

**LEVELS OF ENVIRONMENTAL NOISE AND PERCEIVED HEALTH  
IMPLICATIONS IN BUS TERMINI IN NAIROBI CENTRAL BUSINESS  
DISTRICT, NAIROBI CITY COUNTY, KENYA**


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Q139/24924/2013**

**THESIS SUBMITTED IN PARTIAL FULFULFILMENT OF THE  
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF  
SCIENCE (ENVIRONMENTAL HEALTH) IN THE SCHOOL OF PUBLIC  
HEALTH OF KENYATTA UNIVERSITY**

**JULY, 2018**

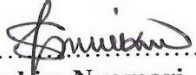
**DECLARATION**


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

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## **DEDICATION**

With appreciation for their patience, understanding and love. I dedicate this to my Wife (Tabbia ) who is also my girlfriend for her encouragement during this study, my son Harold E. Nyaranga, my late Mom and Dad who fed my heart, nourished my soul and empowered my spirit.

God Bless You.

## ACKNOWLEDGEMENT

To the Almighty your divine guidance and direction is cherished forever, completely nothing could have been achieved without you. Thank you for the wisdom, knowledge, and Perseverance to accomplish this.

Sincere appreciation to Kenyatta University for giving me a chance to pursue this course. To my supervisors, **Dr. Jackim Nyamari and Dr. Daniel Akunga** Lecturers at Kenyatta University, School of Public Health, Department of Environmental and Occupational Health without your tireless, kind, timely guidance and advice this work would have not assumed the present shape. Thanks for enabling me to understand the essence of research methodology and how to apply it in real research scenario.

My heartfelt appreciation goes to Mr. Emmanuel Owino and Timothy Makori for your insight during this study, may God bless the work of your hands.

My family members John, Seth, James, Mildren, Charles, Duncan, Dorothy, Sylvia Mourine and to all my prayer cell group members at Seventh Day Adventist Church ,Kahawa Wendani I cherish your moral support and prayers during this study.

Finally my gratitude to entire Nairobi City bus termini fraternity and my research assistants; Vincent Onyango and Wilberforce Okwako for giving me their time through consultation and support on data collection, God bless you.

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**ABBREVIATION AND ACRONYM**

<b>CBD</b>	Central Business District
<b>DALYs</b>	Disability – Adjusted Life Years
<b>dB</b>	Decibels
<b>EBD</b>	Environmental Burden of Diseases
<b>EEG</b>	Electroencephalographic
<b>EMCA</b>	Environmental Management Coordination Act
<b>EPA</b>	Environmental Protection Agency
<b>ILO</b>	International labor Organisation
<b>KMI</b>	Kenya Motor Industry
<b>KNBS</b>	Kenya National Bureau of Statistics
<b>NEMA</b>	National Environmental Management Authority
<b>PTS</b>	Permanent Threshold Shift
<b>TTS</b>	Temporary Threshold Shift
<b>US</b>	United States
<b>USEPA</b>	United States Environmental Protection Agency
<b>WHO</b>	World Health Organization

## OPERATIONAL DEFINITION OF TERMS

**Boom cars:** These are cars with loud stereo systems used for private or public transport.

**Community /Environmental Noise:** Environmental noise (also called environmental noise, residential noise or domestic noise) is noise emitted from all sources except noise at the industrial workplace (WHO, 2008b).

**Hearing impairment:** Refers to the inability to hear things, either wholly or partially.

**Noise:** Is unwanted sound and is among the most pervasive pollutants today. Noise from road traffic, jet planes, jet skis, garbage trucks, construction equipment, manufacturing processes, lawn mowers, leaf blowers, and boom boxes, to name a few, are among the unwanted sounds that are routinely broadcast into the air.

**Sound:** Is a vibration that propagates as a typically audible mechanical wave of pressure and displacement, through a medium such as air or water.

## ABSTRACT

Environmental noise is noise emanating from all other sources except the industrial workplace, main sources include road, rail and air traffic, industries, construction, public works and social activities. WHO and NEMA provides permissible environmental noise level standard to be 75 and 60 dB (A) respectively. Noise pollution has been linked to many adverse health effects and there is limited documentation to this effect within the CBD termini of Nairobi. The aim of this study was to assess noise levels and its perceived health effects across bus termini in Central Business District of Nairobi City. Using a cross-sectional study design and fishers *et al* (1983) to determine the sample size, a random sample of 422 community members working within nine bus termini for more than 8 hours a day were approached and recruited in the study. Noise levels were measured using Calibrated sound level meter (Model # 8926). A self-administered semi-structured questionnaire was used to collect data to identify perceived health risks of noise and safety practices across bus termini. Univariate Chi-square test of independence was used to test the association between noise levels and reported health implications. The response rate was 94.7% (n= 397). The study revealed that 66.8% of respondents (n=265) had awareness on effects of excessive noise exposure as compared to 33.2% (n=132). This study revealed that a higher proportion of respondents spending more than 3 days a week working at the bus termini visited the doctor for a perceived noise induced hearing problem. As such there was a significant association between the number of days spend working at the bus termini in a week and visiting a doctor for a noise induced hearing problem ( $\chi^2=16.52$ ,  $df=2$ ;  $p<0.001$ ). In this study, the leading acute perceived health effects of excessive noise were reported to be sleep disturbance at 24.17% (n=152), hearing impairment at 23.05% (n=145), exhaustion at 13.04% (n=82), high blood pressure at 12.72% (n=80) and annoyance at 10.18% (n=64). This study revealed a high concentration of noise levels ranging between 88.14 to 115.04dB(A) at Tuskys, St Peters Clavers, Central, Latema and Ronald Ngala bus termini as compared to Ngara and Railways bus termini which reported low concentration of noise levels ranging 85.45 to 93.63dB(A). There was a variation in maximum mean noise levels across the day, in the morning the maximum noise level was 93.65dB recorded at Old Nation Bus Terminus, at midday the maximum noise level was 94.28 dB recorded at Tuskys Bus Terminus while in the evening maximum mean noise level was 118.44 dB as recorded at Moi Lane Bus Terminus. This study revealed a significant association ( $\chi^2=27.663$ ;  $df=8$ ;  $p<0.001$ ) between a respondent visiting a doctor for a perceived noise induced hearing problem and bus termini in which they are located. Hence a high proportion of respondents who visited the doctor for a perceived noise induced hearing problem were from bus termini that recorded high noise levels. This study revealed that safety practices most likely to be utilized across all occupational groups include; working few hours in the noisy environment ( $\chi^2=7.746$ ;  $df=2$ ;  $p<0.021$ ); closing windows and doors to eliminate noise ( $\chi^2=3.89$ ;  $df=2$ ;  $p<0.05$ ) and walking away from noise ( $\chi^2=5.29$ ;  $df=2$ ;  $p<0.024$ ). However, a higher proportion of respondents across all the occupational groups reported not using personal protective equipment. In conclusion, this study has demonstrated that noise levels in Nairobi are beyond the permissible levels as per NEMA standards 60 dB(A) and WHO ( 75dB(A) standards. Location of bus termini close to each other contributes to the significant generation of noise. Consequently, the authorities should spread out bus termini to reduce high concentration of noise levels at single hotspots in the city. In addition, the public transport routes should be designed in a manner such that they do not terminate at one point in the city.

## CHAPTER ONE: INTRODUCTION

### 1.1 Background to the Study

Noise refers to unsolicited sound or any unwarranted sound disruption within a useful frequency band (Olayinka, 2013). Conversely, sound is considered to be a sensory perception induced by physiological processes in the auditory brain producing an intricate pattern of waves (Margaritis & Kang, 2017). According to Belojevic *et al.* (2016), environmental noise is also referred to as environmental noise, residential noise or domestic noise emanating from all other sources except the industrial workplace. The main sources of environmental noise include road, rail and air traffic, industries, construction, public works and social activities (Hammersen, Niemann, & Hoebel, 2016).

Noise is an increasingly omnipresent and growing menace, yet an underestimated form of pollution (Cohen *et al.*, 2014). Long periods of exposure to relatively low levels of noise can have adverse effects on human health (UNEP, 2003). Different people in the U.S. suffer from different degrees of hearing loss directly caused by noise. Similarly, the European Union populations suffer unacceptable levels of continuous noise within that are hazardous to their wellbeing (Fan, Zhiyi, Zhujun, & Jiani, 2010).

Noise pollution is a pervading issue in the United States. Over half of the American community is exposed to myriad types of noise pollutants such as traffic noise and noise from entertainment hubs among other social activities (Hammer *et al.*, 2014).

Hammersen *et al.* (2016) argue that the annual exposures to noise are high enough to cause harm to human health. However, regardless of the fact that noise exposure is widespread, this type of pollution has been perceived and treated differently than other forms of pollution such as radiation and chemical hazards. Cohen *et al.* (2014) reports that noise exposure is on the increase, especially in the general living environment, both in industrialized nations and in developing world regions and emphasizes that the noise exposure in the twenty-first century is a major public health problem.

According to Barbara and Rose (2011), maximum and minimum levels of noise should be recorded during community assessment of noise levels, if the level does not drop below 90dB (A) within a timeline of 8 hours a day an unsatisfactory noise exposure should be recorded. World Health Organization (2000) has recommended that an average standard of 70 dB (A) of environmental noise is harmful to health. In Kenya, Legal Notice No. 61; Environmental Management and Coordination (Noise and excessive vibration pollution) (Control) Regulation, 2009 provides 60dB (A) to be the standard of environmental noise level during the day in commercial zones in Kenya (Gongi, 2018).

Noise is a more widespread pollution that may cause interferences in various realms of life. It causes interference with communications, effects on cardiovascular system, social behavior, and productivity, a disorder in concentration, hearing impairment, vigilance, sleep disturbances and noise annoyance (Bluhm *et al.*, 2004). An upsurge in hearing loss and other noise related hazards have been experienced in the past few

decades as compared to before the industrial revolution when few people were exposed to high levels of noise (Barbara & Rose, 2011).

According to WHO (2008b), noise can disturb man's work, rest, sleep, and communication; it can damage his hearing and evoke other psychological, physiological, and possibly pathological reactions. Furthermore, in most countries hearing impairment due to environmental/environmental noise exposure has become a problem of concern. It has been proven that environmental noise may have some direct adverse impacts other than hearing damage (Gongi, 2018; Curhan *et al.*, 2012). These include negative effects on performance, communication, behavior, non-auditory physiological effects, noise-induced disturbance of sleep, and community annoyance (Gongi, 2018). Some of the populations may be more vulnerable to the negative effects of noise as compared to others (Bryan *et al.*, 2008).

According to Münzel, Gori, Babisch, and Basner (2014), exposure to high levels of noise can result in significant adverse health impact. The most important are the loss of hearing acuity caused by repeated exposure to high noise levels, such exposure occurs primarily in the workplace. Furthermore, it can often significantly interfere with communication that leads to quantifiable productivity losses and annoyance that leads to negative community reactions. Basner *et al.* (2014) argue that noise can cause annoyance, interference with speech and community responses, hearing loss and other adverse effects; he explains that the most significant risk factor is Noise is induced hearing loss, heart diseases and accidents (Basner *et al.*, 2014). Noise at every level can

affect our physical health, psychosocial health, and cognitive functions. Potential health effects range from annoyance, sleep disruption, decreased school performance, to ischemic heart disease, high blood pressure, and hearing loss (Hambrick *et al.*, 2008). Hence, Environmental noise is used to estimate the environmental burden of disease (EBD) which is expressed as disability-adjusted life years (DALYs) (WHO, 2011).

## **1.2 Problem Statement**

Exposure to extremely high levels of noise is a major avoidable cause of permanent hearing impairment worldwide. In developing countries, environmental noise (especially traffic noise) is an increasing risk factor for hearing impairment and other health-related risks (Rom & Markowitz, 2007). WHO (2008a) states that 16% of the disabling hearing loss among adults emanates from environmental noise, with a range of 7% to 21% from region to region. Hammer *et al.* (2014) reports that noise-induced hearing loss (NIHL) affects 10 to 15 million people in the USA. In the UK, research shows that the young adults have severe hearing difficulties that point to noise at work (Prendergast *et al.*, 2017). Furthermore, Basner *et al.* (2014) indicated that cases of tinnitus emerge as a result of exposure to concert noise around Nottingham and England. The International Labor Organization (ILO, 2004:9) has noted the lack of reliable data on the situation of persons with disabilities in Kenya, mostly the hearing disability. However, according to 2009 national census 1.3 million Kenyans are living with disabilities whereby fourteen percent of these cases are hearing disabilities (KNBS, 2010).

Noise pollution has been implicated to be the major cause of hearing disabilities in many countries, yet many developing nations such as Kenya often lack effective legislation on noise pollution as well as programs to prevent noise-induced hearing loss and other noise health-related problems. Where such legislation exists such as National Environmental Management Authority (NEMA) and Environmental Management and Coordination Act of 1999, there is often lack of adequate enforcement to control noise pollution (Enda, M. and 2014). In addition, there has been inadequate public health studies and interventions directed towards assessing the prevalence, risk factors and health costs of environmental noise (Musiba, 2015). In Nairobi, Wawa and Mulaku (2015), measured noise levels from predetermined source of noise with the aim of documenting spatial distribution of noise levels in the Nairobi Central Business District. While their study observed high levels of noise between 61-78db, they did not assess the impact of high noise levels on health and well-being in the population. From their findings it was evident that noise levels in Nairobi are high and there is need for further assessment on health effects of noise in the general population. As such it is necessary to conduct this study to not only measure the noise levels but also to assess the perceived health effects of high noise levels in Bus Termini within central business district of Nairobi.

### **1.3 Justification**

Environmental noise pollution has not received adequate attention in Kenya as evidenced by unavailability of data on noise pollution. In addition rapid urban growth

coupled with poorly coordinated public transport has been associated with excess production of noise within urban cities such as Nairobi. On the other hand there is lack of adequate enforcement of environmental laws to effectively control noise level. On overall, there is need to assess awareness on health effects of excessive noise among the general public since adequate public awareness is critical in adoption of measures to prevent generation of excessive noise. Therefore, it is important to investigate levels of environmental noise and its perceived health implications among community members in Nairobi Central Business District, in Nairobi City County being the biggest City in Kenya with the highest volume of both human, vehicle traffic flow and other economic activities.

#### **1.4. Significance of the Study**

Community members need to understand that exposure to noise contributes to both short and long term health consequences. Hence the implementation of the recommendations of this study might help in the reduction of noise pollution through public education on noise control and safety practices. In generating public awareness campaigns and sensitisations bus termini operators and business vendors will understand the implications of environmental noise on health of individuals operating within the terminus, as such this might motivate them to participate in noise control initiatives. Consequently, this might help decrease the prevalence of the noise-related health risks in the population.

Furthermore, there is a need to develop interventions towards noise control as such baseline estimates on noise levels obtained from this study can be used in developing intervention measures. City planners and managers will be aware on sources of noise pollution hence come up with more control measures. The study will add knowledge on environmental noise and its health effects which might assist key stakeholders such as; central government, National Environmental Management Authority, Nairobi County administration and the Parliament in establishing more practical legislative measures and programs to control noise pollution. Findings obtained from this study can be used in appraising Matatu Owners' Welfare Association, to adopt noise control best practices among its workers in the public transport industry and also the public health department may initiate programs on campaigns and sensitisation on health risk of noise pollution. The study will also benefit future researchers, scholars, and academicians wishing to study environmental noise in related issues.

### **1.5 Research Questions**

- i. What are the perceived health effects of the resultant noise levels from the bus termini in Nairobi city?
- ii. What is the effect of time on noise level at bus termini in Nairobi Central Business District, Nairobi City County?
- iii. What are the safety practices on noise pollution among community members in the bus termini of Nairobi Central Business District?

