INVESTIGATION OF NOISE EXPOSURE LEVELS AND HEARING IMPAIRMENT AMONG HOSPITAL WORKERS IN BENIN CITY, NIGERIA

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CERTIFICATION

This is to certify that this research titled **"INVESTIGATION OF NOISE EXPOSURE LEVELS AND HEARING IMPAIRMENT AMONG HOSPITAL WORKERS IN BENIN CITY"** was carried out by **"AVWARODOGHENE FLOURISH"** and presented to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City, in partial fulfillment of the requirements for the award of Bachelor of Science (B. Sc) in Environmental Management and Toxicology. It was conducted under suitable conditions, was carefully supervised and subsequently approved as having met the requirements for the award of a Bachelor of Science degree in Environmental Management and Toxicology.

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DECLARATION

I **"AVWARODOGHENE FLOURISH OGHENENYORE"** declare that **"INVESTIGATION OF NOISE EXPOSURE LEVELS AND HEARING IMPAIRMENT AMONG HOSPITAL WORKERS IN BENIN CITY"** is my work and that all sources that I have used or quoted have been acknowledged using complete references and that this work has not been submitted before for any other degree at any other university.

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AVWARODOGHENE FLOURISH OGHENENYORE **DATE**

DEDICATION

This report is dedicated to God Almighty for his guidance and protection during this project. I also want to dedicate this report to my beloved parents Mr. and Mrs. AVWARODOGHENE for their unwavering support, prayers, love and financial assistance throughout my academic journey.

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ABSTRACT

Noise pollution is an increasingly recognized occupational hazard within healthcare environments, where the continuous operation of medical equipment, alarms, and human activity often generates sound levels exceeding recommended limits. This study investigated noise exposure levels and the prevalence of hearing impairment among hospital workers in Benin City, Edo State, Nigeria. A comparative cross-sectional approach was employed in two hospitals, the University of Benin Teaching Hospital (public) and Faith Mediplex Hospital (private). Noise measurements were conducted in selected wards via a calibrated AR824 sound level meter, while structured questionnaires and the Hearing Health Quick Test (HHQT®) were administered to 152 staff members to assess auditory and nonauditory effects. The findings revealed that average noise levels ranged between 63.1 dB and 77.7 dB, exceeding the permissible limit of the National Environmental Standards and Regulations Enforcement Agency (NESREA). The Pediatrics, Emergency, and COPD wards recorded the highest noise intensities. Statistical analysis revealed significant variation across hospital departments ($p < 0.05$) but no significant difference between public and private hospitals. Among the respondents, 86.2% exhibited signs of potential hearing problems, 21.7% reported hearing difficulty, and 20.4% reported tinnitus. Nonauditory symptoms such as tiredness (52.6%), poor sleep quality (31.6%), and lack of concentration (38.8%) were also prevalent. The study concluded that hospital workers in Benin city are consistently exposed to hazardous noise levels capable of inducing hearing impairment and related health effects. It recommends regular noise monitoring, staff education, and the enforcement of hearing conservation programs within healthcare facilities.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Noise pollution is a pervasive and often overlooked occupational hazard within healthcare environments (Liu *et al*., 2020; Eghomwanre*et al*., 2023). While hospitals are traditionally seen as sanctuaries for healing, they are increasingly characterized by complex acoustic environments shaped by the simultaneous operation of medical equipment, patient activity, communication systems, and general hospital operations. These sources combine to create noise levels that can exceed recommended occupational exposure limits, posing a potential risk to the auditory health and overall well-being of healthcare workers (WHO, 2018; Darbyshire and Young; 2013).

Although much attention has been given to the impact of noise on patient recovery and stress, the occupational risks to hospital staff, particularly in terms of hearing impairment, are only beginning to receive adequate scrutiny (Zhou and Zhang, 2024). Healthcare professionals working in high-activity zones such as emergency departments, operating theaters, and intensive care units are regularly exposed to intermittent and sustained noise from alarms, ventilators, suction machines, air conditioning units, and verbal communication (Armbruster *et al*., 2023). In such environments, noise levels can frequently exceed safety thresholds established by the Occupational Safety and Health Administration (OSHA), which sets the permissible exposure limit (PEL) at 90 decibels (dB) over an 8-hour workday (OSHA, 2013; Zhou and Zhang, 2024).

Prolonged exposure to noise levels above 85–90 dB can result in noise-induced hearing loss (NIHL), a permanent and irreversible sensorineural condition caused by damage to cochlear hair cells (Natarajan *et al*., 2023; Hong *et al*., 2013). NIHL is one of the most common occupational diseases worldwide and is well documented in industrial sectors. However, its prevalence and

impact within healthcare settings remain underexplored, especially in developing countries such as Nigeria, where occupational safety regulations may be poorly enforced or entirely absent (Akinwale and Akinyele, 2017). Healthcare workers may not recognize the gradual onset of symptoms such as tinnitus, speech discrimination difficulty, and eventual hearing loss, often attributing them to aging or nonoccupational causes.

In Nigeria, studies have established a clear link between chronic occupational noise exposure and hearing impairment among industrial workers, with findings indicating that sustained exposure to noise levels exceeding 90 dB leads to a high prevalence of hearing loss, particularly among workers with longer durations of service (Olusanya, 2014). However, the prevalence of hearing impairment due to occupational noise exposure among healthcare professionals remains underresearched, with studies focused primarily on more traditional high-risk sectors, such as construction and manufacturing, thereby overlooking the risks faced by hospital workers who spend extended hours in acoustically intense environments (Akinwale and Akinyele, 2017).

Benin city, the capital of Edo State and a major healthcare hub in the South–South geopolitical zone of Nigeria, hosts several tertiary healthcare institutions serving both urban and rural populations. The rapid expansion of healthcare infrastructure and increasing patient volumes in these facilities, often operating under strained conditions, may have inadvertently contributed to

elevated noise exposure levels among healthcare workers. The situation is potentially exacerbated by the limited use of hearing protection devices, infrequent implementation of regular auditory screening programs, poor awareness of occupational noise hazards among healthcare staff, and the absence of enforced noise control regulations in many healthcare facilities.

Despite the potential magnitude of this occupational health concern, there remains a significant paucity of empirical data documenting noise exposure patterns and associated hearing impairment among hospital workers in Nigerian healthcare settings.

1.2 Statement of the Problem

Hospitals are traditionally regarded as environments of healing, yet many units within them are increasingly characterized by high and persistent levels of noise. From the constant movement of people and equipment to the frequent use of alarms, generators, diagnostic machines, and air conditioning systems, hospital settings have become significant sources of environmental noise. In many cases, these noise levels exceed the safe limits recommended by the World Health Organization (WHO), posing a serious threat to both patient recovery and healthcare worker well-being.

Healthcare workers are particularly vulnerable to occupational noise exposure because of their prolonged and routine presence in these environments. Prolonged exposure to elevated noise levels has been associated with a range of health concerns, including temporary or permanent hearing loss, tinnitus, sleep disturbances, increased stress, and reduced cognitive performance. Despite these known risks, occupational noise hazards in hospitals, especially in Nigeria, are often underassessed and poorly regulated. Furthermore, private and public hospitals may differ significantly in their infrastructure, work processes, and adherence to safety standards, leading to unequal noise exposure and health outcomes for staff.

In Benin city, where a blend of high-traffic government hospitals and relatively quieter private facilities coexist, there is a lack of empirical data comparing noise exposure levels and associated

hearing-related health outcomes across different healthcare settings. This gap presents a challenge for effective policy intervention and occupational health planning.

Therefore, this study sought to measure noise exposure levels in selected departments of UBTH (a public hospital) and Faith Mediplex (a private hospital) and examine the potential relationships between these exposures and self-reported hearing problems among hospital workers. By identifying and comparing the extent of noise pollution and its effects on these two hospital types, this study provides crucial evidence for targeted health interventions, noise control strategies, and policy development in hospital environments.

1.3 Justification of the study

Occupational noise exposure is a significant but often underrecognized health hazard in healthcare settings, particularly in developing countries such as Nigeria. Hospitals are generally perceived as quiet and healing environments; however, various departments, such as emergency units, operating theaters, laboratories, radiology rooms, and generator houses, are frequently exposed to elevated noise levels from medical equipment, alarms, and power-generating machines. Despite daily exposure to such noise, little attention has been given to its potential long-term impact on the hearing health of hospital workers.

In Benin city, where healthcare facilities such as the University of Benin Teaching Hospital (UBTH) and Faith Mediplex Hospital are among the busiest in southern Nigeria, the likelihood of hospital staff being chronically exposed to harmful noise levels is high. However, systematic data on actual noise levels in these hospitals and the prevalence of noise-induced hearing issues among their staff are lacking. This gap in local evidence limits the implementation of appropriate hearing conservation measures in hospital settings.

This study is therefore justified by the need to generate empirical data on occupational noise levels and the associated risk of hearing impairment among healthcare workers in Benin city. By identifying departments with potentially hazardous noise exposure and assessing the extent of hearing loss among workers, the findings of this research can inform hospital administrators, occupational health units, and policymakers. Such evidence is critical for the development of noise control strategies, the adoption of personal protective equipment, periodic hearing screening, and awareness campaigns aimed at preserving auditory health in the workplace.

Furthermore, the outcomes of this study may serve as a baseline for future occupational health research in Nigerian hospitals, contribute to academic knowledge, and stimulate policy discussions on workplace noise regulation and enforcement in the health sector.

1.4 Aim and Objectives

This study was designed to investigate noise exposure levels and the prevalence of hearing impairment among hospital workers in Benin city.

