	15.00	10.00	15.00	31.60	<50	Normal
79	30.00	25.00	15.00	23.30	35.00	30.00	10.00	25.00	48.30	<50	Normal
80	25.00	10.00	5.00	13.30	30.00	25.00	25.00	26.60	39.90	<50	Normal
81	20.00	15.00	5.00	13.30	25.00	10.00	5.00	13.30	26.60	<50	Normal
82	20.00	30.00	30.00	26.60	30.00	20.00	30.00	26.60	53.20	> 50	Impaired
83	40.00	35.00	35.00	36.60	30.00	30.00	30.00	30.00	66.60	> 50	Impaired
84	35.00	30.00	40.00	33.30	35.00	40.00	45.00	40.00	73.30	> 50	Impaired

Appendix X

GPS spatial mapping data for Agbowo Commercial area

Business Area	Classified location	Sampling Points	Longitude (°N)	Latitude (°E)	Elevation (m)
Agbowo	AG1	EC1	7°26’27.00”N	3°54’26.35”E	783
		EC2	7°26’25.17”N	3°54’26.42”E	613
		EC3	7°26’23.81”N	3°54’26.92”E	692
		EC4	7°26’25.30”N	3°54’28.25”E	759
		EC5	7°26’27.38”N	3°54’28.34”E	680
	AG2	RSS1	7°26’29.27”N	3°54’25.36”E	675
		RSS2	7°26’30.78”N	3°54’25.33”E	613
		RSS3	7°26’31.93”N	3°54’25.59”E	690
		RSS4	7°26’33.85”N	3°54’25.37”E	680
		RSS5	7°26’35.26”N	3°54’25.46”E	696
	AG3	SSS1	7°26’29.76”N	3°54’27.39”E	765
		SSS2	7°26’30.89”N	3°54’27.48”E	751
		SSS3	7°26’31.78”N	3°54’27.41”E	700
		SSS4	7°26’33.01”N	3°54’27.47”E	769
		SSS5	7°26’34.43”N	3°54’27.47”E	748

Appendix XI

GPS spatial mapping data for Agbowo Commercial area

Business Area	Classified location	Sampling Points	Longitude (°N)	Latitude (°E)	Elevation (m)
Ajibode	AJ1	EC1	7°27'45.77"N	3°53'34.35"E	621
		EC2	7°27'45.48"N	3°53'34.85"E	617
		EC3	7°27'46.58"N	3°53'34.90"E	626
		EC4	7°27'47.07"N	3°53'34.80"E	667
		EC5	7°27'46.99"N	3°53'34.07"E	698
	AJ2	RSS1	7°27'37.25"N	3°53'33.32"E	768
		RSS2	7°27'37.31"N	3°53'33.74"E	677
		RSS3	7°27'37.80"N	3°53'33.52"E	657
		RSS4	7°27'36.49"N	3°53'34.20"E	665
		RSS5	7°27'36.50"N	3°53'34.23"E	661
	AJ3	SSS1	7°27'40.41"N	3°53'35.55"E	633
		SSS2	7°27'40.98"N	3°53'34.75"E	723
		SSS3	7°27'42.49"N	3°53'35.60"E	711
		SSS4	7°27'40.99"N	3°53'37.21"E	743
		SSS5	7°27'42.51"N	3°53'34.77"E	717

Appendix XII

NOISE LEVEL AT WORKER POSITION (AGBOWO)

Worker	Sound dBA	Worker	Sound dBA	Worker	Sound dBA	Worker	Sound dBA
1	85.10	**30**	80.20	**59**	72.50	**88**	87.50
2	84.90	**31**	87.50	**60**	77.70	**89**	91.70
3	94.40	**32**	85.00	**61**	73.00	**90**	92.50
4	92.90	**33**	75.00	**62**	73.80	**91**	81.70
5	91.20	**34**	80.00	**63**	74.10	**92**	87.70
6	95.00	**35**	80.20	**64**	69.50	**93**	89.90
7	93.20	**36**	80.90	**65**	69.30	**94**	93.90
8	92.10	**37**	91.60	**66**	69.70	**95**	92.40
9	90.60	**38**	90.10	**67**	65.20	**96**	94.40
10	98.90	**39**	77.40	**68**	67.20	**97**	93.20
11	85.70	**40**	88.30	**69**	65.00	**98**	94.20
12	92.90	**41**	87.40	**70**	72.40	**99**	93.30
13	98.20	**42**	69.20	**71**	71.10	**100**	89.90
14	92.70	**43**	81.80	**72**	70.70	**101**	90.20
15	92.60	**44**	82.90	**73**	71.10	**102**	86.90
16	99.20	**45**	84.50	**74**	79.80	**103**	95.10
17	92.50	**46**	80.40	**75**	89.00	**104**	97.80
18	87.60	**47**	83.70	**76**	81.60	**105**	89.90
19	92.80	**48**	84.10	**77**	82.90	**106**	95.00
20	86.90	**49**	80.70	**78**	89.80	**107**	95.40
21	86.90	**50**	82.50	**79**	66.70	**108**	88.10
22	90.00	**51**	80.00	**80**	72.70	**109**	90.10
23	95.30	**52**	72.40	**81**	68.40	**110**	90.20
24	88.50	**53**	78.70	**82**	66.00	**111**	83.70
25	91.10	**54**	79.30	**83**	72.80	**112**	90.90
26	92.60	**55**	78.70	**84**	68.60	**113**	88.70
27	85.00	**56**	81.10	**85**	85.60	**114**	87.90
28	89.00	**57**	77.80	**86**	91.80	**115**	92.50
29	86.50	**58**	79.00	**87**	92.00	**116**	88.80

Appendix XIII

NOISE LEVEL AT WORKER POSITION (AJIBODE)

Worker	Sound dBA	Worker	Sound dBA	Worker	Sound dBA	Worker	Sound dBA
1	75.60	**26**	71.80	**51**	72.50	**76**	87.50
2	70.40	**27**	63.70	**52**	77.70	**77**	91.70
3	69.70	**28**	65.00	**53**	73.00	**78**	92.50
4	75.50	**29**	72.70	**54**	73.80	**79**	81.70
5	71.40	**30**	60.00	**55**	74.10	**80**	87.70
6	71.70	**31**	61.50	**56**	69.50	**81**	89.90
7	69.90	**32**	69.70	**57**	69.30	**82**	93.90
8	68.00	**33**	74.80	**58**	69.70	**83**	92.40
9	87.70	**34**	73.20	**59**	65.20	**84**	94.40
10	72.40	**35**	68.90	**60**	67.20		
11	71.40	**36**	75.10	**61**	65.00		
12	65.90	**37**	72.60	**62**	72.40	**Agbowo Continuation**	
13	74.10	**38**	68.70	**63**	71.10		
14	69.40	**39**	70.10	**64**	70.10		
15	66.50	**40**	68.70	**65**	74.50	**117**	95.10
16	71.30	**41**	67.50	**66**	71.40	**118**	97.80
17	60.50	**42**	70.00	**67**	72.00	**119**	89.90
18	61.20	**43**	65.10	**68**	69.80	**120**	95.00
19	70.50	**44**	63.60	**69**	67.80	**121**	95.40
20	72.80	**45**	67.10	**70**	66.70	**122**	88.10
21	72.30	**46**	71.20	**71**	74.20		
22	72.60	**47**	70.50	**72**	76.50		
23	63.50	**48**	69.10	**73**	77.20		
24	72.60	**49**	71.90	**74**	73.00		
25	68.50	**50**	72.00	**75**	77.30		