## **1.6 General Objective of the Study**

The purpose of the study was to investigate levels of environmental noise, perceived health implications on community members and safety measures employed by these community members in the bus termini in Central Business District of Nairobi City in Kenya.

### **1.6.1 Specific Objectives**

- i. To assess perceived health effects on resultant noise levels on the bus termini of Nairobi Central Business District, Nairobi City, Kenya.
- ii. To determine the effects of time in noise levels in bus termini of Nairobi Central Business District, Nairobi City, Kenya.
- iii. To determine the safety practices on noise pollution among community members in the bus termini in Nairobi Central Business District, Nairobi City, Kenya.

## **1.7 Limitation and Delimitation of the Study**

The study was limited only to bus terminus within the Nairobi Central Business District. Bus terminus is usually very busy places; some respondents showed some signs of declining the researcher's advances by failing to cooperate fully as expected, citing that they had a tight schedule. Due to close location, there is high volume of both human and Vehicle traffic flow at the nine bus termini together with other commercial activities which lead to generation of excess noise.

## 1.8 Assumption of the Study

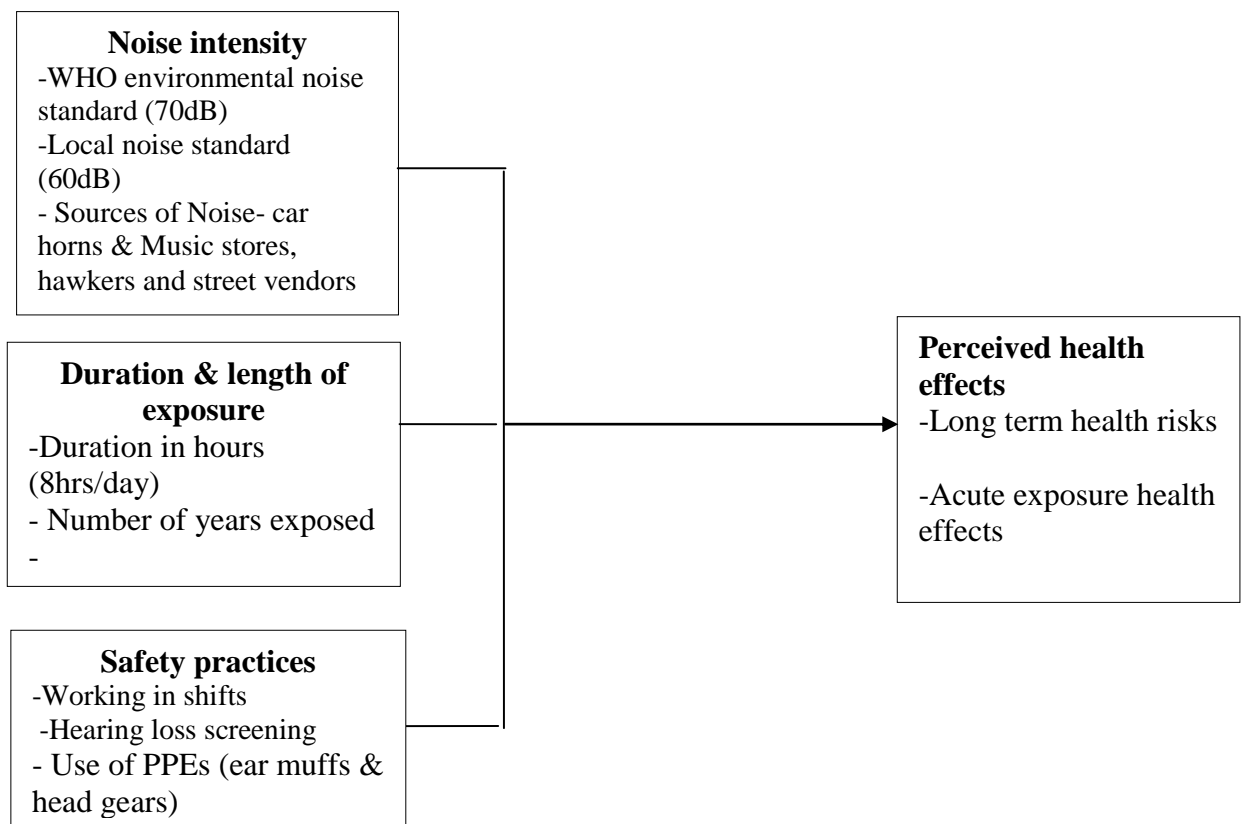
All workers at the bus termini were exposed to noise.

## 1.9 Conceptual Framework

Figure 1.1: illustrates how noise intensity, duration, the length of exposure to noise, and different noise sources would bring possible consequent on the health of community members at the bus termini. Additionally, safety practices among the community members at the termini would intervene on the perceived health effects of the member.

### *Independent Variable*

### *Dependent variable*



**Figure 1.1: Conceptual Framework**

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 Introduction**

This chapter presents the review of the literature on environmental noise; it comprises of theoretical, critical literature review of the study to be addressed.

### **2.2 Review of Theoretical Literature**

Environmental noise must be evaluated to provide management with some assurance regarding its effect (Lerner *et al.* 2010). Despite the fact that it imposes a significant effect on the human beings, little information is available on environmental noise factors that may affect people.

### **2.3 Perceived Health Risks**

Noise is currently one of the most common complaints amongst urban dwellers and workers in a huge metropolis. Restaurants, transportation systems, and other sources of noise in urban environments have been reported as a serious social and serious health. Residents of urban dwellers report myriad perceived effects of high noise levels that have contributed to the formulation of laws and regulations to manage noise. Currently, in advanced nations, town planners are setting up myriad means to mitigate the effects of noise emanating from generating plants, religious activities, vehicular movement, and other noise pollutants (Margaritis & Kang, 2017; Olayinka, O2013). In a nutshell, the effects of noise have become a common point of worry among many people from different communities (Winter & Koger, 2014).

In France, the Ministry of Employment conducted a survey that indicated that around 7% of employees are exposed to extreme noise levels that are over 85 dB (A) for at least 20 hours every week, and around 25% are exposed to hazardous noise exceeding 85 dB(A) working 20 hours per week (Lie et al., 2016). Further, most of the exposed workers belong to industry (18%) and, the agricultural sector, and house building sector (12%). In Europe, more than 90 million people suffer from unacceptable noise levels, and this necessitated the inauguration of the Environmental Noise Directive (END), 2002/49/EC for the region (European Commission News, 2005). The prevalence of hearing loss due to environmental noise is estimated to be 63 million (6.3%) in India and it is a common cause of Years lived with disability (Jamir *et al.*, 2014).

In an environmental evaluation of noise in Abuja City, Nigeria, a study in 35 locations indicated that the Central Business District of Abuja has values ranging between 75.8 to 83.6dB(A) which is above recommended tolerable values by WHO, therefore urgently calls for awareness and legislative regulations (Anomohanran, 2013). Furthermore, little or no concern has been raised for noise pollution, and only very few studies are available in this regard, On the other hand, existing studies in Nigeria have described noise as a slow and subtle killer through its hazardous effects on humans (Eludoyin, 2016).

In Morogoro Tanzania study reported the main impacts of exposure to excess noise were headache, hearing problem, sleeplessness, difficulty to concentrate and

conversation disruption (Gaganija *et al.*, 2012). High noise levels from PSVs in Nairobi put city dwellers at risk of adverse effects of noise as noise-induced hearing loss (NIHL); physiological and psychological noise effects; speech interference, sleep disturbance; annoyance, social and behavioural effects and this calls not only for intensified noise law enforcement in the city, but also puts to question the effectiveness of existing noise laws to control noise in the city (Otieno *et al.*, 2015).

Münzel, Gori, Babisch, and Basner (2014) found that long-term exposure to environmental noise can lead to adverse effects on the cardiovascular system, leading to hypertension, ischemic heart diseases, or even stroke. Also, numerous studies pointed to associations between environmental noise exposure and sleep disturbance, children's cognition, and negative effects in hospitals for both patients and staff (Stickland, Clayton, Sankey, & Hill, 2016).

Traffic-related noise pollution accounts for nearly two-third of the total noise pollution in an urban area (Bhosale *et al.*, 2010). Traffic noise on existing urban roadways lowers the quality of life and property values for a person residing in the vicinity of these urban corridors. Thus, the study of road traffic noise in big cities is an important issue (Bhosale *et al.*, 2010). Due to limited availability of land resources and finances, many highways and important roads are in the residential and commercial areas. Hence there will be some adverse and environmental effects including psychological and physiological effects to those living in proximity of these corridors Tande *et al.* (2011).

According to Lerner *et al.* (2010), annoyance is a feeling of displeasure related to any condition or agent believed by an individual to adversely affect him or her. Annoyance increases in a significant when noise is accompanied by vibration or by low-frequency components (Hammersen *et al.*, 2016). The term annoyance does cover a broad range of undesirable reactions associated with noise pollution; these include resentment, dissatisfaction, disappointment, exhaustion, feebleness, despair, anxiety, distraction, nervousness, or fatigue. According to Bodin, Björk, Ardö, and Albin (2015), lack of control over the noise intensifies these effects.

Social and behavioral influences of noise exposure are complex, subtle, and indirect. Alterations in social behavior that occur because of noise include aggressiveness, unfriendliness, nonparticipation, or disengagement and variations in other social indicators (Slovic *et al.* 2014). Susan *et al.* (2010) indicated that noise exposure per se is not believed to elicit hostile behavior. Notwithstanding, in combination with nagging, preexisting anger or hostility, alcohol or other psychoactive agents, noise may trigger aggressive behavior. The level of infuriation invoked by noise may change with the time of day, the unpleasant features of the sound, the duration, and intensity of the noise, the implication associated with it, and the nature of the action that the noise interrupted. Annoyance is greater when noise progressively increases rather than remaining constant.

Reliable studies now link high noise levels and activation of certain hormones and reactions in the human body. According to Saidatul, Mohammad, and Tamjis (2009),

noise activates the sympathetic-adrenal-medullary axis and the pituitary adrenal-cortical axis, while other scholars have frequently found significant changes in the levels of stress hormones including norepinephrine, epinephrine, and cortisol in acute as well as chronic noise experimentations (Wright, Peters, Ettinger, Kuipers, & Kumari, 2014). Noise is known to disrupt sleep and sleep patterns, and it also affects judgment and mental functioning significantly. Students in noisy environments cannot concentrate or focus on any particular thing for a significant amount of time, and when they do, the retention capacity is low. Noise does impact human behavior and psychological assessments such as heart rate, blood pressure, and blood flow (Field, Diego, & Hernandez-Reif, 2001). These and other popular studies attest to the fact that those who work, live, or spend considerable time in busy and noisy metropolis are susceptible to myriad health risks owing to high levels of noise pollution (Gongi, 2018).

Adverse health impacts seem to be associated with total noise exposure that emanates from all sources and not noise from any single source. The evidence related to low-frequency noise is adequately high to warrant immediate concern (WHO, 2008a). Adverse health effects from low-frequency noise are thought to be more severe than from other forms of environmental noise. This type of noise is underestimated with the usual types of sound measuring equipment. However, because there is widespread ignorance of the hazard, awareness must be increased about the harmful impacts of noise on hearing and the deterrence and regulator of noise-induced hearing loss (Haynes, Moran, & Pindzola, 2012). Morata and Johnson (2012) argue that a positive

image of hearing ought to be promoted, including its contribution to the daily quality of life.

Eliminating or reducing workers' exposure to noise at work is not merely a legal obligation for entrepreneurs and managers; it is also in an organization's commercial interests (Trigenza, 2005). Noise, a noteworthy physical hazard, can be managed through a myriad of measures. Organizations can minimize noise by implementing noise reducing equipment and systems that have been engineered, designed, and developed to operate quietly; by enclosing or shielding noisy equipment; by making sure that certain equipment is in proper working condition with all worn out or unstable parts supplanted; by installing noisy equipment on special props to minimize vibration; and by installing silencers, mufflers, or baffles. Substituting quiet work methods for noisy ones is another significant way to reduce noise. For example, welding parts rather than riveting them. In addition, erecting sound barriers at adjacent workstations around noisy operations will reduce worker exposure to noise generated at adjacent workstations (Staal *et al.* 2004).

#### **2.4 Sound Levels**

Kryter (2013) noted that decibels (dB) are used in measuring sound pressure. Decibels also round up to zero scales, just like a temperature scale. A normal person cannot perceive sound to its minimum level of 0 dB or the sound of rustling leaves. Persons with excellent hearing capabilities can receive sound levels as low as 15 dB (Kanjo, 2010). On the higher end, sound levels that exceed 85 dB can cause damage as bad as

permanent hearing damage. The period spent around loud sound determines the extent of damage that will occur. The calmer the sound, the longer one can withstand it without any alarming effect as found by Lasak et al. (2014). However, exposure to some familiar sounds can lead to permanent hearing damage. With protracted exposure to noise levels that are above or around 85 dB, humans can easily cause their hearing capability to crumble (Kryter, 2013).

In India, Day time noise levels were measured in Asansol Industrial town of Eastern India the levels ranged from 70.1 dB(A) to 120.4 dB(A) which was high above the permissible limits for road traffic noise a major contributor to environmental noise (70 dB[A]) (Banerjee *et al.*, (2008). While in Morogoro town in Tanzania a study was undertaken in 16 points to assess the noise pollution level and its impact on the community within the Municipality the average noise equivalent level at measured points varied between 51.1 to 75.1 dBA and the results established noise levels more than the acceptable limit of 55 dBA, which is the daytime governmentally prescribed noise limit for residential-commercial areas in Tanzania (Gaganija et al., 2012).

In Kenya a study was done to evaluate the extent of noise pollution among three non-formal sectors in Kenya and the results indicated high values of 93.8 dB, 90. And 92.5 dB (A) across all sectors (Gongi, 2016) exceeding the maximum permissible limit of 75 dB (A) (WHO, 1999). Gongi *et al* (2016) also asserts that this high noise levels imply that the workers in non-formal industries are exposed to dangerous noise levels which is likely to have serious health effects. Mithaga *et all* (2013) in their study to evaluate

noise levels in manufacturing industries in Thika District found that the magnitude of noise exposure to the workers in manufacturing industries in Thika District is high ( $p < 0.05$ ) and recommends strict enforcement of noise control regulations supported by necessary trainings, policies and personal protective equipment's. The study also showed that the majority of the employees in the non-formal sector are ignorant of the risk associated with excessive noise in their work environment thus the organization should be conducting regular education on noise hazards and the need to use noise PPE.

Kenyan are exposed to dangerously high noise inside PSVs. An average noise level of  $86.3 \pm 9.5$  dB (A) was recorded inside PSVs in CBD of Nairobi City. These levels are way above the maximum permissible limit of 60 dB (A) and are mainly associated with the use of sound amplifying equipment to play loud music/radio inside PSVs (Otieno *et al.*, 2015). It is commonly known that rock musicians and ardent rock fans often experience noise-induced hearing losses due to exposure to high levels of sound (Chadha & Cieza, 2017). Other than the musicians and their ardent fans, other key people in the music industry such as club employees often experience hearing issues because of their exposure to extreme levels of noise. Elsewhere, over 75% of the students working as part-time employees in entertainment venues have been found to have some degree of hearing the loss of over 30 dB (Carlson *et al.*, 2013).