The specific objectives include the following:

1. Measuring the noise levels in selected wards in the hospital
2. The temporal variation in noise levels at selected wards in the hospital was assessed.
3. The prevalence of reported health effects and hearing impairment among workers should be determined.
4. The risk factors associated with noise-related health effects among workers were examined.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Occupational noise exposure in healthcare settings

Occupational noise exposure in healthcare settings refers to the persistent presence of unwanted or harmful sounds within hospital environments, which can adversely affect both patients and healthcare workers. The primary sources of noise in hospitals include medical equipment (such as alarms, monitors, and ventilators), heating, ventilation, and air conditioning (HVAC) systems, and human activity, which encompasses conversations, movement, and operational tasks. These sources often operate simultaneously, contributing to elevated ambient noise levels throughout various hospital departments (De-Lima *et al*., 2021; Nyembwe*et al*., 2023; Alduais and Salama, 2019).

For example, studies have shown that intensive care units (ICUs) and surgical wards experience particularly high noise levels due to the density of alarms and life-support equipment, as well as continuous staff activity (Alduais and Salama, 2019). The reflective surfaces and architectural design of hospitals can further amplify noise, making it difficult to maintain quiet zones essential for patient recovery and staff concentration (De-Lima *et al*., 2021).

The World Health Organization (WHO) and the US Occupational Safety and Health Administration (OSHA) have established guidelines to mitigate the risks associated with excessive hospital noise (Nyembwe*et al*., 2023). The WHO recommends that average sound levels in hospital inpatient care areas should not exceed 35 dB(A) during the day and 30 dB(A) at night, with a maximum of 40 dB(A) overnight to promote patient rest and staff well-being.

Similarly, the US Environmental Protection Agency (EPA) suggests limits of 45 dB(A) during the day and 35 dB(A) at night for hospitals (Nyembwe*et al*., 2023).

Despite these recommendations, empirical studies consistently report that actual noise levels in hospitals often surpass these thresholds. For example, measured daytime noise levels in hospital environments range from 37--88.6 dB(A), and nighttime noise levels range from 38.7--68.8 dB(A), far exceeding the recommended limits (De-Lima *et al*., 2021; Arsal*et al*., 2024). This chronic exposure places both patients and healthcare workers at risk for adverse health outcomes, including hearing impairment and increased stress (Arsal*et al*., 2024; Wang *et al*., 2024).

Comparative research across hospital departments reveals significant variability in noise exposure. Intensive care units (ICUs) and critical care settings such as cardiac surgical ICUs (CSICUs) consistently report the highest noise levels, with maximum recorded values reaching 74.3 dB(A) and above during both day and night shifts (Alduais and Salama, 2019). Operating theaters also exhibit elevated noise levels, with mean values documented between 61.8 and 74.5 dB(A) depending on the specific theater and time of measurement (Jadon and Kedia, 2015).

Other departments, such as endocrinology clinics, may have lower noise exposure (as low as 52 dB(A)), whereas units such as aspodology have recorded noise levels as high as 91 dB(A) (Arsal*et al*., 2024). These findings highlight that noise exposure is not uniform across hospital settings, with staff in high-intensity departments facing greater risks of noise-induced hearing loss and psychological stress (Arsal*et al*., 2024; Wang *et al*., 2024).

Recent longitudinal studies have demonstrated a clear association between occupational noise exposure and hearing loss among healthcare workers. For example, workers exposed to mean noise levels above 65 dB(A) over a six-month period experienced significant increases in hearing

threshold levels, particularly at low and middle frequencies (0.25–4.0 kHz) (Wang *et al*., 2024). These results underscore the importance of regular noise monitoring, hearing assessments, and the implementation of effective hearing conservation programs in healthcare settings (Wang *et al*., 2024).

2.2 Sources of noisein healthcare settings

Healthcare facilities are characterized by mechanical, human, and environmental noise sources. Medical equipment is among the most prominent contributors. Devices such as ventilators, infusion pumps, suction machines, and patient monitors emit continuous or intermittent sounds. Alarm systems, especially in intensive care units (ICUs), are among the most frequent and disruptive sources (Zhou *et al*., 2022).

Communication devices also play a significant role in reducing hospital noise. Mobile phones, intercoms, and paging systems are widely used, particularly in high-traffic areas such as emergency departments and operating rooms, thereby elevating background sound levels (Aparício, 2020).

Human activity constitutes another major source. Conversations among healthcare staff, patient vocalizations, and routine movements through corridors contribute to fluctuating peaks in noise levels. The periods of staff interaction during shift changes and clinical procedures are particularly noisy (Johansson *et al*., 2012).

Facility infrastructure further influences hospital soundscapes. Heating, ventilation, and air conditioning (HVAC) systems, elevators, automatic doors, and other mechanical installations

generate continuous background noise. Additionally, architectural design and building materials determine how sound propagates across hospital spaces (Zhou *et al*., 2022).

External sources also affect noise levels in urban hospitals. Traffic, construction, and other environmental sounds penetrate wards and operating rooms, particularly when windows are open or insulation is poor (Andrade *et al*., 2021).

The World Health Organization (WHO) recommends that noise levels in hospital wards should not exceed 30 dB during the night and 35 dB during the day (Berglund *et al*., 1999). However, empirical studies consistently show that actual levels often range between 37–88.6 dB during the day and 38.7–68.8 dB at night, far exceeding these thresholds (Andrade *et al*., 2021). These elevated levels pose risks not only to patient recovery but also to the auditory health of healthcare workers.

Continuous exposure to high noise levels can result in auditory fatigue, stress, and, in some cases, permanent hearing damage. Healthcare staff working in high-noise zones such as emergency departments, intensive care units, and operating rooms are particularly vulnerable. In addition to auditory effects, noise disrupts communication, concentration, and decision-making, thereby increasing the likelihood of medical errors and compromising patient safety (Aparício, 2020).

2.3 Risk factors associated with noise in healthcare settings

Noise in healthcare environments is not merely a nuisance but also a complex occupational hazard with multiple risk factors that contribute to elevated exposure levels. The architectural and environmental design of hospitals plays a critical role in shaping acoustic conditions. Open-plan layouts, hard surfaces, and the absence of sound-absorbing materials amplify ambient

sounds, whereas heating, ventilation, and air-conditioning systems, elevators, and automatic doors generate continuous background noise that often exceeds safe limits. Hospitals located in urban areas are further exposed to external sources such as road traffic, construction activities, and commercial noise, which penetrate through windows and poorly insulated walls (Andrade *et al*., 2021).

The function and activity level of hospital departments also determine noise intensity. Emergency departments, operating theatres, and intensive care units are particularly noisy environments due to high patient turnover, frequent alarms, and urgent clinical interventions. Empirical studies have shown that these departments often exceed recommended thresholds, with daytime levels reaching up to 88.6 dB(A) and nighttime levels rising to 68.8 dB(A), which are far above the World Health Organization's suggested limits (Andrade *et al*., 2021).

Human activity represents another significant factor. Conversations among staff, patients' vocalizations, and routine clinical communication contribute substantially to sound levels. Situations such as medical rounds, shift changes, and teaching sessions intensify verbal interactions, particularly in teaching hospitals, whereas communication tools such as pagers, mobile phones, and intercom systems further increase background noise (Zhou *et al*., 2022). Medical equipment also adds to the noise burden. The continuous operation of ventilators, infusion pumps, monitors, and dialysis machines produces a persistent soundscape, whereas frequent alarms generate abrupt peaks in noise levels. Alarm fatigue, resulting from excessive and often nonurgent alerts, has been identified as a major risk factor that not only increases exposure but also threatens patient safety by desensitizing staff and increasing the likelihood of clinical errors (Johansson *et al*., 2012).

In addition to physical and technological factors, psychosocial elements also influence the risks associated with noise exposure. Chronic exposure to high noise levels has been linked to stress, fatigue, and burnout among healthcare professionals. These conditions impair concentration, reduce job satisfaction, and can lead to long-term health effects, including sleep disturbances and cardiovascular strain. Importantly, prolonged noise exposure also increases the likelihood of permanent hearing impairment among staff working in high-noise environments such as intensive care units and emergency wards (Hassan, 2024). The duration and frequency of exposure further compound the risks. Healthcare workers engaged in extended shifts or night duties in high-activity departments face a greater probability of developing noise-induced hearing loss, especially when protective measures such as ear protection are not implemented. Repeated exposure without sufficient rest periods amplifies the detrimental impact of hospital noise (Basner*et al*., 2014).

2.4 NIHL and its mechanisms

Noise-induced hearing loss (NIHL) is a sensorineural hearing impairment caused by prolonged or acute exposure to hazardous noise levels (>85 dB(A)). It manifests as temporary or permanent threshold shifts (TTS/PTS), characterized by damage to cochlear hair cells, synapses, or auditory nerve fibres (Natarajan *et al*., 2023). NIHL is irreversible in humans because of the nonregenerative nature of cochlear hair cells (Samara *et al*., 2024).

2.4.1 Key Mechanisms of NIHL

Excessive noise triggers reactive oxygen species (ROS) overproduction in the cochlea, overwhelming endogenous antioxidant defenses (e.g., glutathione, superoxide dismutase) (Samara *et al*., 2024; Le-Prell*et al*., 2007). ROS damage lipids, proteins, and DNA, leading to hair apoptosis. A critical late-phase ROS surge occurs 7–10 days post-exposure, exacerbating

cochlear injury (Samara *et al*., 2024; Le-Prell*et al*., 2007). Mitochondrial dysfunction and calcium influx further amplify oxidative stress, particularly in outer hair cells (Samara *et al*., 2024).

Noise exposure induces vasoconstriction, reducing inner ear blood flow during sound exposure. Subsequent reperfusion upon noise cessation drives ROS generation via hypoxia–reoxygenation mechanisms, worsening oxidative damage (Le-Prell*et al*., 2007; Samara *et al*., 2024).

Noise activates cochlear immune responses, with the levels of proinflammatory cytokines (e.g., TNF-α and IL-1β) and macrophage infiltration peaking 3–7 days post-exposure (Samara *et al*., 2024). Acute noise recruits monocytes, whereas chronic exposure engages resident macrophages, exacerbating tissue damage through sterile inflammation (Samara *et al*., 2024).