According to the WHO (2008), unprotected acquaintance to sound levels over 100 dB, such as the sound of a snowmobile or jackhammer, should be limited to 4h and not

more than four times a year. Pain's threshold is usually given as 140 dB; a level readily achieved in booming cars today (Cole, 2016). During specified impulses, people may be exposed to excessive noise such as gunfire, which occurs only for a short while, and such impulses should never exceed 140 dB among adults and 120 dB among young children. Cap pistols, firecrackers, and other loud toys can generate noise levels that can amount to hazardous noise that can lead to a lasting hearing loss (Pakulski, Glassman, Anderson, & Squires, 2016). Levels greater than 165 dB, even for a few milliseconds, are likely to cause acute cochlear damage. It is essential to recall to advise patients that one cannot get accustomed to loud noise, as the League for the Hard of Hearing notes they get deaf (Chadha & Cieza, 2017).

## **2.5 Safety Practices**

Employees and people working in noisy towns can reduce exposure to harmful and excessive noise with hearing protective devices. Hearing protectors, classified as per the method of wearing, are the keystone of any hearing conservation program. Mandatory application of hearing protective devices, such as muffs, assists employees working in highly noisy environments (Gillver, Williams, & Beach, 2014). Employers and noisy workplaces employ myriad noise protection devices. Protective devices that are in common use today include the insert-type protector, canal caps, and the muff-type protector (Sataloff & Sataloff, 2006). Insert-type protector reduces noise through plugging the external ear canal. On the other hand, the muff-type protector encloses the lobe of the ear to provide an acoustical cover (Barbara & Rose, 2011). According to

Gillver *et al.* (2014), people working in noisy environments are provided for or have to seek hearing protectors to prevent hearing loss and associated damages.

Safety practices that can assist in preventing hearing losses and other harmful effects call for personal, physician, and administrative engagement. Administratively, employers have an obligation to provide safety devices that prevent hearing loss or impairment. Benard and Kenneth (2009) asserts that employers should provide personal protective equipment to abate noise levels and that employers should give all employees an opportunity select hearing protectors that vary from entire head enclosures, canal caps, earplugs, to ear mugs. Moreover, employers should conduct frequent tests on the effect of noise and treatments. Physicians have the responsibility to supervise hearing conservation programs within large, noisy plants (Gillver *et al.*, 2014). Normally, the industrial physician will work together with consultants to express an expert opinion (Sataloff & Sataloff, 2006). The Occupational Safety and Health Act provides for the above and other standards that ought to be followed in a hearing conservation program.

There is also extensive literature on specialized hearing protectors and how they function (Chadha & Cieza, 2017). Specialized hearing protectors include passive, active, and communication headsets (Arenas & Suter, 2014). Passive protectors do not include any electronics or amplifications while active hearing protectors subsume electronics and power supply. Passive hearing protectors, which include uniform or flat attenuating hearing protectors, employ mechanical means to screen sound and offer almost equal reduction across the perceptible frequency range. In general, they make the

sound signals clearer, natural, and less distorted than the sound from orthodox hearing protector (Chadha & Cieza, 2017). Active hearing protectors are level dependent or sound restoration hearing protectors that block sound as well as employ electronic circuitry to transmit sounds that are of low levels. They are advantageous, as users do not have to remove them in the absence of noise to hear well. Users can also benefit from earmuffs with communication features such as FM, infrared, or wired technology for communication (Arenas & Suter, 2014).

## **CHAPTER THREE: MATERIALS AND METHODS**

### **3.1 Introduction**

This chapter presents the methodology of the study, and it encompasses the research design, population, data collection, data analysis and ethical considerations.

### **3.2 Study Design**

This study employed a cross-sectional descriptive study design. Noise levels were measured at different times of the day in each of the selected bus terminal. Data were collected at a specific point in time suggested by Yin (2013), and no follow-ups was done.

### **3.3 Variables**

#### **Independent variables**

The independent variables in this study were noise intensity with WHO(2000) and EMCA (1999) standards as the gold standard, noise sources, Duration and length of noise exposure and Safety practices towards high noise levels.

#### **Dependent variable**

The dependent variable was perceived health effects.

### **3.4 Location of the Study**

The study was carried out in the Central Business District of Nairobi City, the capital, and largest city of Kenya. Nairobi City differs in several ways from other Kenyan

counties since it is entirely urban. The county borders Kiambu County to the West and North, Kajiado County to the South and Machakos County to the East. It covers an area of 695 KM<sup>2</sup>. (KNBS,2009). The temperature ranges from a minimum of 10 degrees Centigrade to a maximum of 24 degrees Centigrade with an average of 17 degrees Celsius. The average rainfall is 925litres/M<sup>2</sup> per annum with a subtropical highland climate of 1795 Meters above the sea level. Nairobi County has a population of 3,138,369 with males being approximated to be 1,605,219 and the female population being 1,533,150 (KMI, 2007). The population density is 4,515inh/km<sup>2</sup> people per KM<sup>2</sup>. Nairobi County has 84 Sub-counties and Central Sub County/Central Business District is purposively selected as the study area, and it has a total population of 13,325 and covers an area of 1.7KM<sup>2</sup> (Appendices I).

### **3.5 Study Population**

Comprised of all community members at the bus termini.

#### **3.5.1 Target Population**

The target population comprised of men and women who operated daily in the gazetted bus termini within Nairobi central business district namely; Old Nation Bus Station, Ngara Bus Station, Railways Bus Station, Tyskys Bus Station, St Peters Clavers, Latema Bus Station, Central Bus Station, Ronald Ngala Bus station, Moi Lane( Mondlane). The accessible population was defined as community members comprising of business vendors, conductors, drivers, and supervisors within the respective bus termini.

### **Inclusion criteria**

- Business owners and matatu operators within the selected bus-termini.
- Having operated for at least 6 months as business owner and matatu operator in the bus-termini
- Participant who spend at least 8 hours a day as either a business owner or a matatu operator in the respective bus termini

### **Exclusion Criteria**

- Passengers moving in and out of the bus termini who would spend few hours at the termini
- Participant who were not willing to provide consent for participation.

## **3.6 Sampling Technique**

### **3.6.1 Sampling of Bus Termini**

A list of bus termini was generated and all the bus termini was purposively sampled and assigned a sequential number from 1-9. In selection of respondents, a geographical center of each terminus was identified and marked.

### **3.6.2 Sampling the Community Members**

Simple random sampling was used to sample the study population that comprised of all community members at the termini. A list of bus termini was generated and each bus termini was assigned a sequential number from 1-9. In selection of respondents, a geographical center of each terminus was identified and marked. A random direction

was identified by spinning of a pen. Thereafter business owners and operators were then counted in the selected direction to the end of a marked boundary within each terminus. Each business owner and matatu operators were then assigned random numbers. The same process was repeated in the opposite direction across each terminus. One matatu operator was then selected at random at each bus termini as the first participant using the assigned random numbers. Data was then collected from the participants at each terminal until the sample size was achieved. The population was considered homogenous because the targeted groups were all dwellers at the bus termini and all exposed to the same noise. Thus, the study adopted simple random sampling (Patton, 2005).

### **3.7 Sample Size Determination**

The following method was adopted for calculation of the sample size as suggested by Suresh and Chandrashekara (2012).

$$n = Z^2 pq / d^2$$

n=desired sample size

Z=standard normal deviation (1.96) that corresponds to 95% confidence level

P= Proportion of the population considered having a desired characteristic that in this study is unknown; therefore, 0.5 will be used.

Q =1.0- p for a binomial distribution

D =the degree of accuracy desired (0.05 will be used)

$$n = 1.962 \times 0.5 \times 0.5$$

0.052

$n = 384 + 10\% \text{ attrition rate} = 422$

### **3.8 Research Instruments**

#### **3.8.1 Noise Measurement**

A calibrated sound level meter model 8926 was used to investigate the noise level in dB (A). The investigation was done at every terminal; the work area was limited within 1000 sq. ft.(93sqM) in every terminal at a particular time. Each terminal was divided into a grid and evenly spaced at an approximate distance of 10 ft. (3.05 Sq. M) and sound levels taken and recorded. If the sound varied significantly, the grid spacing was reduced. The noise level at each terminal was measured at three different times of the day; morning (6-8am), noon (12-2.00pm) and late evening( 6.00- 8.00pm) during working days this is a procedure according to Barbara and Rose ( 2011) on measuring environmental noise at a public place . While conducting a noise survey using sound level meter it is required to set A-scale slow response, the regularly occurring maximum noise level are recorded at the center of each work area and usually the work area should be limited to 1000sq. ft (93 sq.M) or smaller (Shield & Dockrell, 2004).

#### **3.8.2 Questionnaire Administration**

A Semi-structured questionnaire was used to collect data to ascertain the bio data of the respondents, perceived health risks of noise, duration and length of noise exposure, noise sources and safety practices towards noise among community members in the termini.

### **3.9 Pre-test**

The pre-test was conducted using the semi-structured questionnaires and 2 calibrated digital sound level meter model 8926. 10% of the sample size was randomly picked at two bus termini in Thika town: Landless and Makongeni bus termini. 2 calibrated digital sound level meter model 8926 were also used to measure noise level in the two bus termini. The pilot testing was to establish that the research design was accurate and appropriate; this pilot study enabled the researcher to modify and fine tune the research instrument; therefore, it enhanced validity and reliability of the study (Kothari, 2004).

#### **3.9.1 Validity**

Content validity was peer reviewed by University supervisors to assess the relevance of questions. It was appraised and ascertained that it would elicit adequate information to achieve the objective and to test the hypothesis of the study. Creswell, & Clark, (2007) supports that recommendations and suggestions should get incorporated into the final questionnaire before data collection, and that has been done here. There was an editing, handling the blank response from the questionnaires after the pre-test, editing involved checking the data and correcting any errors noticed and reported by the respondent. The data collection instruments were designed in such a way that they measure the perceived health effects and safe practices against environmental noise on the population of study (Roberts *et al.* 2006).

### **3.9.2 Reliability**

Cronbach's alpha reliability scale was used to measure the internal consistency of the questionnaire. A Cronbach's Alpha score of 0.5 was obtained.

### **3.10 Data Collection Techniques**

Two research assistants were recruited and trained on the use of noise meter to measure noise level and also taken through the questionnaire. They had all graduated with bachelors in Environmental Sciences and were familiar with the topography of the Nairobi City to help reach the sampled termini. The primary objective of the training was to harmonize concepts on study design and content of the tools that were used in the study, after that; they were involved in collecting data. A semi-structured questionnaire was self-administered to the respondents, and those who were not able to respond individually were guided by the research assistants to help collect the data.

### **3.11 Data Entry and Analysis**

The data collected by sound level meter was simultaneously measured at different grid in each bus termini by two research assistants using a calibrated noise level meter each at three points and listed. They were then entered in an excel spreadsheet and the formula  $10 \cdot \log(\text{average}(10^{\text{user range}/10}))$  was used to calculate the average noise level in each terminal at a particular time (Barbara & Rose, 2011). The socio-demographic characteristics were analysed and presented by use frequencies and percentages. Association between noise levels, demographic factors and outcome of interest (health effects) was assessed using Chi Square test of independence. The level

of association was reported using crude Odds Ratio (COR) at a 95% confidence interval (95%CI). A *p* value less than 0.05 was considered statistically significant. Analysis was done using Statistical Package for Social Sciences (SPSS)-software Version 20 (SPSS Inc., Chicago, Illinois, USA).

### **3.12 Ethical Considerations**

All procedures and conduct in the study were scrutinized and approved by the school of public health sciences, Kenyatta University. Ethical clearance was sought from the Graduate School of Kenyatta University, and Kenyatta University Ethics Research Committee (KUERC) respectively. Authority was sought from National Council for Science and Technology (NACOSTI) and Nairobi County Administration, Department of Public health was informed of the study for approval, community leaders were briefed on the purpose of the study and their authority too sought before the study commenced, they were requested to intervene in mobilization to avoid resistance. Consent for the inclusion of subjects in this study was sought through a consent form that was read and presented to the informants for their approval or disapproval. Privacy and confidentiality of the information was provided, voluntary participation and withdrawal from the study at any stage without victimization. The anonymity of the subjects was assured where the identity of the individuals was protected by using numbers. The study results will be made available to the world of academia in the university libraries.

## CHAPTER FOUR: RESULTS

### 4.1 Introduction

This chapter presents data analysis and comprehensive report findings of the study. The findings are presented using tables, graphs and pie charts; analysis was guided by the objectives and research questions. The chapter therefore, presents results about the respondent's socio-demographic characteristics, perceived health effects of noise, noise levels and suggested safety practices to reduce harmful effects of noise. In this study, a total of 422 respondents were sampled to participate in the study, out of which the response rate was 94.08% (n= 397).

**Table 4.1: Descriptive summary of demographic characteristics**

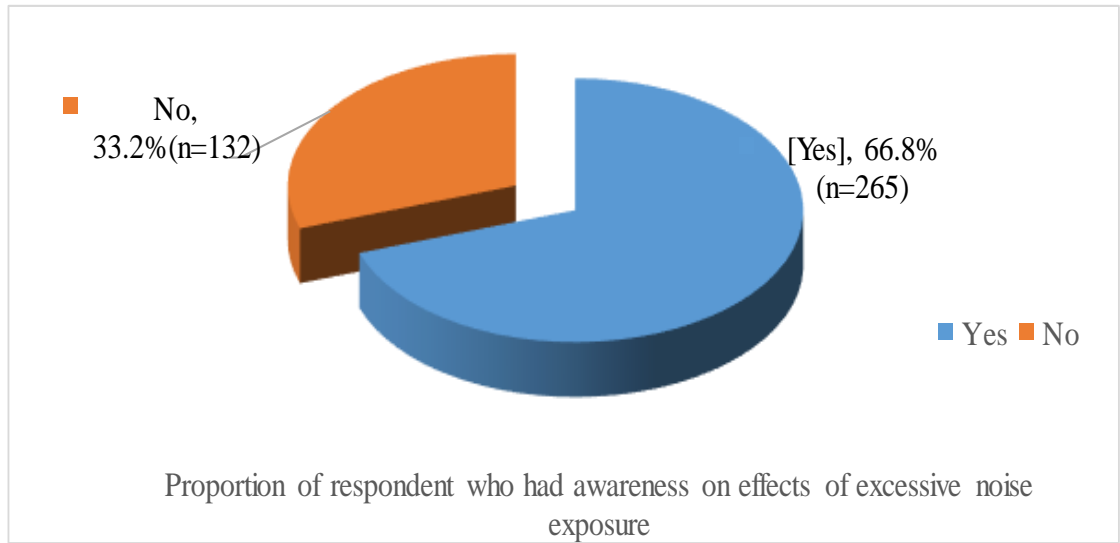
<b>Demographic</b>	<b>Categories</b>	<b><i>n</i></b>	<b>%</b>
Gender	Male	266	67.5
	Female	128	32.5
Education	Primary	51	13.4
	Secondary	125	32.7
	Tertiary	206	53.9
Occupation	Matatu Operators	202	52.2
	Business vendor	122	31.0
	Terminus Regulators	38	9.7
Length in Years spent at Termini	Less than 1 year	81	20.8
	1 to 5 years	176	45.1
	6 to 10 years	64	16.4
	11 to 15 years	69	17.7
No of days spent at the termini	1 to 2 days	41	10.6
	3 to 4 days	205	52.7
	5 days and above	143	36.8
Number of hours spent at Termini per day	1 – 4 hours	47	12.2
	5 - 7 hours	189	49.1
	8 hours and above	149	38.7
Termini	Central	48	12.1
	Latema	46	11.6
	Moi-lane	35	8.8
	Ngara	50	12.6
	Old Nation	47	11.8
	Railways	38	9.6
	Ronald Ngala	31	7.8
	Tuskys	56	14.1
	St Peters Claver	46	11.6

In this study, most respondents had reported to have achieved tertiary level of education as represented by 53.9% (n=206). Being a matatu operator (conductors, drivers) was the leading occupational activity at 52.2% (n=202) as compared to other occupational activities such as business vendors and terminus regulators. Most respondents reported to have worked for a period of between one to five years at the respective bus termini as represented by 45.1% (n=176). In terms of days spent at work most respondents reported to be spending up to 4 full days working at the bus termini as represented by 52.7%(n=205). Majority of the respondents as represented by 49.1% (n=189) spend between 4-8 hours as compared to 38.7 %( n=149) who spend more than 8 hours at the respective bus terminus per day.