High-intensity sound waves cause direct mechanical trauma to hair cell stereocilia, leading to cilia

disarray or detachment (Natarajan *et al*., 2023; Samara *et al*., 2024). This disrupts Mechan transduction, impairing signal transmission. Permanent threshold shifts (PTSs) arise from hair cell death or spiral ganglion neuron loss (Natarajan *et al*., 2023; Kurabi*et al*., 2017).

Loss of cochlear synaptophysin in ribbon synapses between inner hair cells and auditory nerve fibres precedes hair cell degeneration, causing "hidden hearing loss" (difficulty hearing in noisy environments). Noise also alters central auditory processing in the brainstem and cortex, compounding functional deficits (Samara *et al*., 2024).

2.4.2 Cellular pathways and therapeutic targets

Noise exposure can trigger apoptosis in cochlear hair cells through the activation of caspase-dependent and mitochondrial pathways (Kurabi*et al*., 2017). This process contributes to noise-induced hearing loss (NIHL) by promoting cell death in the auditory system. To counteract this damage, antioxidant defenses such as manganese superoxide dismutase (Mn-SOD) and heme oxygenase-1 are upregulated, helping mitigate the harmful effects of reactive oxygen species (ROS), as demonstrated in murine models (Samara *et al*., 2024). Pharmacological interventions, including antioxidants such as N-acetylcysteine and various anti-inflammatory agents, which have shown potential in reducing NIHL in preclinical studies, are also being explored.

2.5 Global and Regional Studies on NIHL among Healthcare Workers

2.5.1 Global Perspective on NIHL in Healthcare Workers

Hearing loss affects billions of people worldwide, with NIHL being a preventable but irreversible condition resulting from prolonged exposure to hazardous noise levels (above 85 dB(A)) (Alberti *et al*., 2023). Healthcare professionals, such as ear surgeons, orthopedic surgeons, dentists, and dental hygienists, are at particular risk due to their routine use of noisy instruments. Although studies specifically quantifying noise exposure in these groups are limited, evidence suggests that the cumulative effect of such exposure can lead to significant auditory damage (Alberti *et al*., 2023).

A longitudinal study conducted in a hospital setting demonstrated that healthcare workers exposed to mean noise levels above 65 dB(A) over six months experienced significant hearing threshold shifts at multiple frequencies, indicating early signs of NIHL (Zhou and Zhang, 2024). This study underscores the need for regular audiometric monitoring and hearing conservation programs tailored to healthcare environments.

2.5.2 Regional studies and epidemiological characteristics

Regional studies further illustrate the burden of NIHL among workers exposed to occupational noise, including healthcare personnel. For example, a cross-sectional study in Ethiopia reported a 24.6% prevalence of NIHL among air base workers exposed to noise levels exceeding 90 dB(A), with male workers and those with prior noise exposure at higher risk (Alberti *et al*., 2023). Although this study focused on military workers, the findings highlight the general occupational risk factors relevant to healthcare workers in noisy hospital departments.

In China, occupational noise-induced deafness (ONID) has become the second most common occupational disease, with an increasing number of new cases annually (Wang *et al*., 2024; Hailu *et al*., 2024). The pathological changes observed include cochlear hair cell damage, synapse loss, and spiral ganglion neuron degeneration, which are consistent with NIHL mechanisms. Although these data primarily reflect industrial workers, the findings emphasize the severity of NIHL and the need for preventive strategies applicable to healthcare settings where noise exposure is also significant.

Despite the recognized risk, awareness and preventive measures for NIHL among healthcare workers remain inadequate. Engineering and administrative controls, such as equipment maintenance and noise reduction protocols, along with the consistent use of hearing protection devices, are crucial but underutilized (Alberti *et al*., 2023). Early detection through modified screening protocols combining questionnaires, audiometry, and diagnostic tests is advocated to identify and manage hearing impairments promptly (Alberti *et al*., 2023).

Furthermore, the psychosocial impacts of NIHL, including effects on sleep quality, cognitive function, and workplace performance, have been documented, emphasizing broader health

implications beyond auditory damage (Jo and Baek, 2024). This holistic understanding supports comprehensive occupational health policies that integrate noise monitoring, worker education, and hearing conservation programs in healthcare institutions.

2.6 Noise Measurement and Assessment Methodologies

Accurate measurement and assessment of noise exposure are fundamental for understanding and mitigating the risks of noise-induced hearing loss, particularly in occupational and healthcare settings. The methodologies employed for noise measurement have evolved to address the complexity of modern work environments, including hospitals, where noise sources and exposure patterns are highly variable.

The most widely used instruments for workplace noise assessment include sound level meters (SLMs), integrated sound level meters (ISLMs), and noise dosimeters. SLMs are typically used for spot measurements and noise surveys, providing readings in decibels (dBA) at specific locations or times. ISLMs are capable of measuring equivalent sound levels over a defined period, making them suitable for environments with fluctuating noise. Noise dosimeters, worn by workers, are considered the gold standard for assessing personal noise exposure, especially when individuals are mobile or noise levels vary significantly throughout the shift. These instruments must be properly calibrated and operated according to the manufacturer's guidelines to ensure accuracy and reliability (CCOHS, 2023).

Noise assessment generally begins with a noise survey to determine if a noise problem exists and whether further, more detailed measurements are necessary. If workplace noise is steady and workers are stationary, survey data may suffice. However, in settings where workers are mobile or noise varies, personal noise dosimetry is recommended. For mapping noise levels generated by specific sources, SLMs are positioned 1 to 3 m from the source, whereas ISLMs are used for highly variable environments to capture time-averaged sound levels (CCOHS, 2023).

In hospital settings, studies have shown significant variability in measurement approaches. Most studies utilize SLMs, which are often positioned near patient beds or in high-activity areas such as intensive care units (ICUs) and operating theaters. Dosimeters are also used, particularly for assessing staff exposure. The measurement durations can range from short intervals to continuous 24-hour monitoring, with devices often set to A-weighting to reflect the response of the human earto sound. The most common metrics reported are the equivalent continuous sound level (LAeq), maximum (Lmax), and minimum (Lmin) sound pressure levels (Wallis *et al*., 2019; Naef*et al*., 2022).

Methodological rigor is critical in healthcare noise measurement. The placement of devices should minimize observer bias and not interfere with routine activities. For example, SLMs may be placed at head level near patient beds or attached to staff clothing for personal exposure assessment. A continuous power supply and regular data downloads are necessary for long-term monitoring. Studies recommend the use of A-weighted filters and fast time-weighting settings for measurements, as these best approximate human auditory perception in indoor environments (Naef*et al*., 2022).

Despite the widespread use of these methods, a rapid review of hospital noise studies revealed inconsistency and poor reporting in measurement protocols, with only a minority of studies providing enough detail for replication. This highlights the need for standardized, transparent methodologies to ensure the comparability and reliability of findings across studies (Wallis *et al*., 2019).

Hospital noise studies commonly use sound level meters (66%) for area measurements and dosimeters (20%) for personal exposure. Nearly half (47%) recorded noise near patient beds,

with others targeting nursing stations and operating theaters. The measurement durations varied from brief to 24-hour monitoring. Common metrics include LAeq (58%), Lmax (38%), Lmin (28%), and arithmetic averages (26%), although calculation methods are sometimes unclear (Wallis *et al*., 2019).

2.7 Effects of Chronic Noise Exposure Beyond Hearing Loss

While noise-induced hearing loss (NIHL) remains the most recognized consequence of chronic noise exposure, emerging evidence highlights a spectrum of nonauditory health effects. These impacts span cardiovascular, psychological, cognitive, and metabolic domains, underscoring noise as a multifaceted public health challenge.

2.7.1 Cardiovascular effects

Chronic noise exposure activates the sympathetic nervous system and hypothalamic–pituitary–adrenal (HPA) axis, leading to sustained increases in stress hormones such as cortisol and adrenaline. This dysregulation contributes to endothelial dysfunction, arterial stiffness, and hypertension (Sante, 2022). For example, a Canadian study revealed that workers exposed to high noise levels faced 2–3 times greater risks of heart problems (Sante, 2022; CCOHS, 2023; Baczalska*et al*., 2022). Aircraft noise exposure specifically correlates with elevated diastolic blood pressure and arterial stiffness, even in individuals with preexisting cardiovascular conditions. Over time, these physiological changes increase the risk of myocardial infarction, stroke, and atherosclerosis (Hahad*et al*., 2024).

2.7.2 Mental health and psychological distress

Noise acts as a chronic stressor, exacerbating anxiety, depression, and annoyance. The noise/stress

concept posits that prolonged exposure to even moderate noise (50–70 dB(A)) disrupts emotional regulation and coping mechanisms, fostering learned helplessness and maladaptive behaviors such as increased smoking or alcohol use (Hahad*et al*., 2024). Neuroinflammatory pathways, including elevated IL-1β and TNF-α in brain regions such as the hippocampus, further link noise to anxiety- and depression-like behaviors in animal models (Hahad*et al*., 2024; Portagepath. 2024). Human studies have associated environmental noise with a 20–30% increased risk of mood disorders, which is mediated by sleep disruption and chronic stress (Portagepath. 2024).

2.7.3 Sleep disturbances

Noise-induced sleep fragmentation is a key pathway to systemic health deterioration. Nighttime noise exposure triggers microarousals, brief awakenings that impair sleep quality, leading to elevated daytime fatigue and impaired cognitive function (Portagepath. 2024). Poor sleep exacerbates cardiovascular risk by preventing nocturnal blood pressure decreases and increasing oxidative stress. Hospital studies note that ICU noise peaks exceeding 85 dB(A) occur up to 16 times nightly, disproportionately affecting healthcare workers and patients (CCOHS, 2023).

2.7.4 Cognitive and developmental impacts

Children exposed to chronic noise exhibit deficits in reading comprehension, memory, and

attention, likely due to stress-mediated disruptions in neurodevelopment. In adults, noise impairs concentration, vigilance, and task performance, increasing workplace accident risk (CCOHS,

2023). Elderly populations face accelerated cognitive decline, with noise-linked cerebrovascular events potentially contributing to dementia onset.