#### **4.2 Perceived Health Effects of Excessive Noise Levels**

In the figure below most respondents at 66.8% (n=265) had awareness on effects of excessive noise exposure compared to 33.2% (n=132) who indicated that they are not aware of any effects of excessive noise. Consistently the figure above shows that most respondents considered excessive noise as a health hazard.

Proportion of Respondents who had awareness on health effects of excessive noise exposure



**Figure 4.1: Proportion of respondents with awareness on effects of excessive noise exposure**

**Table 4.2: Opinion of respondents on noise as a health risk**

Table 4.2 shows the opinion of respondents on noise as a health risk in association with the demographic characteristics of respondents.

<b>Demographics</b>	<b>Consider Noise is a Health risk</b>		<b>Chi-Square test</b>
	<b>Yes</b>	<b>No</b>	
<b>Gender</b>			
Male	219	44	$(\chi^2 = 4.339; df=1; p<0.036)$
Female	92	32	
<b>Level of Education</b>			
Primary	44	6	$(\chi^2 = 2.603; df=2; p>0.457)$
Secondary	98	26	
Tertiary	162	41	
<b>Occupation</b>			
Matatu Operators	174	35	$(\chi^2 = 24.964; df=2; p<0.000)$
Business vendor	96	23	
Terminus Regulators	42	18	
<b>Duration of Working</b>			
Less than 1 year	61	19	$(\chi^2 = 2.811; df=3; p>0.422)$
1 to 5 years	140	34	
6 to 10 years	50	13	
11 to 15 years	60	9	
<b>Working Days</b>			
1 to 2 days	25	16	$(\chi^2 = 16.52, df=2; p<0.002)$
3 to 4 days	173	30	
5 days and above	111	30	
<b>Average Hours Spent in Terminal</b>			
1 – 4 hours	34	11	$(\chi^2 = 1.870, df=2; p>0.393)$
5 - 7 hours	149	38	
8 hours and above	125	24	

A higher proportion of male respondents who were the majority considered noise to be a health risk ( $\chi^2= 4.339$ ;  $df=1$ ;  $p<0.036$ ). In terms of occupation matatu operators (conductors and drivers) considered noise to be a health risk ( $\chi^2= 24.964$ ;  $df=2$ ;  $p<0.000$ ). A higher proportion of respondents who worked for more than 3 days in a week significantly considered noise to be a health risk as compared to those who worked for less than 2 days ( $\chi^2=16.52$ ,  $df=2$ ;  $p<0.002$ ). On the other hand, level of education of respondents ( $\chi^2= 2.603$ ;  $df=2$ ;  $p>0.457$ ), number of years spent working at the bus termini ( $\chi^2=2.811$ ;  $df=3$ ;  $p>0.422$ ) and hours spent in a day working in the terminal ( $\chi^2=1.870$ ,  $df=2$ ;  $p>0.393$ ) were not significantly associated with opinion of respondents on noise as a health risk.

**Table 4.3: Demographic Characteristics and visiting a doctor due to noise induced hearing problem**

Table 4.3 shows the health seeking behaviour due to noise effects. Respondents were asked to indicate if they have sought for treatment at one point due to a hearing problem that can be associated with excessive noise exposure.

Demographics	Visited a Doctor Due to a hearing problem		Chi-Square test
	Yes	No	
<b>Gender</b>			
Male	30	227	$(\chi^2=10.799; df=1; p<0.001^*)$
Female	30	95	
<b>Level of Education</b>			
Primary	7	44	$(\chi^2=3.158; df=2; p>0.206)$
Secondary	15	106	
Tertiary	39	160	
<b>Occupation</b>			
Matau Operators	28	175	$(\chi^2=1.326; df=2; p>0.515)$
Business vendor	18	100	
Terminus Regulators	8	30	
<b>Duration of Working</b>			
Less than 1 year	10	70	$(\chi^2=3.767; df=3; p>0.288)$
1 to 5 years	33	137	
6 to 10 years	10	53	
11 to 15 years	7	60	
<b>Working Days</b>			
1 to 2 days	25	16	$(\chi^2=16.52, df=2; p=0.002^*)$
3 to 4 days	173	30	
5 days and above	111	30	
<b>Average Hours Spent in Terminal</b>			
1 – 4 hours	8	39	$(\chi^2=2.474; df=2; p>0.290)$
5 - 7 hours	34	148	
8 hours and above	18	128	
<b>Aware of effects of Excessive Noise Exposure</b>			
Yes	33	26	$(\chi^2=6.82; df=1; p>0.009)$
No	226	84	

Table 4.3 shows the association between demographic characteristics and visiting a doctor due to a noise induced hearing problem. Equal number of male and female respondents visited the doctor due to a noise induced hearing problem. A significant association exist between the proportions of respondents in terms of gender and visiting the doctor for a noise induced hearing problem ( $\chi^2= 10.799$ ;  $df=1$ ;  $p<0.001$ ). A higher proportion of respondents who spend more than 3 days working at the bus termini visited the doctor for a noise induced hearing problem as such, there is a significant association between the number of days spend working at the bus termini in a week and visiting a doctor for a noise induced hearing problem ( $\chi^2=16.52$ ,  $df=2$ ;  $p<0.002$ ). Among those respondents who had indicated they were aware of the harmful effects of excessive noise, a higher proportion of them visited the doctor for a noise induced hearing problem ( $\chi^2=6.82$ ;  $df=1$ ;  $p>0.009$ ). Level of education ( $\chi^2=3.158$ ;  $df=2$ ;  $p>0.206$ ), number of years spend working at the termini ( $\chi^2=3.767$ ;  $df=3$ ;  $p>0.288$ ), occupation ( $\chi^2=1.326$ ;  $df=2$ ;  $p>0.515$ ), and hours spend working at the termini ( $\chi^2=2.474$ ;  $df=2$ ;  $p>0.290$ ) were not significantly associated with visiting a doctor for a noise induced hearing problem.

**Table 4.4: Acute Health Effects of excessive noise exposure as reported by respondents**

This table shows acute common health effects due to excess noise exposure as perceived by the respondents

<b>Common Health effects</b>	<b>N</b>	<b>%</b>
Sleep Disturbance	152	24.17
Hearing impairment	145	23.05
Exhaustion	82	13.04
High Blood Pressure	80	12.72
Annoyance	64	10.18
Increases risk of Road accidents	46	7.31
Cause Disturbance to Immune system	40	6.36
It is harmful to babies	20	3.18

Table 4.4 above the five leading acute health effects of excessive noise were perceived to be sleep disturbance at 24.17% (n=152), hearing impairment at 23.05% (n=145), exhaustion at 13.04% (n=82), high blood pressure at 12.72% (n=80) and annoyance at 10.18% (n=64). Other acute effects of excessive noise exposure were; increased risk of road traffic accidents, disturbances to the immune system and noise as being harmful to babies.

**Table 4.5: Odds ratios (OR) and 95% confidence intervals (95% CI) on likelihood of an event being reported as a health effects of excessive noise**

An ordinal logistic regression was performed to estimate the likelihood of an event being reported as an effect of excessive noise exposure among respondents.

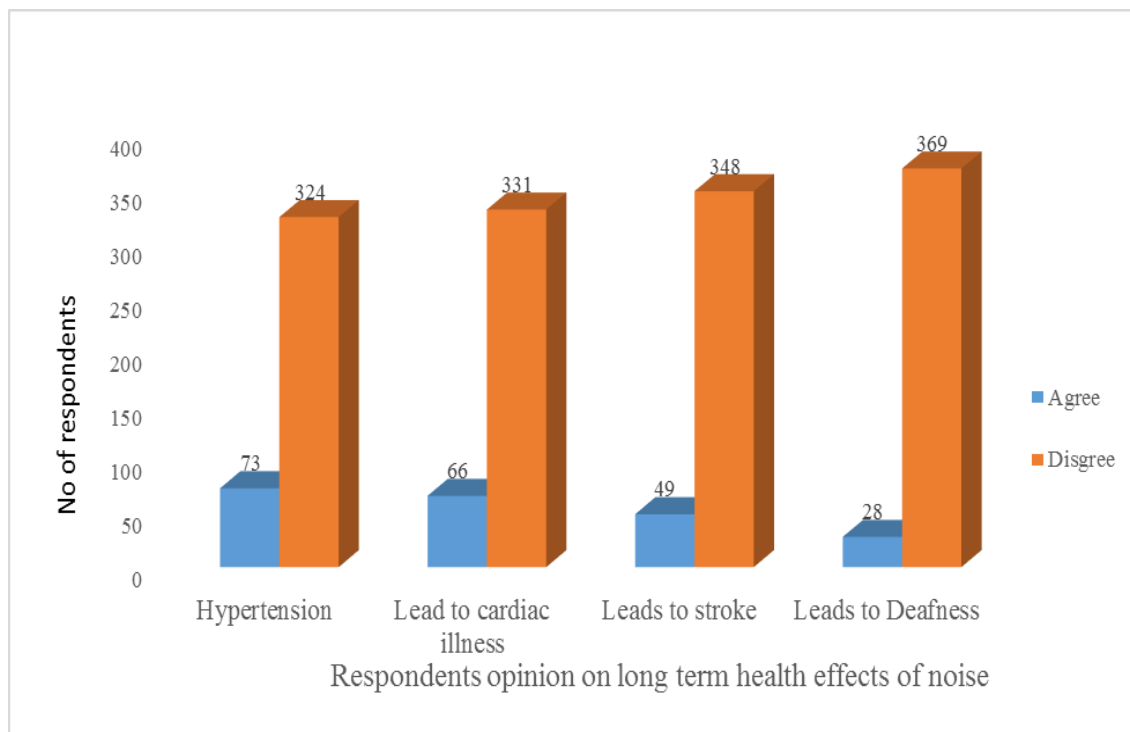
<b>Perceived Health Effects</b>	<b>OR</b>	<b>(95%CI)</b>	<b>Significant p-value</b>
Hearing problem/ impairment	0.040	(0.013-0.124)	p<0.000*
Tinnitus	0.177	(0.131-0.422)	p<0.000*
Accidents	0.235	(0.131-0.432)	p<0.000*
Annoyance	0.191	(0.102-0.361)	p>0.006*
Withdrawal	1.061	(0.586-1.920)	p>0.85
Anger	1.305	(0.711-2.396)	p>0.390
Exhaustion	1.01	(0.557-1.825)	p>0.98
Headache	0.179	(0.083-0.387)	p<0.000*
Speech interruption	0.441	(0.235 -0.826)	p<0.015*

Table 4.5 shows Odds ratios (OR) and 95% confidence intervals (95% CI) on likelihood of an event being reported as a health effects of excessive noise. Health events that were likely to be reported as effects of excessive noise include; hearing impairment (OR 0.040; 95%CI=0.013-0.124); tinnitus (OR 0.177; 95%CI= (0.131-0.422)); accidents (OR 0.235; 95%CI=0.131-0.431); annoyance (OR 0.191;95%CI=0.102-0.361); headache (OR 0.179;95%CI=0.083-0.387) and speech interruption (OR 0.441;95%CI=0.235-

0.826). On the other hand, the events that were less likely to be reported as health effects of excessive noise exposure includes withdrawal (OR 1.061; 95%CI=0.586-1.920); anger (OR 1.305; 95%CI=0.711-2.396) and exhaustion (OR 1.01; 95%CI=0.557-1.825).

#### 4.2.1 Long Term Effects of Excessive Noise Exposure

This study sought to gauge what respondents considered to be the long-term effects of excessive noise exposure. Respondents were asked to indicate their level of agreement with health events they consider to be as a result of prolonged exposure to excessive noise. The results are as shown in figure 4.2 below



**Figure 4.2: Respondents opinion on long term health effects of noise**

In the figure above a significant number of respondents (n=73) identified hypertension as a leading long term health effects of noise as compared to n=324 respondents who disagreed that hypertension is not a long term health effects of noise exposure. On the other hand, only 28 compared to 369 respondents agreed that excessive noise exposure can lead to deafness. Other long term effects of excessive noise exposure were; occurrence of cardiac illness (n=66) and occurrence of stroke (n=49). Further analysis was done using Chi-Square test of independence to assess for the relationship between demographic characteristics and opinion on long term health effects of excessive noise exposure, the results are presented in tables 4.2.5 below.

**Table 4.6: Demographic characteristics and perceived chronic effects of noise**

The table shows the association between demographic characteristics and opinion on perceived chronic effects of excessive noise

	Hypertension	Cardiac Illness	Stroke	Noise Induced hearing loss
Gender	$\chi^2=0.148;df=1;$ p>0.700	$\chi^2=0.001;df=1;$ p>0.982	$\chi^2=1.019;df=1;$ p>0.313	$\chi^2=6.844;df=1;$ p<0.009*
Level of education	$\chi^2=2.386;df=2;$ p>0.496	$\chi^2=4.821;df=2;$ p>0.185	$\chi^2=4.069;df=2;$ p>0.254	$\chi^2=6.977;df=2;$ p>0.026
Occupation	$\chi^2=2.404;df=2;$ p>0.662	$\chi^2=5.960;df=2;$ p>0.202	$\chi^2=3.525;df=2;$ p>0.474	$\chi^2=8.878;df=2;$ p>0.028

There was a significant association between gender ( $\chi^2=6.844$ ;  $df=1$ ;  $p<0.009$ ), level of education ( $\chi^2 =6.977$ ;  $df=2$ ;  $p>0.026$ ) and occupation ( $\chi^2=8.878$ ;  $df=2$   $p>0.028$ ) with perceived of noise induced hearing loss as chronic health effect of excessive noise.

In this study it was observed as indicated in table 4.1, that 35%(n=133) of the respondents have spent more than 5 years working at the bus termini as compared to 65%(n=257) who had spent between less than 5 years working at the bus termini. A Chi-Square test of independence was performed in order to assess the association between lengths of years spent working at the termini versus reporting of chronic effects of noise exposure as shown in table 4.7 below.

**Table 4.7: Length of years at the Terminus versus perceived chronic Effects of Noise Exposure**

Perceived Long Term Health Effects	Opinion	Length of working(in years) at Terminus		Chi-Square test
		<5Yrs	>5Yrs	
Hypertension	Agree	53	60	$(\chi^2=8.131;df=1;p<0.043)^*$
	Disagree	16	36	
Heart diseases	Agree	51	66	$(\chi^2=9.13; df= 1; p<0.028)^*$
	Disagree	15	42	
Stroke	Agree	40	83	$(\chi^2=7.508; df=1; p<0.05)^*$
	Disagree	9	49	
Noise Induced hearing loss	Agree	18	105	$(\chi^2=34.50;df=1;p<0.02)^*$
	Disagree	10	54	

It was observed as indicated in table 4.7 above that working for longer period (more than 5 years) was statistically significantly associated with reporting of chronic health effects of prolonged exposure to noise. This includes, hypertension ( $\chi^2 = 8.131$ ;  $df=1$ ;  $p<0.043$ ), Heart diseases ( $\chi^2 = 9.13$ ;  $df=1$ ;  $p<0.028$ ), stroke at ( $\chi^2 = 7.508$ ,  $df=1$ ;  $p<0.05$ ), and noise induced hearing loss ( $\chi^2=34.50$ ;  $df=1$ ;  $p<0.02$ ).