2.7.5 Metabolic and Immune Dysregulation

Emerging evidence links noise exposure to metabolic disturbances, including increased waist circumference and adiposity, likely via stress-induced glucocorticoid release. Chronic noise also promotes systemic inflammation, marked by elevated C-reactive protein and oxidative stress markers, which may exacerbate insulin resistance and immune dysfunction (Baczalska*et al*., 2022).

2.8 Mitigation of noise pollution in health care settings

One of the most effective long-term solutions for reducing hospital noise is through architectural and structural design improvements. The incorporation of sound-absorbing materials such as acoustic ceiling tiles, carpets, and wall panels reduces reverberation and lowers ambient sound levels. Hospitals with private patient rooms, as opposed to open wards, report better acoustic conditions because noise transmission between spaces is minimized. Facilities that have undergone acoustic renovations have also documented improvements in staff concentration and patient satisfaction (Andrade *et al*., 2021; Shishodia, 2023). Additionally, strategically relocating noisy equipment away from patient care areas helps isolate sound sources and limits unnecessary exposure.

Medical alarms remain among the most frequent and disruptive contributors to hospital noise. Excessive and often nonurgent alarms not only increase auditory stress but also increase the risk

of clinical errors by contributing to alarm fatigue. Mitigation strategies in this domain include the adoption of smart alarm systems that prioritize alerts on the basis of urgency, thereby reducing false alarms and overall noise levels (Johansson *et al*., 2012). The regular maintenance of medical devices, along with the replacement of outdated machines with low-noise alternatives, has also been shown to reduce background sounds in clinical environments (Andrade *et al*., 2021).

In addition to engineering solutions, behavioral interventions play a key role. Training healthcare workers to adopt quieter work habits, such as lowering voices, minimizing unnecessary conversations, and closing doors gently, contributes to creating a calmer acoustic environment. Unit-based noise reduction programs, including the designation of quiet hours and staff awareness initiatives, have demonstrated success in reducing perceived noise exposure, particularly in intensive care units (Armbruster, 2023). The establishment of quiet zones within wards provides additional respite for both patients and staff.

Technological innovations also present new opportunities for hospital noise control. Noise-monitoring sensors and real-time feedback systems enable staff to track sound levels and take immediate corrective actions when thresholds are exceeded. Some hospitals have integrated these systems into their operational dashboards to promote accountability. In addition, sound masking technologies that emit low-level, controlled background noise have been used to neutralize disruptive peaks, thereby improving both patient rest and staff focus (Shishodia, 2023).

Finally, the establishment of institutional policies and adherence to international guidelines remain fundamental to sustainable noise mitigation. The World Health Organization recommends that hospital noise levels not exceed 35 dB(A) during the day and 30 dB(A) at night (Berglund *et*

al., 1999). Achieving these targets requires coordinated action involving facility management, clinical teams, and hospital administration. Policy-driven approaches ensure that noise reduction is not left solely to individual departments but is embedded within the organizational culture of healthcare delivery (Andrade *et al*., 2021).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

The study was conducted in Benin city, a prominent urban center in Edo State, southern Nigeria. The city is situated at a latitude of 6° 20'N and a longitude of 5° 37'E, placing it within the tropical rainforest belt, which may have influenced daily weather patterns and ambient noise. Benin city encompasses a landmass of 1,204 km² and has an elevation of 89 feet (approximately 27 metres) above sea level.

The city is well known as the administrative and commercial hub of Edo State, with a growing population engaged in diverse economic activities. Major roads, markets, and transport terminals contribute to the ambient noise environment. The healthcare sector in cities includes tertiary, secondary, and primary health facilities that operate continuously, employing large numbers of health workers across different departments. These hospitals are located in both high-traffic and residential areas, making them subject to varying levels of environmental noise. The selection of hospitals for this study reflected this diversity, ensuring that the data represented workers in facilities exposed to different noise intensities.

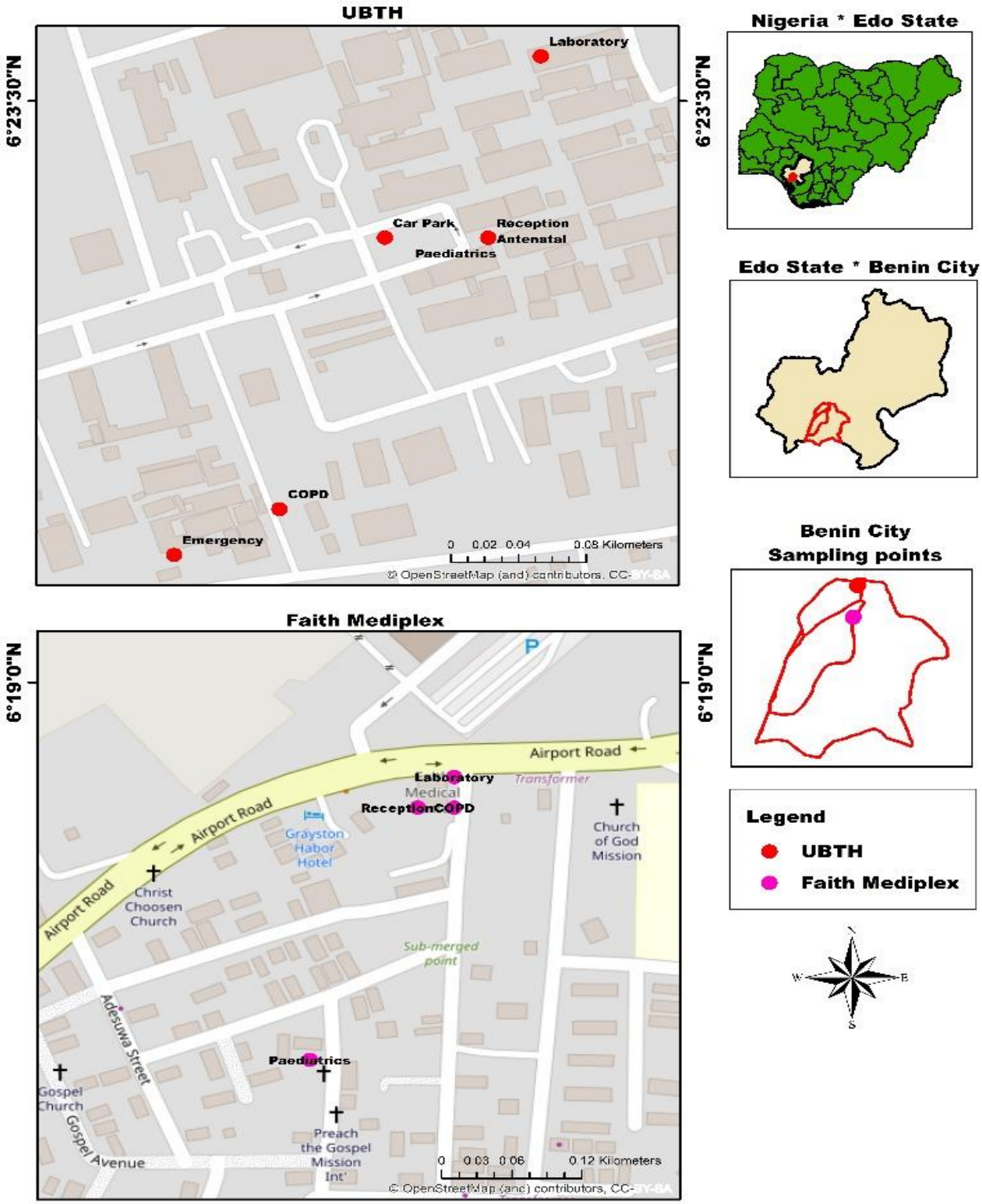

Figure 3.1: Map of Benin City showing the sampling locations

3.2 Description of Sampling Sites

The study specifically focused on two major healthcare facilities in Benin city: the University of Benin Teaching Hospital (UBTH) and Faith Mediplex Hospital. This dual-hospital approach facilitated a comparative analysis of noise exposure levels and their impacts across different healthcare environments (public and private).

3.2.1 University of Benin Teaching Hospital (UBTH)

UBTH was established in 1972 and formally opened in 1973. It was Nigeria's sixth first-generation teaching hospital. Initially, it had a bed capacity of 360, which had since expanded to over 900. Located in Ugbowo, Benin city, UBTH serves as a major hub for clinical care, research, and health professional training for the Edo and Delta States and the broader South–South region of Nigeria. It included specialized units such as a Dialysis Centre, CT Scanning Service, Accident Centre, and an in-house oxygen production plant. UBTH also played a vital role in postgraduate and undergraduate medical education, maintaining strong academic ties with the University of Benin.

3.2.2 Faith Mediplex Hospital

Founded in 1989 as a healthcare initiative of the Church of God Mission International, Faith Mediplex Hospital was envisioned to integrate spiritual care with modern medical practice. It began as the first of three planned hospitals by the Church of God Mission and had grown into a reputable multispecialty private hospital with a capacity of 140 inpatient beds. Its outpatient clinics are among the busiest in the region. The hospital employs over 25 physicians across

major specialties and is recognized as a training site for family medicine residency programs and other healthcare professionals. Faith Mediplex expanded its services by establishing additional facilities in Abuja and Uyo.

Specific sampling areas within both hospitals were chosen on the basis of patient volume, operational activities, and the presence of noise-generating equipment. Sampling focused on both indoor and outdoor environments, targeting departments such as the Children's Ward, Intensive Care Unit, Surgical Ward, Emergency Unit, and Male and Female Wards.

3.3 Study Design and Population

This study included a combination of noise pollution assessment in various hospital wards and a cross-sectional investigation of the auditory health status of hospital workers. Noise pollution assessment was carried out in a public hospital (UBTH) and a private hospital (Faith Medicalx Hospital) via a hand-held noise monitoring device. The study population consisted of hospital staff working in designated departments of the two major hospitals in Benin city, Nigeria.

3.4 Sample size determination and sampling technique

The total study population comprised 246 staff members (164 from UBTH and 82 from Faith Medicalx Hospital) sourced from the hospitals' human resources departments. The Taro Yamane method (1967) was used to determine the sample size. The formula was as follows:

Equation 1.

$$n = \frac{N}{1 + N \times e^2}$$

where:

N = sample size

P = maximum variability (0.5)

n_o = infinite sample size

N = Total population (246)

E = margin of error (0.05) The calculated sample size was approximately 152.

A stratified sampling technique was employed to ensure a balanced and representative selection of respondents from both hospitals. The two hospitals were treated as separate strata due to differences in staff size and potential characteristics. The samples were allocated proportionally to each stratum as follows:

Table 3.1. Selection of representative samples

Hospital	Staff (N)	Sample (Proportional n)
Selected wards, UBTH	164	(164/246) × 152 = 101
Faith Mediplex Hospital	82	(82/246) × 152 = 51
Total	246	152

3.5 Data collection instruments and procedures

Data collection for this study involved both objective noise measurements via environmental monitoring devices and subjective health and exposure information gathered through questionnaires.

3.6 Noise Measurement in Hospitals

Noise level monitoring was conducted via a precision-grade AR824 sound level meter (Beijing, China), which featured a half-inch Electret Condenser microphone, a frequency range of 31.5 Hz to 8.5 kHz, a measurement range of 30–130 dB, and an accuracy of ±1.5 dB. GPS coordinates were also recorded for each sampling location via a portable global positioning system (GPS) device.

Sampling occurred over a two-month period (July–August 2025) on a weekly basis. Measurements were taken at three different time slots each day to capture diurnal variations in noise levels: morning (7–8 am), afternoon (1–2 pm), and evening (5–6 pm).

3.7 Calibration and Setup

Prior to the measurements, the noise meters were calibrated via their internal sound level calibrator to ensure accuracy and reliability. The microphone was systematically directed towards the four cardinal points (North, East, South, and West) at each sampling location for a comprehensive representation of the sound environment. To minimize reflections, the microphone was positioned approximately 1.2 meters away from any reflecting surfaces or bodies.

3.8 Sampling procedure

Measurements were recorded at 30-second intervals for a duration of 6 minutes, with each 6-minute session repeated in triplicate, yielding 12 readings per sampling location. This rigorous procedure ensured robustness and statistical representativeness. The "max" button on the sound

level meter was used to capture the maximum noise values in triplicate for the entire measurement duration.

The collected noise data were analysed by obtaining the mean values of the noise levels across all the sampling sites. These average noise levels were then compared against established environmental noise standards, specifically referencing the World Health Organization (WHO, 2001) guidelines for community noise and the National Environmental Standards and Regulations Enforcement Agency (NESREA, 2009) regulations for noise standards and control in Nigeria.

3.9 Questionnaire Administration and Hearing Health Assessment

3.9.1 Questionnaire Survey

A cross-sectional questionnaire survey was conducted among stratified, randomly selected hospital staff from UBTH and Faith Mediplex. Participation was voluntary, and informed consent was obtained. For respondents who were not fluent in English, the questionnaire was explained in the native Bini language.

The questionnaire was divided into four sections:

- **Section A: Sociodemographic characteristics:** This section collected information on gender, age, education, marital status, workplace, and job role.
- **Section B: Noise exposure:** Data on employment duration, daily hours, perceived noise levels, timing, and noise sources were gathered.

- **Section C: Perceived noise-related effects:** This section recorded self-reported auditory and nonauditory symptoms such as hearing loss, tinnitus, hypertension, sleep disturbances, mental health issues, fatigue, and concentration problems.
- **Section D: Awareness of Noise Health Effects and Controls:** This section assessed knowledge of noise-related health risks, acceptable noise limits, use of hearing protection, governmental noise control programs, and hospital noise monitoring.

This comprehensive questionnaire allowed for a quantitative assessment of noise exposure, identification of knowledge gaps and risk factors, and an evaluation of institutional practices and compliance.

3.9.2 Hearing Health Quick Test (HHQT)

To further assess the self-reported hearing health of the participants, the Hearing Health Quick Test (HHQT), a validated questionnaire designed by the American Academy of Audiology (AAA), was utilized. This tool collects subjective data on participants perceived hearing difficulties, which are correlated with objective noise measurements and other self-reported health symptoms, to provide a comprehensive understanding of the impact of noise exposure.

3.10 Reliability of the questionnaires

Internal consistency was not applicable to this study, but its reliability was ensured by the use of standardized protocols throughout the data collection process. Cronbach's alpha test was performed to assess the reliability of the structured questionnaire (Bonnet and Wright, 2015). The resulting alpha value of >0.85 indicated strong internal consistency for the survey instrument.

3.11 Data analysis

Upon completion of data collection, all the data were accurately entered into a Microsoft Excel spreadsheet for initial coding and organization. These coded data were then exported to SPSS 21.0 for comprehensive statistical analysis.

The questionnaire data were subjected to both descriptive and inferential statistical analyses. For descriptive analysis, metrics such as frequency counts, percentages, and means were calculated to summarize demographic characteristics and self-reported perceptions and health outcomes. For the inferential analysis, chi-square tests and binomial regression models were primarily utilized to determine associations between self-reported risk factors (e.g., duration of exposure, perceived noise levels) and reported acoustic effects among exposed worker groups. Noise readings were analysed via measures of central tendency, specifically the mean, to represent average noise levels at each location and time. Further statistical investigation involved analysis of variance (ANOVA) to assess statistically significant differences in noise levels across various monitoring locations. To pinpoint specific differences between individual locations or time periods, student-paired t tests were used to compare noise levels between paired conditions, such as indoor versus outdoor levels or morning versus afternoon readings, to identify significant variations.

CHAPTER FOUR

4.0 RESULTS AND INTERPRETATION

This chapter presents the results of the study on noise exposure levels and hearing impairment among hospital workers in Benin city. The findings are organized according to the following specific objectives: (1) measurement of noise levels at selected wards in public and private hospitals; (2) assessment of temporal variations in noise levels; (3) determination of the prevalence of reported health effects and hearing impairment among workers; and (4) examination of risk factors associated with noise-related health effects. Data, including noise measurements across various sampling locations and self-report surveys, were collected from 152 hospital workers. Descriptive statistics, ANOVA, ttests, and chi-square tests were used for analysis. All noise levels are reported in decibels (dB) with standard deviations (±SD), and significance was set at $p < 0.05$. The NESREA (2009) permissible limit for noise in hospital environments is 60 dB LAeq.

4.1 Average noise level across hospital sampling locations

Table 4.1 presents the average noise levels measured across seven sampling locations in both public and private hospitals during the morning and afternoon periods. The results revealed considerable variation in noise exposure across different hospital areas and between the two hospital types.

In the Public Hospital, the noisiest wards were COPD (77.68 dB), Pediatrics (77.49 dB), and Reception (76.05 dB) during the morning. The afternoon session also revealed critically high levels in these same areas, with the emergency ward (76.00 dB) also being particularly loud. Car Park was the only location that intermittently fell within acceptable limits.

In private hospitals, high noise levels are also prevalent. The Pediatrics (76.87 dB), COPD (77.13 dB), and Antenatal (75.85 dB) wards recorded the highest morning levels. Interestingly, Car Park in the private hospital was a major source of noise, exceeding 70 dB in both sessions, which was significantly higher than that in the public hospital.

Table 4.1: Average noise level across hospital sampling locations

Sampling Locations	Public Hospital		Private Hospital	
	Morning (dB)	Afternoon (dB)	Morning (dB)	Afternoon (dB)
Emergency	74.20±1.47	76.00±0.72	64.12±2.14	65.48±2.05
Antenatal	64.30±1.53	61.98±1.81	75.85±1.65	69.69±2.78
Pediatrics	77.49±0.91	76.42±1.64	76.87±0.85	67.23±2.58
Reception	76.05±1.86	74.21±1.23	71.33±2.17	72.41±1.93
Car Park	57.70±2.97	63.11±3.29	70.38±2.02	73.32±1.58
COPD	77.68±2.15	76.22±1.19	77.13±1.29	74.40±1.65
Lab	67.11±2.57	70.67±1.85	65.78±2.21	70.14±3.52
NESREA (2009) Limit LAeq (dB)	**60**	**60**	**60**	**60**

4.2 Temporal variation in noise levels

Temporal variations were assessed by comparing morning and afternoon noise levels within and between hospitals via ANOVA and ttests. The ANOVA results are presented in Table 4.2.

Significant differences were found in the public hospitals both in the morning ($F = 14.507$, $p = 0.001$) and afternoon ($F = 11.606$, $p = 0.001$), indicating variability between wards. In the private hospital, significant variation occurred in the morning ($F = 8.373$, $p = 0.001$) but not in the afternoon ($F = 1.854$, $p = 0.093$). Table 4.3 shows ttest comparisons between hospitals.

Table 4.2: Summary of ANOVA tests on noise levels across sampling locations

Locations	Source	Sum of Squares	df (Degrees of Freedom)	Mean Square	F	Sig. (p value)
Public Hospital (Morning)	Between Groups	7525.874	6	1254.312	14.507	0.001
	Within Groups	12104.831	140	86.463		
	Total	19630.705	146			
Public Hospital (Afternoon)	Between Groups	4939.145	6	823.191	11.606	0.001
	Within Groups	9930.171	140	70.93		
	Total	14869.316	146			
Private Hospital (Morning)	Between Groups	3522.939	6	587.156	8.373	0.001
	Within Groups	9817.086	140	70.122		
	Total	13340.024	146			
Private Hospital (Afternoon)	Between Groups	1332.574	6	222.096	1.854	0.093
	Within Groups	16772.287	140	119.802		
	Total	18104.86	146			

4.3 Variations in the Mean Noise Levels in Public and Private Hospitals

Table 4.3 presents the comparison of the mean noise levels between public and private hospitals via independent samples ttests. The results indicate no statistically significant differences in noise levels between the two hospital types for either morning or afternoon measurements.