As indicated in the table 4.1, over 88% ( $n=338$ ) of the respondents spent more than 4 hours in a day working at the bus termini while only 12% ( $n=47$ ) of the respondents spent less than 4 hours working at the bus termini. As such it is evident that a high number of respondents were exposed to noise at bus termini for more than 4 hours on each working day. As shown in table 4.8 below, a chi-square test was performed to assess the significance of hours spent at the terminus on reporting of perceived health effects of noise exposure.

**Table 4.8: A Chi- square test: Number of hours at terminus per day versus perceived health effects**

Perceived Health Effects	Opinion	Number of Hours at the Terminus		Chi-Square test
		< 4Hrs	>4Hrs	
Hypertension	Agree	8	18	$(\chi^2=0.671; df=1; p>0.715)$
	Disagree	64	174	
Heart diseases	Agree	7	20	$(\chi^2=0.710; df= 1; p>0.701)$
	Disagree	58	193	
Stroke	Agree	6	26	$(\chi^2=0.301; df=1; p>0.860)$
	Disagree	41	228	
Noise Induced Hearing Loss	Agree	17	270	$(\chi^2=6.113; df=1; p<0.04)*$
	Disagree	23	35	

Table 4.8 shows the relationship between numbers of hours spent in a day at bus terminus and reporting of perceived health effects of noise pollution. Spending more than 4 hours at the bus termini was statistically significantly associated with reporting of hearing impairment ( $\chi^2 = 6.113$ ,  $df=1$ ;  $p<0.04$ ) as a health effect of noise pollution. On the other hand spending more than four hours at any of the bus termini were not significantly associated with reporting of hypertension ( $\chi^2 = 0.671$ ,  $df=2$ ;  $p>0.715$ ), Heart diseases ( $\chi^2 = 0.701$ ,  $df=2$ ;  $p>0.701$ ) and stroke at ( $\chi^2 = 0.301$ ,  $df=2$ ;  $p>0.860$ ) as perceived health effects of noise pollution respectively.

### 4.3 Noise Intensity in the Termini

**Table 4.9: Average noise levels in decibels in the 9 bus termini**

Distribution of noise levels in decibels for the nine bus termini at different times of the day

<b>Location</b>	<b>6-8am</b>	<b>12-2pm</b>	<b>6-8 pm</b>
Old Nation Bus Station	93.65	91.39	104.97
Ngara Bus Station	93.63	85.45	92.31
Railways Bus Station	92.60	91.08	91.68
Tuskys Bus Station	91.00	94.28	115.04
St Peters Clavers	90.80	90.88	90.53
Latema Bus Station	89.54	92.08	85.56
Central Bus Station	88.35	93.99	90.13
Ronald Ngala	88.14	91.50	99.18
Moi Lane(Mondlane)	84.18	90.62	118.44
<b>Average</b>	<b>90.21</b>	<b>91.25</b>	<b>98.65</b>

Table 4.9 displays the distribution of average noise levels in decibels for the 9 bus stations. In the morning the maximum mean noise level was 93.65 dB recorded at Old Nation Bus Station with a minimum of 84.18 dB recorded at Moi Lane Bus station. At midday the maximum mean noise level was 94.28 dB recorded at Tuskys Bus Station with a minimum of 85.45dB recorded at Ngara Bus Station. In the evening, the maximum mean noise level was 118.44 dB recorded at Moi Lane Bus Station with a minimum of 85.56 dB recorded at Latema noise level.

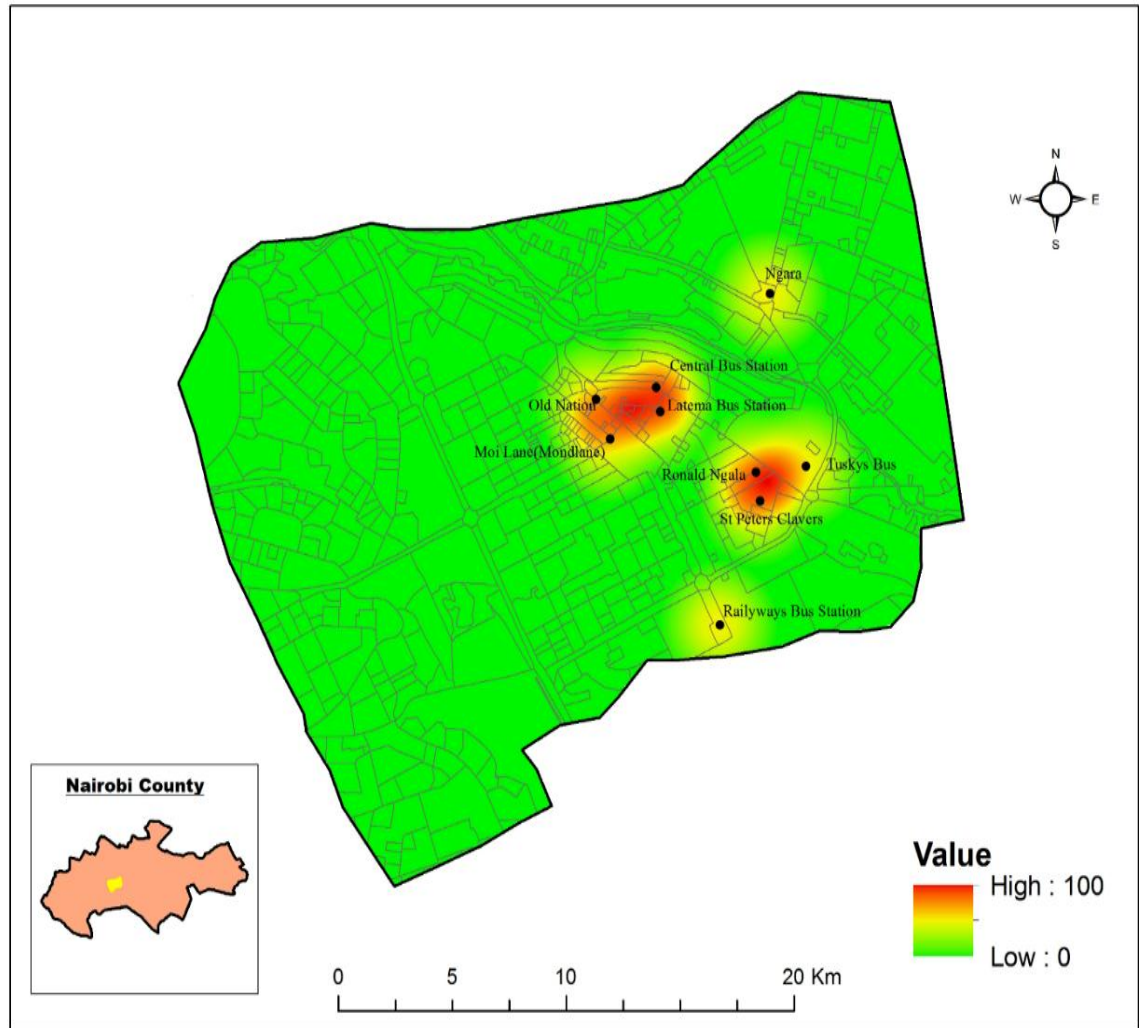
**Table 4.10: One-Way ANOVA: Mean Noise Levels at 3 Time points**

The table shows the results of one-way ANOVA conducted to test if the mean noise level varies across the three time points (6-8 am, 12-2 pm, and 6-8 pm) at the bus termini

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	296.74	2	148.37	2.67	p>0.09	3.4668
Within Groups	1167.21	21	55.58			
<b>Total</b>	<b>1463.95</b>	<b>23</b>				

The results as indicated in this table shows that the mean noise levels is not different across the three-time points [F=2.67; df= (2, 21); p>0.009].

Figure 4.3 shows the Arc GIS map concentration of noise levels across the main bus termini in the Central business District of the city of Nairobi.

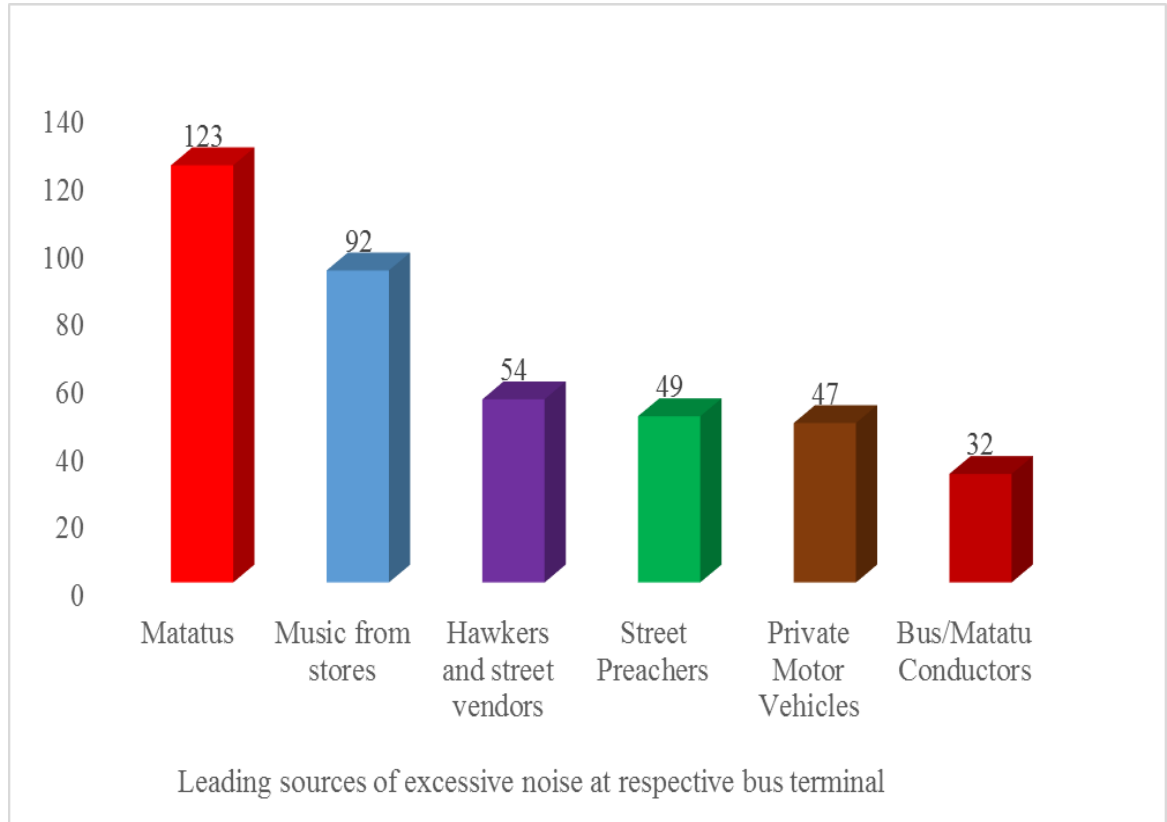


**Figure 4.3: Heat Map showing: Concentration of noise pollution at bus termini in Nairobi**

Bus termini that reported very high concentration of noise levels include: Tuskys, St Peters Clavers, Central Bus station, Latema and Ronald Ngala. Those that reported moderately low concentration of noise levels are Ngara and Railways bus station.

### 4.3.1 Major Sources of Excessive Noise levels

Figure 4.4 shows the perceived leading sources of excessive noise at bus termini

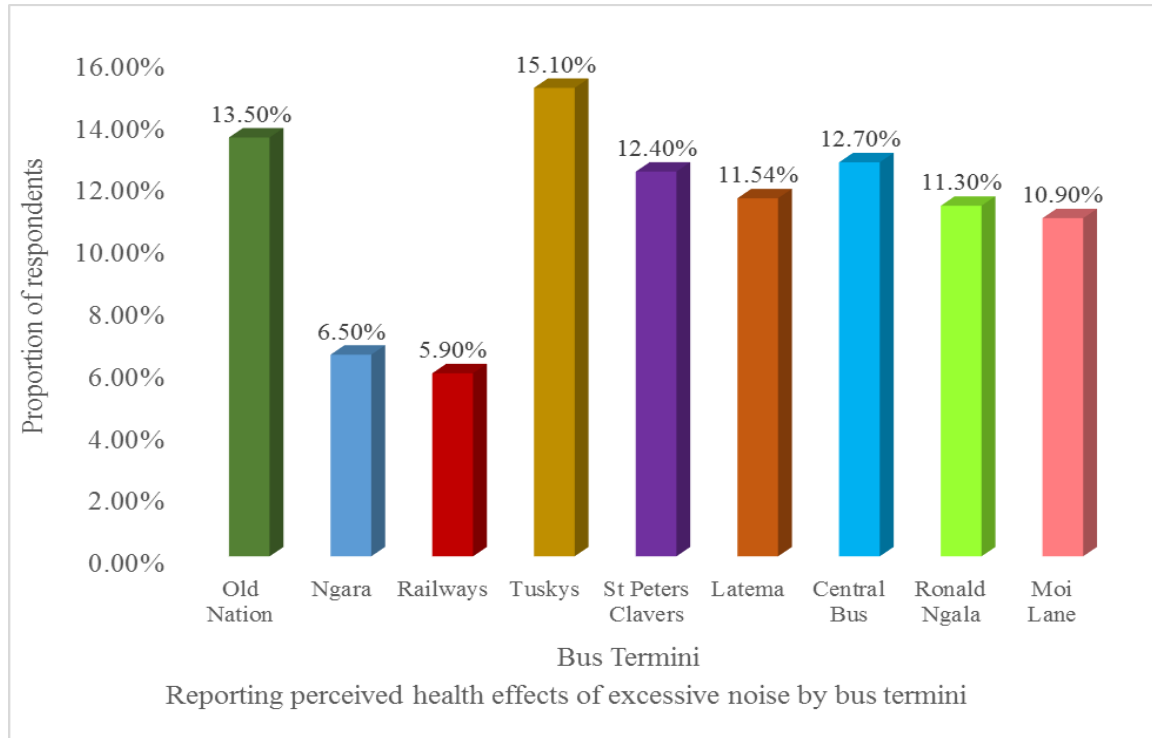


**Figure 4.4: Sources of excessive noise at respective bus termini**

In this study respondents were asked to identify what they considered as major contributors of noise in their respective bus termini. Across all the termini respondents identified the leading sources of noise were; matatu (n=123), music form stores (n=92), hawkers and street vendors (n=54). On the other hand respondents also associated street preachers (n=49), private motor vehicles (=47) and bus/matatu conductors (n=32) as sources of excessive bus termini.

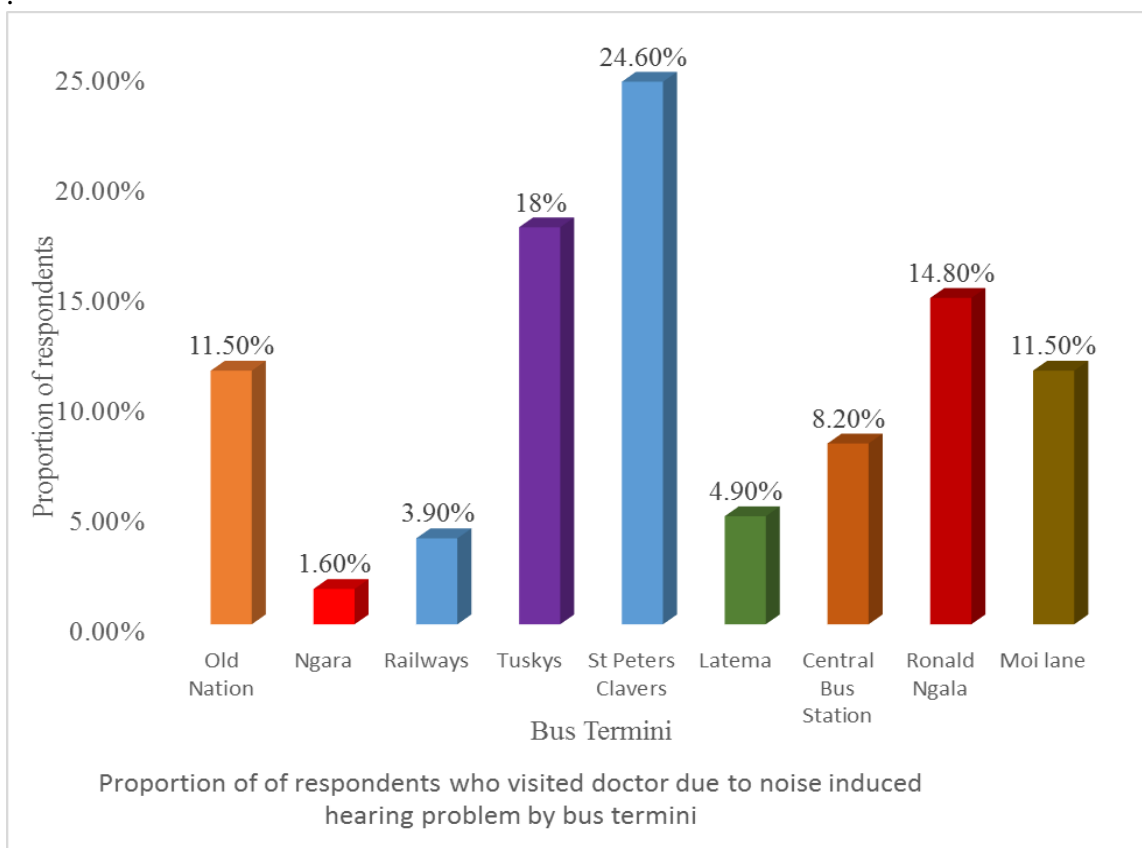
#### 4.4 Health Effects of Noise across Bus Termini

Figure 4.5 shows reporting of perceived health effects of excessive noise across bus termini



**Figure 4.5: Proportion of respondents reporting perceived health effects of noise by bus termini**

A high proportion of perceived health effects of excessive noise were reported from bus termini with high concentration of noise levels such as Tuskys, Old Nation, Central Bus station and St Peters Clavers. On the other hand, a lower proportion of perceived health effects of excessive noise were reported from bus termini with moderately low concentration of noise levels such as Ngara and Railways respectively.



**Figure 4.6: Proportion of respondents who visited doctor due to noise induced hearing problem by bus termini**

Figure 4.6 shows the proportion of respondents who visited the doctor due to noise induced hearing problem across the nine bus termini. A higher proportion of respondents who visited the doctor due to noise induced hearing problems were from bus termini that recorded high concentration of noise levels such as Tuskys (18%), St Peter's Clavers (24.6%) and Ronald Ngala (14.8%) respectively. On the other hand, a low proportion of respondents who visited the doctor were from bus termini that recorded

moderately low concentration of noise levels such as Ngara (1.60%) and Railways (3.9%) respectively.

**Table 4.11: Visiting a doctor for noise induced hearing problem versus Bus**

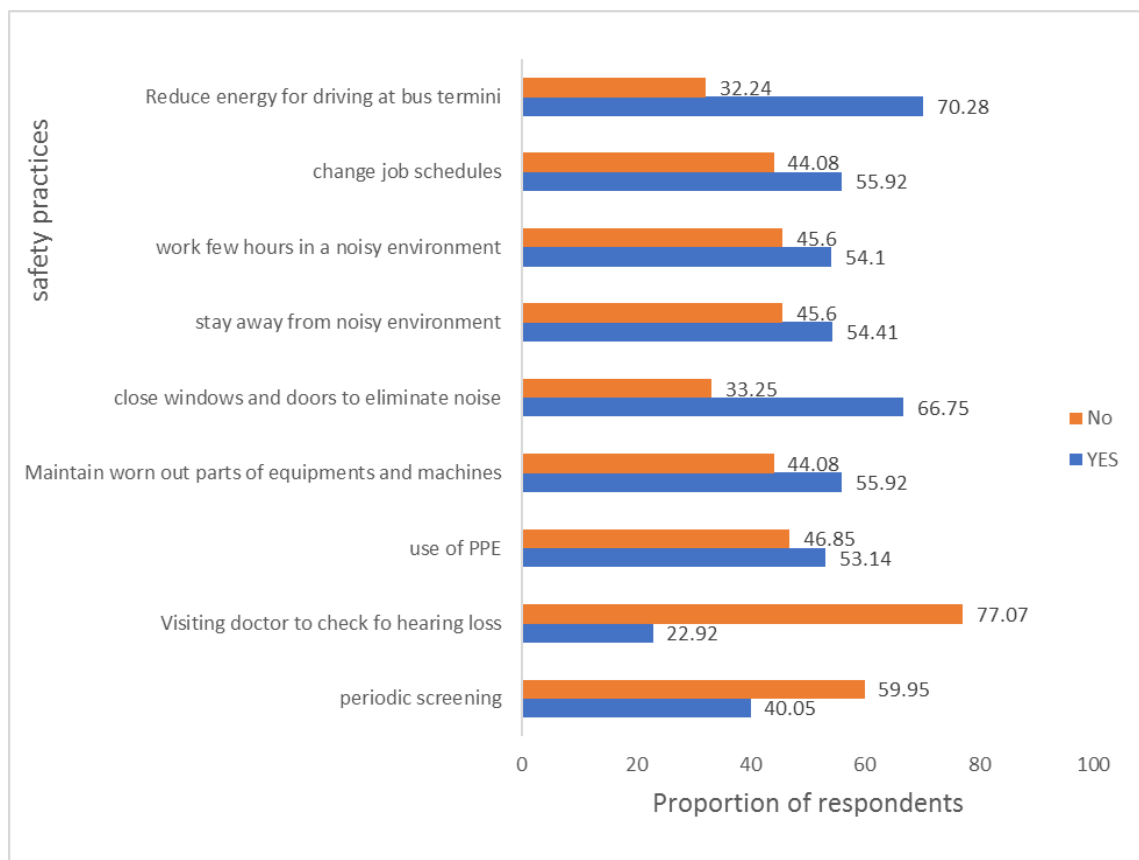
**Termini**

Termini	Visited Doctor for noise induced Hearing Problem		Chi-Square Test
	Yes	No	
Old Nation	7	40	$(\chi^2=27.663; df=8; p>0.001)$
Ngara	1	47	
Railways	3	34	
Tuskys	11	45	
St Peters Clavers	15	32	
Latema	3	40	
Central Bus Station	5	40	
Ronald Ngala	9	19	
Moi lane	7	27	

Table 4.11 shows the association between bus termini and visiting a doctor for noise induced hearing problem. This table shows there is a significant association ( $\chi^2=27.663; df=8; p>0.001$ ) between a respondent visiting a doctor for a noise induced hearing problem and the bus termini in which they are located. Hence a high frequency of respondent who visited the doctor for noise induced hearing problem were from bus termini that recorded high noise levels such as Tuskys, St Peter's Clavers and Ronald Ngala.

#### 4.5 Safety Practices Used As Measures against Noise Pollution among Respondents across Termini

Uptake of safety practices was assessed among respondents who included matatu/bus drivers, conductors/touts, business vendors and terminus clerks. Figure 4.7 shows the general overview on use of safety measures in the study population. While table 4.13 compares uptake of safety practices across different groups working at the bus termini.



**Figure 4.7: A bar graph: Safety practices on noise among respondents across termini**

Figure 4.7 shows safety practices and measures used by respondents. A higher proportion of respondents at 70.8% (n=279) indicated that they would reduce energy level when driving at bus termini as compared to 32.245 (n=128) who indicated otherwise. On the use of personal protective equipment (PPE) 53.14% (n=211) indicated that they were using personal protective equipment as compared to 48.85% (n=186) who stated otherwise. On minimizing external interruption from noise 66.75% (n=265) of the respondents indicated that they would consider closing windows to eliminate outside noise while 33.25% (n=132) indicated otherwise. On reducing frequent exposures 55.92% (n=222) of the respondents indicated they would change job schedules to coincide with time when noise levels is at lowest. On the other hand, 54.41% (n=216) indicated they would stay away from noisy environment and work for fewer hours in the noisy environment respectively.

**Table 4.12: Type of Occupation and uptake of safety practices**

Safety Practices		Type of Occupation			Chi-Square Test
		Matatu Operators	Business Vendors	Terminus Regulators	
Work Few Hours in Noisy Environment	Yes	105	67	28	$(\chi^2=7.746; df=2; p>0.021) *$
	No	101	54	9	
Use Personal Protective Equipment	Yes	97	51	15	$(\chi^2=9.683; df=2; p<0.016) *$
	No	110	70	22	
Periodic Screening on Hearing Loss	Yes	92	44	17	$(\chi^2=2.412; df=2; p>0.299)$
	No	114	77	20	
Close Windows and Doors to Eliminate Noise	Yes	133	87	28	$(\chi^2=3.89; df=2; p>0.05) *$
	No	75	32	9	
Walk Away from Noisy Environment When Free	Yes	106	66	25	$(\chi^2=5.29; df=2; p>0.024) *$
	No	93	54	12	

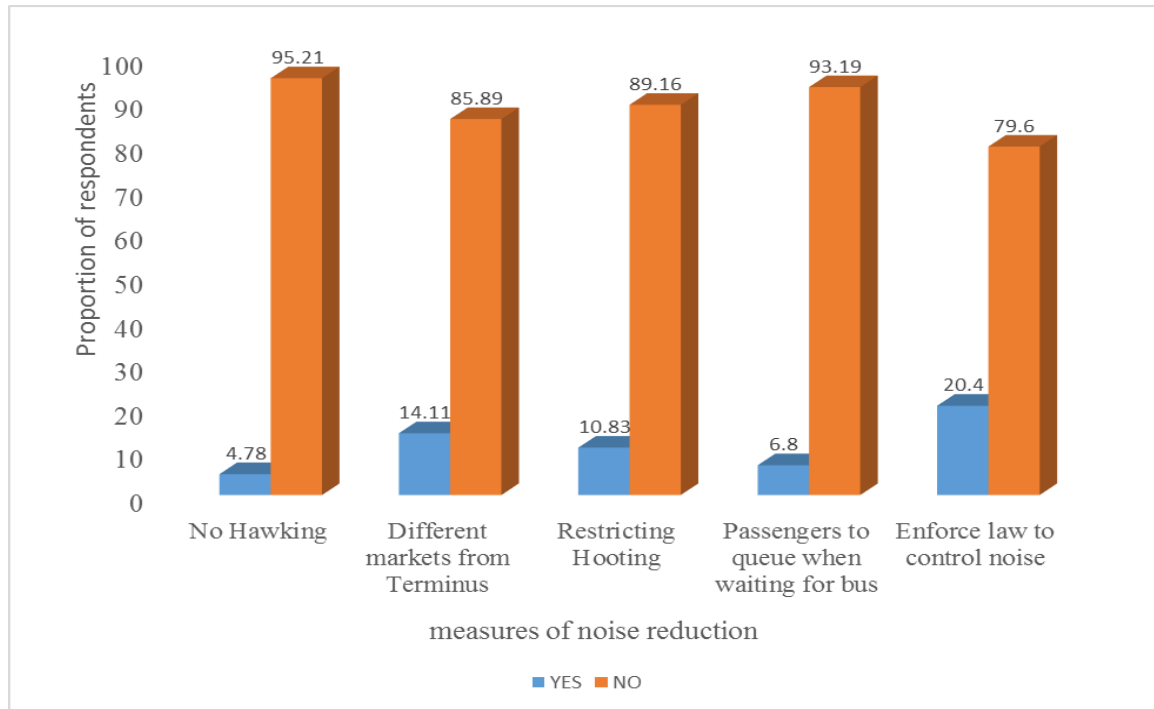
Table 4.12 shows the association between occupation and utilization of safety practices among respondents. Safety practices that were significantly associated with being utilized across all occupational groups include; working few hours in the noisy environment ( $\chi^2=7.746; df=2; p<0.021$ ); closing windows and doors to eliminate noise ( $\chi^2=3.89; df=2; p>0.05$ ) and walking away from noise ( $\chi^2=5.29; df=2; p>0.024$ ). A higher proportion of respondents across all the occupational groups significantly reported not using personal protective equipment ( $\chi^2=9.683; df=2; p>0.016$ ).

**Table 4.13: Odds ratios on reporting perceived health effects of excessive noise versus taking action to reduce noise**

Perceived Health Effects	Significant		
	OR	(95%CI)	p-value
Causes Hearing problem/ impairment	0.640	(0.420-0.994)	p<0.038*
Tinnitus	0.997	(0.784-1.268)	p<0.585
Accidents	1.042	(0.876-1.238)	p<0.656
Annoyance	0.590	(0.351-0.991)	p<0.041*
Withdrawal	1.061	(0.586-1.920)	p>0.851
Anger	1.305	(0.711-2.396)	p<0.390
Exhaustion	0.534	(0.320-0.891)	p<0.021
Headache	1.086	(0.849-1.397)	p<0.000*
Leads to Hypertension	0.657	(0.522-0.827)	P<0.000*
Leads to noise induced hearing loss	0.646	(0.420- 0.994)	P<0.003*
Speech disturbance	0.441	(0.235 -0.826)	p<0.015*

Table 4.13 show the odds ratio on reporting perceived health effects of excessive noise against taking action to prevent excessive noise. It is evident that those who took action to reduce noise levels were less likely to report health effects of excessive noise such as hearing problem impairment (OR 0.640;95% CI=0.420-0.994); annoyance (OR 0.590;95CI%=0.351-0.991); exhaustion (OR 0.534;95%CI=0.320-0.891); headache (OR 1.086;95%CI=0.849-1.397); leads to hypertension(OR 0.657;95%CI=0.522-0.827); leads to noise induced hearing loss (OR 0.646;95%CI =0.420- 0.994) and speech disturbance (OR 0.441;95%CI=0.235 -0.826). On the other hand there was no difference between taking action to reduce noise levels and reporting of perceived

health effects such as tinnitus, accidents, anger and headache since the corresponding confidence intervals of each OR includes 1.



**Figure 4.8: A Bar graph: Respondents suggestions on measures to control noise pollution**

Figure 4.8 shows measures suggested by respondents towards controlling noise pollution at bus termini. About 6.8% (n=27) of respondents indicated that passengers should queue while waiting for buses, 4.78% (n=19) of respondents suggested that no hawking should take place at bus terminus, 14.11% (n=56) of the respondents suggested bus termini be separated from markets, 10.83% (n=43) of the respondents suggested restricting hooting in bus termini while a majority at 20.4% (n=81) suggested that there is need to enforce laws to control noise at bus terminus.

## **CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS**

This chapter presents a discussion of the findings of the study on investigating levels of community noise and its perceived health implications on community members in the bus termini in Central Business District of Nairobi City in Kenya.