For morning noise levels, the mean difference between public and private hospitals was -0.585 dB ($t = -0.586$, $df = 146$, $p = 0.559$), indicating that private hospitals had slightly higher morning noise levels, although this difference was not significant. For afternoon measurements, public hospitals presented marginally higher noise levels, with a mean difference of 1.26 dB ($t = 1.047$, $df = 146$, $p = 0.297$), but again, this difference was not statistically significant.

Table 4.3: Variations in the Mean Noise Levels in Public and Private Hospitals

Variables	Mean Difference (dB)	t	df	Sig. (p value)
Morning Noise (PublicM - PrivateM)	-0.585	-0.586	146	0.559
Afternoon Noise (PublicA - PrivateA)	1.2558	1.047	146	0.297

4.4 Prevalence of Reported Health Effects and Hearing Impairment among Workers

The demographic characteristics of the 152 respondents are shown in Table 4.4.

Table 4.4 presents the demographic profile of the 152 hospital workers who participated in the study. The sample comprised 101 (66.4%) workers from the public hospital and 51 (33.6%) from the private hospital. The gender distribution revealed a predominance of female workers, with 103 (67.8%) females and 49 (32.2%) males, reflecting the typical gender composition in healthcare settings.

The age distribution revealed that the largest group was in the 18--30 years category (73 workers, 48%), followed by workers above 51 years (23 workers, 15.1%), those below 18 years (20 workers, 13.2%), the 31--40 years group (19 workers, 12.5%), and the 41--50 years group (17 workers, 11.2%). The predominance of younger workers suggests a relatively youthful workforce in the surveyed hospitals.

With respect to educational attainment, the vast majority of participants (138 workers, 90.8%) had tertiary education, whereas only 14 (9.2%) had secondary education as their highest qualification. This high level of education is expected given the professional nature of healthcare work. In terms of marital status, 109 (71.7%) participants were single, whereas 43 (28.3%) were married.

The occupational distribution revealed that laboratory scientists formed the largest group (48 workers, 31.6%), followed by pharmacists (42 workers, 27.6%), patients who were in the hospital environment (31 workers, 20.4%), doctors/nurses (18 workers, 11.8%), and cleaners (13 workers, 8.6%). This distribution reflects the diverse workforce exposed to hospital noise.

Table 4.4: Demographic characteristics of hospital workers (N=152)

Variable	Category	Frequency (N)	Percentage (%)
Location	Public	101	66.4
	Private	51	33.6
Sex	Male	49	32.2
	Female	103	67.8
Age	<18yrs	20	13.2
	18−30yrs	73	48
	31−40yrs	19	12.5
	41−50yrs	17	11.2
	>51yrs	23	15.1
Education	Secondary	14	9.2
	Tertiary	138	90.8
Marital Status	Married	43	28.3
	Single	109	71.7
Category of Respondent	Doctor/Nurse	18	11.8
	Laboratory scientist	48	31.6
	Pharmacist	42	27.6
	Cleaner	13	8.6
	Patient	31	20.4

4.5 Perceived risk factors for noise pollution

Table 4.5 presents the perceived risk factors associated with noise exposure among hospital workers. With respect to job duration, the majority of workers (96, 63.2%) had been working for 2--4 years, followed by those with more than 15 years of experience (22, 14.5%), 5--7 years (21, 13.8%), and 8--15 years (13, 8.6%).

The daily duration of noise exposure revealed that more than half of the participants (86 workers, 56.6%) were exposed to noise for 8–12 hours daily, representing full work shifts. Another 51 workers (33.6%) experienced noise exposure for 3–7 hours, whereas only 15 workers (9.9%) reported 1–2 hours of daily exposure.

Workers' perceptions of noise levels revealed that 92 (60.5%) perceived the noise as moderate, 36 (23.7%) perceived it as high, and 24 (15.8%) perceived it as low. Regarding the period when noise was most noticeable, the majority (109 workers, 71.7%) indicated that noise was highest during the afternoon, while 36 (23.7%) reported morning noise as the peak period, and only 7 (4.6%) identified evening noise.

Table 4.5: Perceived risk factors for noise pollution (N=152)

Variable	Category	Frequency (N)	Percentage (%)
Job Duration	2−4 yrs	96	63.2
	5−7 yrs	21	13.8
	8−15 yrs	13	8.6
	>15 yrs	22	14.5
Daily Duration	1−2 hrs	15	9.9
	3−7 hrs	51	33.6
	8−12 hrs	86	56.6
Noise Level	High	36	23.7
	Moderate	92	60.5
	Low	24	15.8
Period of Noise Occurrence	Morning	36	23.7
	Afternoon	109	71.7
	Evening	7	4.6
	Yes	91	59.9

4.6 Sources of noise pollution in hospitals

Table 4.6 lists the various sources contributing to noise pollution in the surveyed hospitals. Human activities emerged as the most prevalent source, with 140 workers (92.1%) identifying it as a contributor to hospital noise. This includes conversations, footsteps, movement of staff and visitors, and general human-generated sounds.

Outdoor sources were identified by 95 workers (62.5%) as contributing to hospital noise, including traffic, construction activities, and environmental sounds penetrating the hospital environment. Hospital equipment was recognized by 91 workers (59.9%) as a noise source, encompassing medical devices, air conditioning systems, and other mechanical equipment. Emergency alarms were identified by 77 workers (50.7%) as noise contributors.

Table 4.6: Sources of noise pollution in hospitals (N=152)

Variable	Category	Frequency (N)	Percentage (%)
Hospital Equipment	No	61	40.1
	Yes	91	59.9
Human Activities	No	12	7.9
	Yes	140	92.1
Emergency Alarms	No	75	49.3
	Yes	77	50.7
Outdoor Sources	No	57	37.5
	Yes	95	62.5

4.7 Reported Noise-Related Health Effects among Hospital Workers

Table 4.7 presents the prevalence of various noise-related health effects reported by hospital workers. The most commonly reported effect was tiredness, with 80 workers (52.6%) experiencing this symptom. This was followed by poor sleep quality, reported by 48 workers (31.6%), and disturbance of mental health, reported by 44 workers (28.9%).

In terms of auditory effects, hearing difficulty was reported by 33 workers (21.7%), whereas tinnitus affected 31 workers (20.4%). Only 14 workers (9.2%) reported experiencing hearing loss, although this may reflect underrecognition or early-stage impairment. A lack of concentration was reported by 59 workers (38.8%). Interestingly, 30 workers (19.7%) reported hypertension, suggesting potential cardiovascular effects of chronic noise exposure.

Table 4.7: Reported noise-related effects among health workers (N=152)

Variable	Category	Frequency (N)	Percentage (%)
Hearing Loss	No	138	90.8
	Yes	14	9.2
Tinnitus	No	121	79.6
	Yes	31	20.4
Hearing Difficulty	No	119	78.3
	Yes	33	21.7
Hypertension	No	122	80.3
	Yes	30	19.7
Poor Sleep Quality	No	104	68.4
	Yes	48	31.6
Disturbance of Mental Health	No	108	71.1
	Yes	44	28.9
Tiredness	No	72	47.4
	Yes	80	52.6
Lack of Concentration	No	93	61.2
	Yes	59	38.8

4.8 Prevalence of Hearing Impairment

Table 4.8 presents the results of the hearing assessment via the HHQT® (Hearing Handicap Questionnaire Tool). The findings reveal a concerning prevalence of potential hearing problems among hospital workers. Only 21 workers (13.8%) were categorized as having no hearing loss. The majority, 109 workers (71.7%), were classified as needing a hearing test suggestion, indicating possible hearing impairment requiring professional audiological evaluation. Additionally, 22 workers (14.5%) were identified as potentially having a hearing problem.

Overall, 131 workers (86.2%) reported hearing impairment or potential hearing problems on the basis of the HHQT® screening tool.

Table 4.8: Prevalence of Hearing Impairment via the HHQT® Tool

Characteristic	Frequency (N)	Percentage (%)
No Hearing Loss	21	13.8
May have a hearing problem	22	14.5
A Hearing Test is suggested	109	71.7

4.9 Awareness of Noise Pollution among Hospital Workers

Table 4.9 presents the level of awareness regarding noise pollution among hospital workers. The results show that awareness varies considerably depending on the specific aspect of noise pollution being considered.

Almost all workers (149, 98%) reported awareness of noise exposure in their workplace, indicating good recognition of the problem. However, awareness of safe hospital limits for noise was moderate, with 78 workers (51.3%) being aware and 74 (48.7%) lacking this knowledge. This suggests a need for better education about permissible noise standards in healthcare settings.

Awareness of government intervention regarding noise pollution was very low, with only 9 workers (5.9%) reporting knowledge of such interventions, whereas 143 (94.1%) were unaware.

Table 4.9: Level of Awareness of Noise Pollution among Health Workers (N=152)

Variable	Category	Frequency (N)	Percentage (%)
Noise Exposure Awareness	No	3	2
	Yes	149	98
Hospital Safe Limits Awareness	No	74	48.7
	Yes	78	51.3
	Total	152	100
Govt Intervention Awareness	No	143	94.1
	Yes	9	5.9
Routine Noise Pollution Monitoring	No	136	89.5
	Yes	16	10.5

4.10 Association between Sociodemographic Factors and Noise-Related Health Effects

4.10.1 Location (Hospital Type)

Hospital location was significantly associated with all three health outcomes. Compared with private hospital workers (5.9%), public hospital workers had a significantly greater prevalence of tinnitus (27.7%), $\chi^2 = 9.957$, $p = 0.002$. Similarly, hearing difficulty was more prevalent among public hospital workers (28.7%) than among private hospital workers (7.8%), $\chi^2 = 8.684$, $p = 0.003$. Hypertension also exhibited this pattern, with 26.7% of public hospital workers affected compared with 5.9% of private hospitals, $\chi^2 = 9.300$, $p = 0.002$.