### **5.1 Discussion**

#### **5.1.1 Perceived Health Effects on Resultant Noise Levels on Bus Termini**

This study demonstrated that respondents were aware of harmful effects of excessive noise and considered excessive noise to be a health hazard. It was observed that Matatu operators (conductors and drivers), as well as other respondents who spent more than 3 days in a week working at the respective bus termini, indicated that noise is a health risk and that prolonged exposure would lead to hearing impairment. On exploring the health effects of excessive noise, it was observed from this study that an equal number of male and female (M30, F30) respondents visited the doctor due to the hearing problem perceived to have been caused by excessive noise exposure. It was further observed that a significant association exist between number of days spend working at the bus termini in a week and visiting a doctor for a noise induced hearing problem ( $\chi^2 = 6.113$ ,  $df=1$ ;  $p<0.04$ ). In which those who had spent more than 3 days working at the bus termini reported visiting the doctor more often for noise induced hearing problem. These findings are consistent with those of Carlson *et al.* (2013) who reported that occupational exposure to noise among students working as part-time employees in entertainment venues had contributed to hearing impairment as well as frequent visits to

ear specialists for management of the hearing problem. This study demonstrates that noise pollution in bus terminus is a health hazard that needs to be controlled since according to World Health Organization (2010), noise is currently one of the most common complaints amongst urban dwellers and workers in a huge metropolis.

Public awareness on health effects of noise is an important step in controlling noise pollution. As such respondents in this study identified, sleep disturbance, hearing impairment, exhaustion, high blood pressure and annoyance as acute health effects of excessive noise. This study established that a significant proportion of respondents 68% (n=254) indicated that noise levels in bus terminus are annoying. In this regard, Lerner *et al.* (2010) concurs that annoyance (a feeling of displeasure) increases when noise is accompanied by vibration or by low-frequency components. Similar findings have been reported by Pathak *et al.* (2008) who in their study to evaluate the noise pollution problem in the Varanasi city and its effect on the exposed people observed that 85% of the people were disturbed by traffic noise with 90% of the people reporting that traffic noise is the main cause of headaches, high BP problem, dizziness, and fatigue (Mansouri et al., 2006). Pathak *et al.* (2008) further reported that traffic noise was found to be interfering with daily activities such as at resting, reading, communication among urban residents.

On the other hand, hearing impairment, tinnitus, accidents, annoyance, headache and speech interference were reported as adverse effects of excessive noise in the city bus terminus. This demonstrates that the public have awareness on potential effects that

arise from noise pollutions in the bus terminus. However, what is lacking is the inability of authorities to control the high noise levels to protect the public from developing the adverse effects they have identified. The findings of this study concur with Basner *et al.* (2014) recommendations that tinnitus often follows acute and chronic noise exposure, and persists in a high proportion among the affected individuals for extended periods. In this regard, they indicate that tinnitus can affect the quality of life in several ways, including causing sleep disturbance, depression, and inability to sustain attention.

Furthermore, this study established that prolonged exposure to noise pollution was significantly associated with the ability of respondents to identify long-term effects of noise pollutions such as the occurrence of hypertension and associated cardiac conditions. In explaining the role of noise in leading to hypertension Saidatul *et al.* (2009) indicates that noise activates the sympathetic-adrenal-medullary axis and pituitary adrenal-cortical axis causing an increased production of stress hormones including norepinephrine thus leading to increase in heart rate, blood pressure, and respiratory rate. Therefore, as observed from this study prolonged exposure to high noise levels would lead to increased production of stress hormones which contribute to increased risk of hypertension among frequent users of bus terminus in the city.

Additionally, physical effects of hearing impairment at bus terminus were associated with spending more than four working hours at any of the bus termini. These points to the fact that since most respondents spend much of their time at the bus terminus, there is an increased risk of developing hearing impairment. In a similar study, Pelegrin *et al.*

(2015) observed from their study on predictive factors of occupational noise-induced hearing loss in Spain that 73.7% of their respondents had pathological audiograms associated with the noisy working environment. They concluded that long duration of noise exposure and lack of use of hearing protection measures were the predictive factors of the risk to develop objective hearing impairment, as indicated by the audiometric test. On the other hand, Rabinowitz *et al.* (2011) indicate that noise-induced hearing loss is prevalent and there is a need to develop interventions to reduce their impacts. From their study, they observed that daily use of devices that monitor noise exposure on a daily basis might decrease occupational hearing loss risk since hearing loss develops gradually over time.

### **5.1.2 Noise Level in Bus Termini**

High noise levels were observed across the city bus terminus with the maximum mean level of 98.65dB being reported in the evenings. The noise levels observed in this study were above the maximum permissible noise level of 70dB and 60 dB as recommended by WHO (2008a). While the maximum noise level was above the permissible limits, the lowest noise levels of 90.21dB recorded in the city bus terminus were equally above the permissible noise limits. The difference in the average noise level between morning and evening hours observed in this study can be attributed to traffic movements in the city. In the morning public buses and matatu drop passengers in the city and then rush back to the residential areas to pick other passengers, hence they do not spend much time in the city bus terminus. While in the evening most passengers are rushing to go

hence most public vehicles are in the city picking passengers, and in the process, they emit much noise as they compete to attract passengers.

The findings from this study concur with those of Bhosale *et al.* (2009) on assessment of noise levels in Aurangabad, India which they observed a higher noise level at dense traffic zones during morning and evening sessions. They concluded that a number of vehicles passing on the road in unit time and the time of the day either morning, afternoon or evening contributes to variation in noise level. Additionally, Tande *et al.* (2011) in their study on urban corridor noise pollution in Surat city in India also concluded that traffic flow (vehicles/min) is responsible for noise generation in most of the cities.

It was observed in this study that there was no significant difference in mean noise levels across the three-time points that are morning, daytime and evening. However, there was a clear difference regarding the concentration of noise levels due to the location of the bus terminus in the city. There was a high concentration of noise levels at Old Nation, Moi Lane, Central Bus station, Latema, Ronald Ngala, St. Peters Clavers compared to Ngara, Railways, and Tuskys bus station respectively. High concentration of noise levels in five bus terminus can be attributed to their close location of within a 1 km radius of each other.

On the other hand, there was a low concentration of noise levels at Ngara and Railways since there are located far away from other bus terminus. As such, close location of

several bus termini within a small radius contributes to the significant generation of noise in the city. In concurring with the findings from this study Ozer *et al.* (2009) in their evaluation of noise pollution caused by vehicles in the city of Tokat Turkey suggested that routes of public transportation vehicles should be reorganised so as not to accumulate at one point in the city. Due to the close location, there is a high volume of both human and vehicle traffic flow at the five bus terminus together with other commercial activities which lead to the generation of excess noise. The findings of this study show that spreading bus terminus further apart from each other would help reduce noise pollution in the city. Consistent with the findings of this study Banerjee (2012), in a systematic review of literature related to research on traffic noise pollution in India observed that road traffic is the major source of urban noise emission. He argued that growing number of vehicles emit more unrestrained noise pollution in cities and thus there is a need to regulate the flow of traffic as a way of controlling noise pollution. Zannin *et al.* (2006) in their evaluation of noise pollution in urban parks in Curitiba concurs with the finding of the study that heavy traffic in urban areas together with intense commercial activities significantly contributes to noise pollution in urban areas.

In assessing the health effects of noise concentration across bus termini it was observed that a high proportion of perceived health effects of excessive noise were reported from bus termini with a high concentration of noise levels such as Tuskys, Old Nation, Central Bus station and St Peters Clavers. On the other hand, lower proportion of perceived health effects of excessive noise were reported from bus termini with

moderately low concentration of noise levels such as Ngara and Railways respectively. Furthermore, it was observed that a higher proportion of respondents who visited the doctor due to noise induced hearing problems were from bus termini that recorded high concentration of noise levels as compared to respondents from Termini with a moderately low concentration of noise levels. This finding showed that there is a significant association ( $\chi^2=27.663$ ;  $df=8$ ;  $p>0.001$ ) between a respondent visiting a doctor for a noise induced hearing problem and bus termini in which they are located. In this regard, this study demonstrates that noise exposure is a public health problem that needs to be addressed. Basner *et al.* (2014) concurs there is need to regulate and reduce noise levels at the source and also enforce exposure limits to reduce the negative health consequences of prolonged exposure to excessive noise.

In this study, public vehicles fitted with booming music systems were identified as responsible for increased noise pollution in the city. In association to the public vehicles, their operators commonly known as conductors were identified as major contributors to the sustained occurrence of noise in the city. This is confirmed by the conductor's mode of operation of shouting while hustling for passengers to board their vehicles in which they generate a significant amount of noise. From this finding, public transport systems need to be improved so as to reduce noise levels reported in this study. Similarly, Tandel *et al.* (2011) observed that poor transportation systems in urban areas contribute to increased noise hence there is a need to develop an efficient Mass Transit System.

### **5.1.3 Safety Practices on Noise Pollution at the Bus Termini**

The study participants reported using a number of safety practices and measures in order to reduce the harmful effect of noise exposure. Some of the practices being utilised across all occupational groups include; working few hours in the noisy environment, closing windows and doors to eliminate noise and walking away from the noise. A higher proportion of respondents across all the occupational groups reported not using personal protective equipment on their ears to reduce noise effects.

At a personal level, it was observed that respondents would consider closing windows to minimise external interruption from noise. As earlier reported most respondents considered noise as an annoyance in the city bus terminus hence they would consider closing windows as a way of limiting the level of annoyance. It is evident that closing windows only works in controlling external noise but may not control internal noise coming from the music systems fitted inside the public buses and matatu. Olayinka (2013) in his study on effective noise control measures and sustainable development in Nigeria concurs with the findings of this study by suggesting that noise results from citizen's behavior (driver, music player and hawkers) hence there is a need to educate the public on noise pollution.

It was observed from this study that respondents would consider changing job schedules to coincide with the time when noise levels are low. While other respondents would consider staying away from the noisy environment and work for fewer hours in the noisy environment respectively. It is evident that these actions point to the individual

measures taken to protect oneself from harmful effects of noise pollution. While these steps may work at an individual level, there is a need to have measures that work at all levels, since there are people who spend most of their time at the bus terminus. For example, Pelegrin *et al.* (2015) suggested that routine monitoring of noise levels and assessment of hearing status are part of effective hearing conservation programs. In contrast, it was observed from this study that periodic screening was the least used measure to track the effect of noise pollution to an individual. Therefore, at the individual level, it will be necessary for those who spend more than 8 hours a day at the bus terminus to undergo periodic screening for hearing impairment.

The findings of this study show that noise pollution at bus terminus emanates from a variety of sources, such as hawkers, boom cars, and conductors. Hence controlling noise pollution will require measures that target the individual source of noise. In this study, respondents suggested that bus terminus should be separated from markets so that noise from hawkers and business people can be controlled. Bhosale *et al.* (2010) concur with the findings of this study by suggesting that developing alternative roads and bus terminus would help avoid the heavy traffic in city areas which are the main source of noise pollution.

It was observed that controlling noise pollution would require restricting hooting in bus terminus. This is because uncontrolled hooting in bus termini as vehicles struggle to find their way in and out of the terminus generates much noise. Uncontrolled hooting is a behavioural problem that requires systematic education on behavioural change on part

of the drivers. As indicated by Olayinka (2013) noise pollution can be reduced by prescribing noise limits for vehicular traffic, ban on honking of horns in certain areas, in addition, he recommends that public vehicles drivers should be educated not to horn unnecessarily on the roads. Furthermore, it was observed that practices such as driving at high acceleration emit significant energy changes in the vehicle which in-turn produces high noise levels. Consistent with the findings of this study Annecke *et al.* (2008) indicates that there is a correlation between acceleration and noise for passenger cars as such they indicate that noise increase depends on the level of acceleration.

Public order and organisation in bus terminus are key in controlling noise pollution in cities. As observed from this study respondent suggested that passengers should queue while waiting for buses as a way of controlling noise. This is a practical suggestion since in most cases noise at the bus terminus emanates from bus/matatu conductors calling and pleading with passengers to board their vehicles. This is in line with the findings of the study by Olayinka (2013) who suggested that public awakening is very essential for the control and prevention of environmental noise pollution. Therefore, since noise results mostly from the citizen's behaviour, public education would produce good results in the long term. Similar observations were reported by Ozer *et al.* (2009) who recommended that increasing the public awareness can be mentioned among other noise preventive methods in urban areas.

While there are significant findings from this study, it is important to consider a number of limitations that would affect the generalizability of findings from this study. First,

this was a cross-sectional study that measured noise levels in selected bus terminus for a short duration of time. Secondly, counting of a number of vehicles per hour was not part of this study; hence it might not be possible to measure the effect of car units in the generation of noise in the city. However, despite the above limitations, this study identified that there are high noise levels in the bus terminus with combined motor and human traffic being responsible for generating excessive noise levels observed in this study. Furthermore, this study has demonstrated the existence of harmful health effects of noise across the bus termini in Nairobi.

## **5.2 Conclusions**

This study measured the noise levels across nine bus terminus in the city of Nairobi. From this study, various perceived health effects of noise pollution was identified, and this study confirms the existence of noise-induced hearing problems in the general public. This study has also demonstrated the existence of non-auditory health defects such as hypertension, annoyance, headache and accidents that was perceived to might have occurred due to high levels of noise pollution in the City.

The findings of this study confirmed that noise levels in the city of Nairobi are beyond the permissible levels as per local standards as well as World Health Organization recommendations on noise levels. From this study, it is concluded that location of bus termini close to each other significantly contributes to noise generation as such spreading the bus terminus far apart would help in reducing the noise levels. Consistent with existing social situation, this study confirms that public vehicles, bus conductors

and music from boom cars are the leading sources of noise at bus terminus in the city of Nairobi.

On prevention, this study confirms that there is the low uptake of noise control measures in the general public. On the other hand, this study has demonstrated a lack of public awareness on the importance of routine screening for hearing noise especially among those who are frequently exposed to high noise levels. This study has equally demonstrated that creating order in the public transport system would help reduce noise levels in the city of Nairobi. The study has further demonstrated that challenges posed by noise pollution on human health and the environment have not yet received full attention. Although statutory provisions regulating noise levels in Kenya do exist there implementation and enforcement are still low, and there is a need to scale up enforcement of laws on noise pollution.

### **5.3 Recommendations**

This study has demonstrated important findings from which the following recommendations have been drawn.

- There is need for annual screening for hearing loss and other noise health risks among community dwellers of the Central business District of Nairobi City.
- There is need for awareness and sensitisation campaigns on noise health risks/effects among the community dwellers of central business district of Nairobi City.

- There is a need for generation of noise maps in the city of Nairobi so as to measure both spatial and temporal distribution of noise levels in the city. The noise maps will provide vital information to city authorities, public works and the general public with information necessary to control noise pollution in the city of Nairobi.
- There is a need for regulatory bodies such as NEMA, County Public health officials, to conduct regular measuring of noise levels in the city with a focus on maintaining recommended noise levels at all times.
- There is a need for city management to spread out bus termini far apart from one another so as to reduce high concentration of noise levels at single hot spots in the city
- There is need for awareness and sensitisation campaigns on occupational health and safety/ on safety practices on noise pollution among the community dwellers of the Central Business District of Nairobi City.

#### **5.4 Suggestions for Further Research**

There is a need for longitudinal studies to measure noise exposure and health outcomes. Further studies are required to demonstrate the annual spatial and temporal distribution of noise levels in the city of Nairobi.

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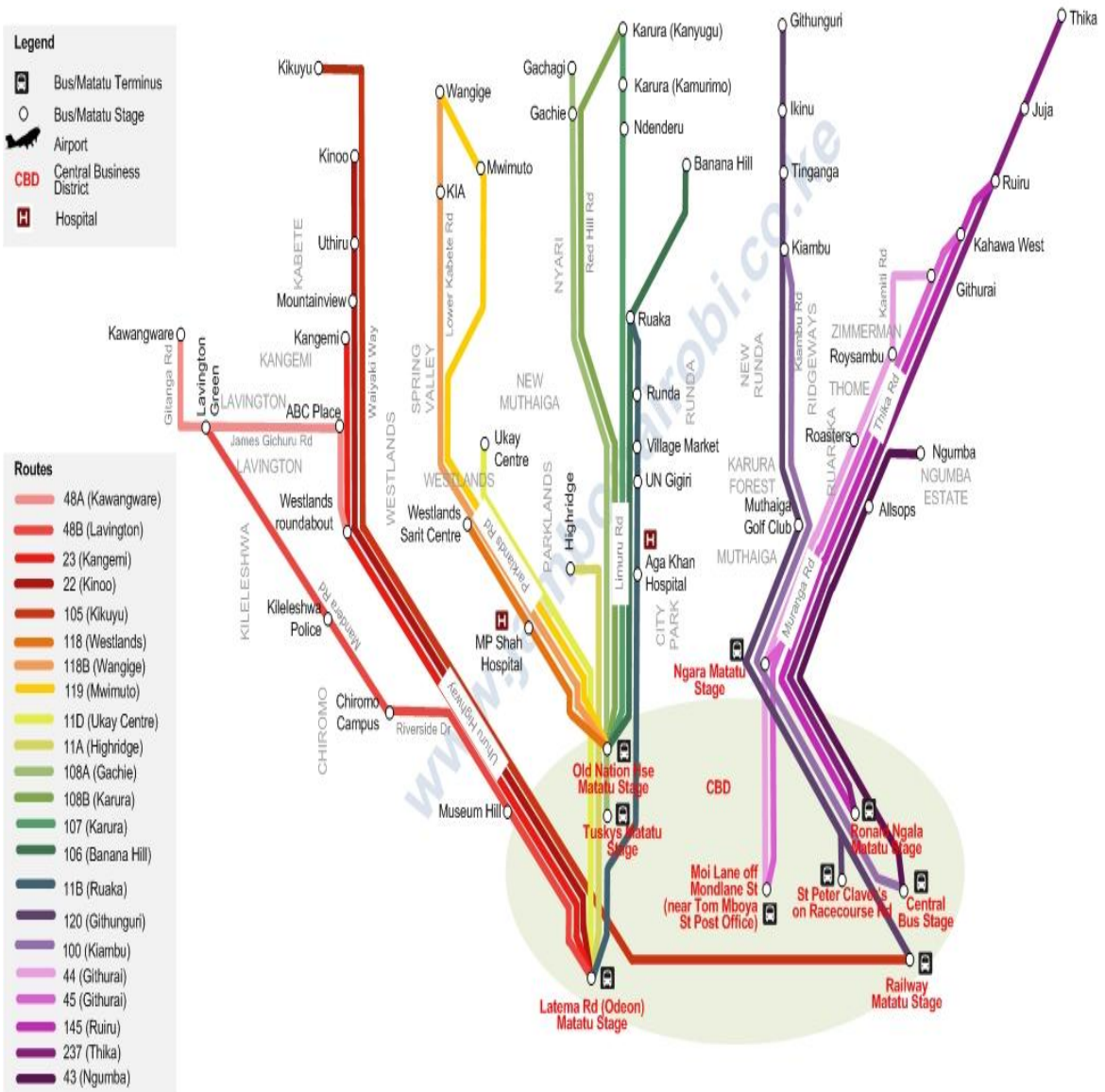
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APPENDICES

Appendix 1: Matatu Routes and Termini Within Nairobi Central Business District

District

Nairobi Matatu Route Map (3 of 3)  
Northern Suburbs



## **Appendix 2: Letter of Introduction and Informed Consent**

My name is Nyaranga Kogutu Caleb, a student at Kenyatta University pursuing Master of Science in Environmental Health. I am carrying out a study on “Levels of *Environmental noise and Perceived Health Implications in Selected Bus Terminus in Nairobi City County, Kenya*” The information is for my academic purposes and may help the ministry of Health and environment with baseline data that can help them on intervention strategies on health risks of noise.

### **Study procedures**

In this study I and my two research assistants will ask you questions on demographic and socio-economic characteristics, your perception on effects of noise pollution and your safety practices towards noise pollution.

You have the right to refuse participation in this study. You will continue with your normal operations in the terminus as usual whether you agree to participate in the study or not and your decision will not affect the support you receive from the terminus managers, Nairobi County Government or from any other relevant authority.

Participation in this study is voluntary and you may ask questions related to the study at any time.

You may refuse to respond to any questions and you may stop an interview at any time.

You may also stop being in the study at any time without any consequences to the

services you receive from managers of terminus and other relevant authorities managing the terminus or Nairobi County Government.

### **Discomforts and Risks**

There will be no risks involved during research process since the questionnaires will self-administered and only those who request to be assisted will be helped out by the research assistants. There will be no chemicals or drugs that will be ingested or administered neither sample that will be collected during the study that may amount to any adverse effects.

The interview will take approximately half an hour of your time.

### **Benefits**

The findings of this study may help identify some of the health problems workers at the terminus are facing due to noise at work place so that the corrective measures may be taken by the relevant authority. The results of this research will also help other stakeholders; Matatu Owners' Welfare Association, Non-Governmental Organizations, medical team and other private institutions to develop interventions and management strategies on workers that are exposed and already affected by the noise problem.

### **Reward**

If you agree to participate in this study, there is no reward that will be given.

**Care and protection of research participants**

The participants for this research will be community members who usually work at the bus terminus. The interviews will be conducted privately at their usual work place or at any other place as will be preferred by them. Procedures for gathering the data will be followed carefully to ensure the participants are comfortable in the process.

**Confidentiality**

The interviews will be conducted privately at work place or at any other place as will be preferred by participants. Your name will not be recorded on the questionnaire .All the information you will provide will be confidential and I will only share with my supervisors. The questionnaires will be kept in a locked cabinet for safe keeping and everything will be kept private.

Your participation in this research is very important and I therefore highly request you to participate.

NB: In case you need more information and clarification, please contact the following:

1. Nyaranga Kogutu Caleb

Phone number: 0720912409

Kenyatta University,

Department of Environmental and population Health

P.O Box 43884-00100, Nairobi – Kenya

2. Dr. Jackim Nyamari

Phone number: 0722589335

Kenyatta University

P.O Box 43884-00100, Nairobi-Kenya

3. Chairman KUERC

Kenyatta University

P.O Box 43884-00100, Nairobi-Kenya

[Chairman.kuerc@ku.ac.ke](mailto:Chairman.kuerc@ku.ac.ke) , secretary.kuerc@ku.ac.ke

Interviewer: Signature/thumb print .....Date: .....

Witness: Signature/thumb print .....Date: .....

**Informed consent form**

I confirm that I have been informed about the purpose, duration and benefits and the risks of this study and my participation in the process. I acknowledge that I am free to withdraw from the study at any stage if so I wish, without giving any explanation and that I will not be compromised in any way since my participation is voluntary. I have been assured of confidentiality in all the information that I will provide. I have been given chance to ask questions and my questions have been answered to my satisfaction.

I am also aware that the information I provide may be published, but my name will not appear on any part of the study, nor will any information that may identify me be used in the study. I therefore, accept willingly to participate in the research.

Signature or thumb of interviewee: ..... Date: .....

Witness: .....

**Investigator statement**

I, the undersigned, have explained to the volunteer in a language s/he understands, the procedures to be followed in the study, the risks and the benefits involved.

Name of the interviewer -----

-----

-----

Interviewer Signature

Date



**PART B: SOUND LEVEL (Tick appropriately)**

7. Are you comfortable with the level of noise in the terminal?  Yes  No

8. If 'No' above, what is your opinion about the level since you started to work here?

Increased/has gone high  Remained the same  Decreased  No idea

9. Who/what do you consider to be the greatest contributor of noise in this bus terminal?

Motor vehicles  Train  Boom cars  Car horns  Sellers advertising their goods  Conductors'  Preachers'  Music from stores or matatus

Others, specify .....

10. Is there any noise source that originate from your point of work  Music  Car horns  people advertising their goods  poorly maintained vehicle parts

Refrigerators

Others, specify.....

11. Please indicate by ticking, which of the following do you perceive to cause more risk to you?

Boom cars  Car horns  Car alarms

Public transits systems  Music from the music stores  Noise from people advertising their goods  Conductors'  Preachers'

12. In your opinion who is most affected by noise?  Conductors  Drivers  Sellers in the terminal  Passengers  All of the above.

13. Rate the overall satisfaction with your working environment?  Very high extent  High extent  Moderate extent  Low extent  not at all

Give reason.....

14. Have you visited a Doctor or hospital due to hearing problem?  Yes

No (If NO skip question 16)

16. If YES above what do you think is the cause of your hearing problem?  Injury  Noise at work place  Inherited/Genetically  Infection/Disease  Others, specify .....

**PART C: HEALTH RISKS**

17. Would you consider that noise is a risk to the health of people working at the terminus?

Yes  No

18. Are you aware of any effects of excessive noise exposure?

Yes  No

If YES above please list

- i. \_\_\_\_\_
- ii. \_\_\_\_\_
- iii. \_\_\_\_\_
- iv. \_\_\_\_\_

## INSTRUCTIONS

Please read each item carefully and circle the appropriate choice (5, 4, 3, 2, or 1) that best reflects the extent to which you are aware that the problem may be caused by excessive noise exposure. Please use the scale below

### Level of agreement on acute/ chronic and long term health effects/risks

Strongly agree (SA) =5    Agree (A) =4    Neither (N) = 3    Disagree = (D) 2    strongly disagree (SD) = 1

Are you aware that the following health effects may be as a result of excessive noise exposure?

		<b>SA</b>	<b>A</b>	<b>N</b>	<b>D</b>	<b>SD</b>
19	Hearing problem/ impairment					
20	Tinnitus/wheezing sounds in the ear					
21	Low performance at work					
22	Accidents					
23	Annoyance					
24	Withdrawal					
25	Unfriendliness					
26	Mood Changes/ swings					
27	Anger					
28	Exhaustion					
29	Anxiety					

30	Speech interference					
31	Headache					
	<b>LONG TERM EXPOSURE EFFECTS</b>					
32	High blood pressure					
33	Heart diseases					
34	Stroke					
35	Deafness/Noise induced hearing loss					

36. Are you aware of any noise risk early warning signs?  Pain in the ear   
 headache  stress/depression  Shouts while communicating  Speech  
 interference  tinnitus or wheezing sound in the ear

Others, specify .....

37. Rate the annoyance due to noise  very annoying  Annoying  
 Moderate  Not at all

#### **PART D: SAFETY PRACTICES**

38. Are you aware of any measures that you or can be put in place to reduce excessive  
 noise in the termini?  Yes  No

If yes, specify .....

39. Are you taking any action to reduce excessive exposure to noise at work place?  
 Yes  No

Do you practice either of the following at work place? (Tick appropriately)

	Item	Yes	NO
40	Reduce energy for driving when approaching the terminus		
41	Change your job schedules eg miss work at times or be in the terminus for few hours		
42	Work few hours in a noisy environment		
43	Walk away from a noisy environment when having nothing to do		
44	Close windows and doors to eliminate outside noise		
45	Maintain worn out parts of equipment's and machines used		
46	Use of personal protective equipment's ( ear muffs and head gears)		
47	Do you periodically visit the doctor to check your hearing loss		
48	Periodic screening on hearing loss		

49. What would you like changed in the termini to enable you to cope better with noise as a community in your work place .....

50. Do you think that the Nairobi City County/Government is doing enough to help reduce the amount of noise in the terminal?  Yes  No

If yes above, what are they doing .....

## Appendix 4: Research Approval



KENYATTA UNIVERSITY  
GRADUATE SCHOOL

E-mail: [dean-graduate@ku.ac.ke](mailto:dean-graduate@ku.ac.ke)

P.O. Box 43844, 00100

Website: [www.ku.ac.ke](http://www.ku.ac.ke)

NAIROBI, KENYA

Tel. 020-8704150

Internal Memo

FROM: Dean, Graduate School

DATE: 5<sup>th</sup> October, 2015

TO: Kogutu Nyaranga Caleb  
C/o Environmental Health Department.

REF: Q139/24924/2013

SUBJECT: APPROVAL OF RESEARCH PROPOSAL  
=====

We acknowledge receipt of your revised Research Proposal as per our recommendations raised by the Graduate School Board of 16<sup>th</sup> September 2015 entitled "Levels of Community Noise and Perceived Health Implications in Selected Bus Terminus in Nairobi City County, Kenya".

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology and Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

EDWIN OBUNGU  
FOR: DEAN, GRADUATE SCHOOL

CC. Chairman, Environmental Health Department

Supervisors:

1. Dr. Jackim Nyamari  
C/o Environmental Health Department  
**Kenyatta University**
2. Dr. Daniel Akunga  
C/o Environmental Health Department  
**Kenyatta University**

EO/nn

## Appendix 5: Research Authorization



### NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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P.O. Box 30623-00100  
NAIROBI-KENYA

Ref. No.

Date:

**NACOSTI/P/16/69450/10412**

**29<sup>th</sup> April, 2016**

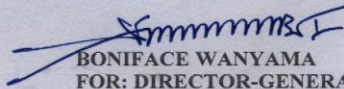
Caleb Kogutu Nyaranga  
Kenyatta University  
P.O. Box 43844-00100  
**NAIROBI.**

#### **RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on "*Levels of community noise and perceived health implications in selected bus terminus in Nairobi City County,*" I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for the period ending **29<sup>th</sup> April, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Nairobi County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

  
BONIFACE WANYAMA  
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner  
Nairobi County.

The County Director of Education  
Nairobi County.



## Appendix 6: Ethical Approval



### KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE

Email: [chairman.kuerc@ku.ac.ke](mailto:chairman.kuerc@ku.ac.ke)  
[secretary.kuerc@ku.ac.ke](mailto:secretary.kuerc@ku.ac.ke)  
[erc.ku2008@gmail.com](mailto:erc.ku2008@gmail.com)  
 Website: [www.ku.ac.ke](http://www.ku.ac.ke)

P. O. Box 43844 - 00100 Nairobi  
 Tel: 8710901/12  
 Fax: 8711242/8711575

Our Ref: KU/R/COMM/51/605

Date: 18<sup>th</sup> January, 2016

Kogutu Nyaranga Caleb,  
 Kenyatta University,  
 P.O Box 43844,  
 Nairobi

Dear Nyaranga,

RE APPLICATION NUMBER PKU/429/I 398 – “LEVELS OF COMMUNITY NOISE AND PERCEIVED HEALTH IMPLICATIONS IN SELECTED BUS TERMINUS IN NAIROBI CITY COUNTY, KENYA”.

1. IDENTIFICATION OF PROTOCOL

The application before the committee is with a research topic “Levels of community noise and perceived health implications in selected bus terminus in Nairobi City County, Kenya” received on 16<sup>th</sup> October, 2015.

2. APPLICANT

Kogutu Nyaranga Caleb, Department of Environmental Health

3. STUDY SITE

Nairobi City County, Kenya.

4. DECISION

The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.3) and the Kenyatta University Ethics Review Committee Guidelines AND APPROVED that the research may proceed for a period of ONE year from 18<sup>th</sup> January, 2016.

5. ADVICE/CONDITIONS

- i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.
- ii. Serious and unexpected adverse events related to the conduct of the study are reported to this board immediately they occur.
- iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.
- iv. Submit an electronic copy of the protocol to KUERC.

When replying, kindly quote the application number above.

If you accept the decision reached and advice and conditions given please sign in the space provided below and return to KU-ERC a copy of the letter.

**DR. TITUS KAHIGA**  
 CHAIRMAN ETHICS REVIEW COMMITTEE

I, Nyaranga Kogutu Caleb accept the advice given and will fulfill the conditions therein.

Signature..... [Signature] ..... Dated this day of 18/01/2016 ..... 2016.

cc. Vice-Chancellor  
 DVC-Research Innovation and outreach