4.10.2 Gender

Sex was not significantly associated with any of the three health outcomes. The prevalence of tinnitus was 22.4% in males and 19.4% in females ($\chi^2 = 0.188$, $p = 0.665$). Hearing difficulty affected 22.4% of the males and 21.4% of the females ($\chi^2 = 0.023$, $p = 0.879$). The prevalence of hypertension was 22.4% in males and 18.4% in females ($\chi^2 = 0.336$, $p = 0.562$).

4.10.3 Age

Age was significantly associated with all three health outcomes. For tinnitus, the prevalence increased with age, ranging from 9.6% in the 18–30 years group to 41.2% in the 41–50 years group ($\chi^2 = 13.882$, $p = 0.008$). Hearing difficulty showed a similar pattern, with the highest prevalence (52.9%) in the 41–50 years age group ($\chi^2 = 14.478$, $p = 0.006$). The hypertension incidence also increased with age, reaching 58.8% in the 41–50 years group ($\chi^2 = 15.295$, $p = 0.004$).

4.10.4 Level of Education

Educational level was significantly associated with only tinnitus ($\chi^2 = 4.792$, $p = 0.029$), with tertiary-educated workers reporting a higher prevalence (21.0%) than those with secondary education (14.3%). However, education was not significantly associated with hearing difficulty ($\chi^2 = 1.776$, $p = 0.183$) or hypertension ($\chi^2 = 2.485$, $p = 0.115$).

4.10.5 Years of Work Experience

Work experience was significantly associated with all three health outcomes. The prevalence of tinnitus was lowest among workers with 2–4 years of experience (13.1%) and highest among those with 8–15 years (53.8%), $\chi^2 = 15.672$, $p = 0.001$. Hearing difficulty was most prevalent among workers with more than 15 years of experience (52.6%) and those with 8–15 years (46.2%), $\chi^2 = 13.634$, $p = 0.003$. Hypertension showed similar patterns, with the highest prevalence in workers with more than 15 years (47.4%) and 8–15 years (46.2%) of experience, $\chi^2 = 16.956$, $p = 0.001$.

Table 4.10: Association between Sociodemographic Factors and Reported Noise Effects

Variables	Tinnitus		χ^2 (p value)	Hearing difficulty		χ^2 (p value)	Hypertension		χ^2 (p value)
	Yes n (%)	No n (%)		Yes n (%)	No n (%)		Yes n (%)	No n (%)	
Location			9.957 (0.002)			8.684 (0.003)			9.300 (0.002)
Public	28(27.7)	73(72.3)		29 (28.7)	72 (71.3)		27 (26.7)	74 (73.3)	
Private	3 (5.9)	48 (94.1)		4 (7.8)	47 (92.2)		3 (5.9)	48 (94.1)	
Gender			0.188 (0.665)			0.023 (0.879)			0.336 (0.562)
Male	11 (22.4)	38 (77.6)		11 (22.4)	38 (77.6)		11 (22.4)	38 (77.6)	
Female	20 (19.4)	83 (80.6)		22 (21.4)	81 (78.6)		19 (18.4)	84 (81.6)	
Age			13.882 (0.008)			14.478 (0.006)			15.295 (0.004)
<18yrs	3 (15.0)	17 (85.0)		3 (15.0)	17 (85.0)		3 (15.0)	17 (85.0)	
18-30yrs	7 (9.6)	66 (90.4)		8 (11.0)	65 (89.0)		12 (16.4)	61 (83.6)	
31-40yrs	6 (31.6)	13 (68.4)		6 (31.6)	13 (68.4)		7 (36.8)	12 (63.2)	
41-50yrs	7 (41.2)	10 (58.8)		9 (52.9)	8 (47.1)		10 (58.8)	7 (41.2)	
>51yrs	8 (34.8)	15 (65.2)		3 (15.0)	17 (85.0)		10 (43.5)	13 (56.5)	
Level of Education			4.792 (0.029)			1.776 (0.183)			2.485 (0.115)
Secondary	2 (14.3)	12 (85.7)		5 (35.7)	9 (64.3)		5 (35.7)	9 (64.3)	
Tertiary	29 (21.0)	109 (79.0)		28 (20.3)	110 (79.7)		25 (18.1)	113 (81.9)	
Years of work Experience			15.672 (0.001)			13.634 (0.003)			16.956 (0.001)
2-4 yrs	13 (13.1)	86 (86.9)		14 (14.1)	85 (85.9)		12 (12.1)	87 (87.9)	
5-7 yrs	7 (33.3)	14 (66.7)		3 (14.3)	18 (85.7)		3 (14.3)	18 (85.7)	
8-15 yrs	7 (53.8)	6 (46.2)		6 (46.2)	7 (53.8)		6 (46.2)	7 (53.8)	
>15 yrs	4 (21.1)	15 (78.9)		10 (52.6)	9 (47.4)		9 (47.4)	10 (52.6)	

Table 4.10 presents the results of a chi-square ($\chi 2$) test examining the relationships between different demographic and occupational variables and the prevalence of three health conditions: tinnitus, hearing difficulty, and hypertension. A significant association ($p<0.05$) was found for the following variables with all three health outcomes. The location where people work was significantly associated with the presence of tinnitus ($\chi 2=9.957$, $p=0.002$), hearing difficulty ($\chi 2 =8.684$, $p=0.003$), and hypertension ($\chi 2 =9.300$, $p=0.002$). A significantly greater percentage of people working in the public setting reported having all three conditions (tinnitus: 27.7%; hearing difficulty: 28.7%; hypertension: 26.7%) than did those working in the private setting (tinnitus: 5.9%; hearing difficulty: 7.8%; hypertension: 5.9%). Age was significantly associated with tinnitus ($\chi 2 =13.882$, $p=0.008$), hearing difficulty ($\chi 2 =14.478$, $p=0.006$), and hypertension ($\chi 2 =15.295$, $p=0.004$). The percentage of individuals reporting these health conditions generally increases with age, with the highest percentages often seen in the 41–50 and >51 age groups across the conditions. For example, Hearing difficulty was reported by 52.9% of the 41–50 age group and 9.6% of the 18–30 age group. Years of work experience was significantly associated with tinnitus ($\chi 2 =15.672$, $p=0.001$), hearing difficulty ($\chi 2 =13.634$, $p=0.003$), and hypertension ($\chi 2 =16.956$, $p=0.001$). There appears to be a link between longer exposure in the workplace and health issues, as the highest percentages for tinnitus (53.8%) and hearing difficulty (46.2%) are found in the 8–15 years category, and the highest percentage for hypertension (47.4%) is in the >15 years category. Sex was not significantly associated with tinnitus ($p=0.665$), hearing difficulty ($p=0.879$), or hypertension ($p=0.562$). This means that the differences in the percentages of males and females reporting these health conditions could be due to random chance. The level of education was not significantly associated with hearing difficulty ($p=0.183$) or hypertension ($p=0.115$). However, it was significantly associated with tinnitus ($p=0.029$). For

tinnitus, there was a significant difference between the secondary (14.3%) and tertiary (21.0%) groups. The nonsignificant results for the other two conditions indicate that there is no strong evidence of a relationship between education level and those two conditions.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Noise Levels and Exceedance of the Recommended Limits

The results revealed that almost all the measured noise levels in both public and private hospitals exceeded the NESREA (2009) permissible limit of 60 dB for hospital environments. Only the public hospital car park fell below this limit in the morning (57.70 dB). The highest noise levels were recorded in the Pediatrics, COPD, and Emergency wards, which averaged between 74 dB and 77 dB.

These findings are consistent with global evidence showing that hospital noise levels often exceed safe thresholds. Basner*et al*. (2014) reported that typical hospital noise ranges between 45 dB and 90 dB, which far surpasses the World Health Organization's (WHO) recommended hospital limit of 35 dB during the day and 30 dB at night. Similarly, Busch-Vishniac*etet al*. (2005) reported that average hospital sound levels have increased steadily since the 1960s and now regularly exceed 70 dB.

The high noise levels observed in this study can be attributed to heavy patient traffic, continuous equipment operation, alarms, conversations, and structural factors such as hard surfaces that amplify sound reflections (Hsu *et al*., 2012). In developing countries, hospitals often lack acoustic design considerations, compounding the problem (Awoyemi and Adeyemi, 2021). The afternoon increases in certain wards may be due to higher patient loads, visiting hours, and peak operational activities.

While the measured noise levels in this study were below industrial thresholds, they were significantly above the hospital environmental limits set by NESREA and the WHO. Sustained exposure to moderate noise (70–80 dB) for long hours can still produce physiological and psychological stress. Chronic noise exposure activates the hypothalamic–pituitary–adrenal (HPA) axis, leading to increased cortisol and sympathetic arousal (Babisch, 2011). This mechanism explains the observed hypertension (19.7%) and mental health disturbances (28.9%) among participants.

5.2 Temporal variation and Ward-specific differences

Analysis of variance (ANOVA) revealed significant temporal variations in noise levels across most

wards in the public hospital and during morning hours in the private hospital ($p < 0.05$). However, the private hospital in the afternoon showed no significant variation ($p = 0.093$), indicating more consistent sound levels.

Temporal variation has been similarly reported by Park *et al*. (2014), who reported that hospital noise fluctuates with patient turnover and clinical workload. Wards such as emergency and pediatric units tend to be noisier due to continuous activity and equipment alarms. The absence of significant differences in the private hospital's afternoon readings may reflect more controlled operations, lower patient influx, or better spatial design.

Overall, the observed patterns confirm that noise exposure is influenced by hospital function, workload rhythm, and time of day rather than by hospital ownership alone.

5.3 Comparison between Public and Private Hospitals

Independent ttests indicated no statistically significant difference in mean noise levels between public and private hospitals in either the morning ($p = 0.559$) or afternoon ($p = 0.297$). This suggests that both facility types expose workers to similar noise environments.

A comparable outcome was reported by Ologe, Akande, and Olajide (2006) in Ilorin, Nigeria, where public and private hospitals showed similar mean sound levels despite differences in funding and infrastructure. This may be because both hospital types use similar equipment, have comparable patient volumes, and rarely enforce noise control measures.

This result implies that noise pollution is a systemic issue across healthcare facilities in Nigeria, cutting across public and private ownership.

5.4 Prevalence of health effects and hearing impairment

The study revealed that 20.4% of the respondents reported tinnitus, 21.7% reported hearing difficulty, and 9.2% reported hearing loss. However, the HHQT® screening indicated that 71.7% of the participants may have potential hearing problems requiring a formal hearing test.

This prevalence is higher than that reported in figures from the United States, where 10% of healthcare and social assistance workers reported hearing difficulty and 7% reported tinnitus (Kerns, Masterson, Themann, and alvert, 2016). The difference may reflect higher exposure levels, longer working hours, and weaker occupational safety enforcement in Nigeria.

Noise-induced hearing loss (NIHL) typically develops from long-term exposure to levels above 85 dB(A) for eight hours daily (Rabinowitz, 2012). Although the measured levels in this study were below the industrial threshold, continuous exposure to 70–80 dB for extended hours can still lead to auditory fatigue and long-term damage (World Health Organization, 2018).

Nonauditory effects such as tiredness (52.6%), poor concentration (38.8%), and sleep disturbance (31.6%) were also common. Similar patterns have been reported among nurses in noisy hospital environments, where noise was associated with increased stress and burnout and decreased job satisfaction (Li *et al*., 2022; Choiniere, 2010). Chronic exposure to hospital noise can also trigger physiological stress responses, increasing blood pressure and the risk of hypertension (Basner*et al*., 2014; Babisch, 2011).

5.5 Risk Factors Associated with Noise-Related Effects

Significant associations were found between location, age, years of experience, and health outcomes ($p < 0.05$). Workers in public hospitals reported more tinnitus, hearing difficulty, and hypertension than did those in private hospitals. Older age and more years of service were also linked to these effects.

These associations align with findings by Fuente and Hickson (2011), who reported that age and cumulative exposure duration are strong predictors of hearing decline. Older workers are more susceptible to both prolonged exposure and age-related hearing sensitivity (presbycusis). Similarly, Wang *et al*. (2023) demonstrated that the risk of NIHL increases significantly after 10 years of occupational exposure.

The higher prevalence in public hospitals may stem from larger patient numbers, older infrastructure, and less effective noise control systems. Educational level was significantly associated with tinnitus ($p = 0.029$), possibly because respondents with tertiary education were more aware and able to identify auditory symptoms.

5.6 Awareness and Institutional Practices

Although 98% of the respondents were aware of workplace noise exposure, only 51.3% were aware of the recommended safe limits, and fewer than 11% reported any routine noise monitoring. This gap between personal awareness and institutional practice mirrors earlier observations by Jansen *et al*. (2015), who reported that awareness does not necessarily translate into protective behavior when institutional policies are lacking.

The Occupational Safety and Health Administration (OSHA) standards recommend hearingconservation programs when exposures exceed 85 dBA over eight hours, including

monitoring, training, and annual audiometric testing (OSHA, 2022). However, similar regulatory enforcement mechanisms are not widely implemented in Nigeria. The lack of systematic noise monitoring observed in this study highlights the need for national guidelines on hospital noise control.

5.8 Conclusion

The study established that hospital workers in Benin city are consistently exposed to noise levels above recommended safety limits. Both auditory (hearing difficulty, tinnitus) and nonauditory (tiredness, hypertension, poor concentration) health effects were prevalent. Age, years of experience, and working in a public hospital were major risk factors. Despite high personal awareness, institutional control and monitoring were inadequate. These findings emphasize the urgent need for occupational noise-management strategies in healthcare settings.

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Appendix 1: Questionnaire

QUESTIONNAIRE

UNIVERSITY OF BENIN, FACULTY OF LIFE SCIENCES,

DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY

Title: Investigation of Noise Exposure Levels and Hearing Impairment among Hospital Workers in Benin City.

TO PARTICIPANTS

INSTRUCTIONS:

- **Please answer the following questions about yourself, your hearing, and any noise you may have been exposed to during the past years. Write an answer in the blank [_____] or check () the best answer to each question.**
- **Be sure to complete all pages.**

SECTION A: Socio-Demographic Characteristics of Respondents

Location (Workplace) _____

1. Gender: Male () Female ()
2. What is your age?

18 years () 18 – 30 years () 31 – 40 years () 41 – 50 years () 51 and above

3. What is your level of Education? Primary () Secondary () Tertiary ()
4. Marital status: Married () Single ()
5. Category of Respondents Doctor () Nurse () Laboratory Scientist () Admin () Others ()

SECTION B: Respondents exposure to Noise pollution

6. How long have been working/been in the Hospital environment? 2-4 yrs () 5-7 yrs () 8-15 yrs () Above 15 yrs ().
7. How long do you spend at the hospital each day? 1-2 hrs () 3 -7 hrs () 8 -12 hrs
8. How will you describe the noise level in the hospital? High () Moderate () Low ()
9. When do you experience noise mostly in the hospital? Morning () Afternoon () Evening ()
10. What are the sources of noise pollution in the hospital environment?

	Perceived Sources of noise pollution	Yes	No
A	Hospital equipment		
B	Human activities		
C	Emergency Alarms		
F	Outdoor sources such as Vehicular noise		

	Perceived Noise-related effects	Yes	No
A	Hearing loss		
B	Tinnitus (ringing or buzzing sound in the ear)		
C	Hearing difficulty		
D	Hypertension		
E	Poor sleep quality		
F	Disturbance of mental health		
G	Tiredness		
H	Lack of concentration		

SECTION C: Perceived noise-related effects.

11. **Tick the noise-related effects you may have/or experience.**

SECTION D:Awareness of noise pollution-related health and control measures.

12. Are you aware that exposure to noise pollution can cause health effects? Yes () No ()
13. Do you have any knowledge of the safe limits of noise pollution levels in the hospital environment? Yes () No ()
14. Do you use any form of personal protective equipment to prevent noise during work? Yes () No ()
15. Do you know about any government intervention programmes on noise pollution in this hospital? Yes () No ()
16. Are you aware of any routine noise pollution monitoring in this hospital? Yes () No ()

Thank you for participating.

Hearing Health Quick Test

1. Do you find it difficult to follow a conversation in a noisy restaurant or crowded room? ☐ Yes ☐ No ☐ Sometimes
2. Do you sometimes feel that people are mumbling or not speaking clearly? ☐ Yes ☐ No ☐ Sometimes
3. Do you experience difficulty following dialogue in the theater? ☐ Yes ☐ No ☐ Sometimes
4. Do you sometimes find it difficult to understand a speaker at a public meeting or a religious service?

   ☐ Yes ☐ No ☐ Sometimes
5. Do you find yourself asking people to speak up or repeat themselves? ☐ Yes ☐ No ☐ Sometimes
6. Do you find men's voices easier to understand than women's voices? ☐ Yes ☐ No ☐ Sometimes
7. Do you experience difficulty understanding soft or whispered speech?

   ☐ Yes ☐ No ☐ Sometimes
8. Do you have difficulty understanding speech on the telephone? ☐ Yes ☐ No ☐ Sometimes

9. Does a hearing problem cause you to feel embarrassed when meeting new people? ☐ Yes ☐ No ☐ Sometimes

10. Do you feel handicapped by a hearing problem? ☐ Yes ☐ No ☐ Sometimes

11. Does a hearing problem cause you to visit friends, relatives, or neighbors less often than you would like? ☐ Yes ☐ No ☐ Sometimes

12. Do you experience ringing or noises in your ears? ☐ Yes ☐ No ☐ Sometimes

13. Do you hear better with one ear than the other? ☐ Yes ☐ No ☐ Sometimes

14. Have you had any significant noise exposure during work, recreation, or military service?

    ☐ Yes ☐ No

15. Has any of your relatives (by birth) experienced hearing loss? ☐ Yes ☐ No

Scoring

2 points for yes

1 point for Sometimes 0 points for No

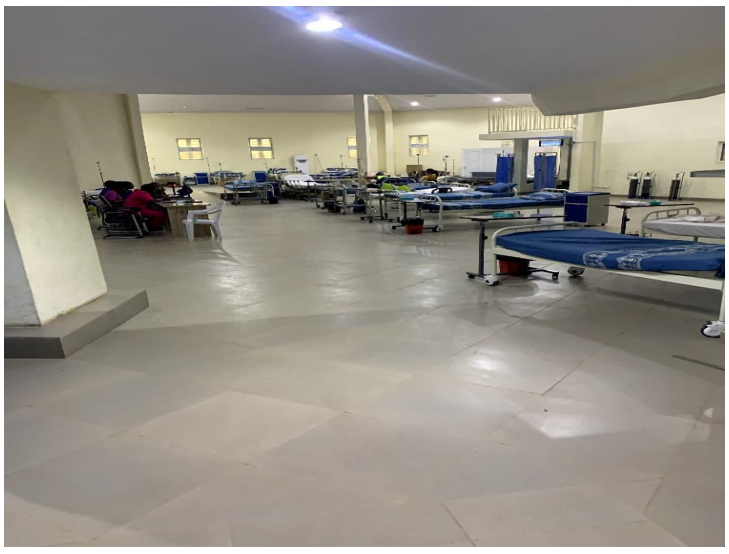
Scores of 3 or more: May means that you have a hearing problem. **Scores of 6 or more** strongly suggest that a hearing check is warranted.

For more information on audiology and hearing loss visit **www.HowsYourHearing.org**

AMERICAN ACADEMY OF AUDIOLOGY

Appendix 2: Fieldwork Activities: Taking Noise Level Data, Sharing Questionnaires, and Capturing Buildings and Wards


ANTENATAL
CLINIC



Appendix 3: Letters for Research Purposes;